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Introduction

Purpose and Development:
The North Dakota Science Content Standards focus on providing hands-on practices as well as rigorous content knowledge. These standards are a collaborative effort of K-12 educators, college instructors, and curriculum advisors from across the state of North Dakota. The standards were developed using the most current research and trends in science education with a focus on embedding the science and engineering practices to develop and support critical thinking skills. The science standards have been aligned vertically across the disciplines and grade levels to provide all students with a solid foundation. North Dakota issues and interests have been considered and emphasized throughout the document while using the Next Generation Science Standards as well as other state science standards as a framework. These standards were developed in a manner that allows local districts and their educators the autonomy to construct curriculum to meet their needs.

Disciplinary Core Ideas (DCIs)
Disciplinary Core Ideas describe the most essential ideas (content) of the performance standards that students will understand. The DCIs are grouped into four science domains.
  1. Physical Science (PS)
  2. Life Science (LS)
  3. Earth and Space Science (ESS)
  4. Engineering, Technology, and Applications of Science (ETS)

Science and Engineering Practices (SEPs)
The SEPs were used to construct the performance standards in order to guide instruction through the use of practices encapsulated by these eight categories.
  1. Asking questions and defining problems
  2. Developing and using models
  3. Planning and carrying out investigations
  4. Analyzing and interpreting data
  5. Using mathematics and computational thinking
  6. Constructing explanations and designing solutions
  7. Engaging in argument from evidence
  8. Obtaining, evaluating, and communicating information
K-12 science instruction utilizing the Science and Engineering Practices will:

1. Have broad importance across multiple sciences or engineering disciplines or be a key organizing principle of a single discipline.
2. Provide a key tool for understanding or investigating more complex ideas and solving problems.
3. Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge.
4. Be teachable and learnable over multiple grades at increasing levels of depth and sophistication. That is, the idea can be made accessible to younger students but is broad enough to sustain continued investigation over years.

Crosscutting Concepts (CCCs)

Crosscutting Concepts are fundamental science concepts which are embedded into each performance standard. These concepts serve the purpose of linking all the domains of science, and the knowledge contained within, in order to foster an intelligible and scientific understanding of the world around us. The CCCs will be utilized at all grade levels in all domains.

The CCCs include these universal scientific concepts:

1. Patterns
2. Cause and Effect
3. Scale, Proportion, and Quantity
4. Systems and System Models
5. Energy and Matter
6. Structure and Function
7. Stability and Change
The following icons represent grade levels, content domains and/or high school courses.

Anatomy  Life Science
Biology    Physical Science
Chemistry  Physics
Earth & Space Science  Engineering & Technology
Environmental Science  ND Connections
Engineering & Technology
The engineering and technology standards are integrated into each grade level and discipline. The engineering and technology performance standards are based upon the application of the engineering design process (EDP). The EDP provides students with a means of doing science rather than just knowing it. These practices help students form an understanding of the crosscutting concepts and disciplinary ideas of science. Practicing the EDP helps students understand the link between science and engineering making their knowledge more meaningful.
Scientific Method

The scientific method is a process for experimentation that is used to explore observations and answer questions. Even though the scientific method is shown as a series of steps, keep in mind that new information or thinking point is considered during the process. But even when modified, the goal remains the same: to discover cause and effect relationships by asking questions, carefully gathering and examining the evidence, and seeing if all the available information can be combined into logical results.
Science and Engineering Practices:

1. Asking questions and defining problems
   – Asking questions and defining problems in K-12 builds on prior experiences and progresses to simple descriptive questions.

2. Developing and using models
   – Modeling in K-12 builds on prior experiences and progresses to include using and developing models (i.e., diagrams, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.

3. Planning and carrying out investigations
   – Planning and carrying out investigations to answer questions or test solutions to problems K-12 build on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.

4. Analyzing and interpreting data
   – Analyzing data in K-12 builds on prior experiences and progresses to collecting, recording, and sharing observations.

5. Using mathematics and computational thinking
   – Using mathematics and computational thinking in K-12 builds logical reasoning and problem-solving skills

6. Constructing explanations and designing solutions
   – Constructing explanations and designing solutions in K-12 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.

7. Engaging in argument from evidence
   – Engaging in argument from evidence in K-12 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s).

8. Obtaining, evaluating, and communicating information
   – Obtaining, evaluating, and communicating information in K-12 builds on prior experiences and uses observations and texts to communicate new information.
Motion & Stability: Forces & Interactions

Plan and Conduct an investigation to prove the effects of balanced and unbalanced forces on the motion of an object.

Clarification Statement
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.

Assessment Boundary
Assessment is limited to one variable at a time: number, size, or direction of forces.

Disciplinary Core Ideas
Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion.

Science & Engineering Practices
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts
Cause and effect relationships are routinely identified.

North Dakota Connection
Apply unbalanced forces to North Dakota winters. Examples include cars sliding on ice, sleds on snow, ice skating, etc.

Content Resources
North Dakota Connection contains resources in North Dakota that relate to this standard.

Content Resources provides a link to evidence of content instruction necessary for performance assessment proficiency.
Elementary science standards are grouped by grade level, and each grade level is identified by an icon.

Elementary science standards include the following content domains.

- Earth and Space Science
- Life Science
- Physical Science
- Engineering & Technology
## Motion and Stability: Forces and Interactions

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Assessment Boundary</th>
<th>Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.</th>
</tr>
</thead>
</table>

### Disciplinary Core Ideas
- **PS2.A: Forces and Motion**
  - Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.

- **PS2.B: Types of Interactions**
  - When objects touch or collide, they push on one another and can change motion.

- **PS3.C: Relationship Between Energy and Forces**
  - A bigger push or pull makes things speed up or slow down more quickly.

### Science & Engineering Practices
- **3. Planning and Carrying Out Investigations**
  - With guidance, plan and investigate in collaboration with peers.

### Crosscutting Concepts
- **Cause and Effect**
  - Simple tests can be performed to gather evidence to support or refute student ideas about causes.

### North Dakota Connection

### Content Resources

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7
## Motion and Stability: Forces and Interactions

**Performance Standard**  
**K-PS2-2**  
Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>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 (Newton’s Law of Motion).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment does not include friction as a mechanism for change in speed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS2.A: Forces and Motion</td>
<td>4. <strong>Analyzing and Interpreting Data</strong></td>
<td><strong>Cause and Effect</strong></td>
</tr>
<tr>
<td>-Pushes and pulls can have different strengths and directions.</td>
<td>-Analyze data from tests of an object or tool to determine if it works as intended.</td>
<td>-Simple tests can be designed to gather evidence to support or refute student ideas about causes.</td>
</tr>
<tr>
<td>ET1.A: Defining Engineering Problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions.</td>
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</tbody>
</table>

| North Dakota Connection                  |                                                                                               |                                                                                       |
| Content Resources                        |                                                                                               |                                                                                       |
### Energy

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Make observations to determine the effect of sunlight on Earth’s surface.</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-PS3-1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Sunlight warms the Earth's surface and all that lives and grows.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment of temperature is limited to relative measures such as warmer/cooler.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Sunlight warms Earth’s surface.</td>
<td>- Make observations (firsthand or from media) to collect data that can be used to make comparisons.</td>
<td>-Events have causes that generate observable patterns.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
<th>ND University Systems, North Dakota Agricultural Network (NDAN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Resources</td>
<td></td>
</tr>
</tbody>
</table>
# Energy

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use tools and materials provided to design and build a structure that will reduce the warming effect of sunlight on Earth’s surface.</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-PS3-2</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**
Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun.

**Assessment Boundary**

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS3.B: Conservation of Energy and Energy Transfer</td>
<td>6. Constructing Explanations and Designing Solutions</td>
<td>Cause and Effect</td>
</tr>
<tr>
<td>-Sunlight warms Earth’s surface.</td>
<td>-Use tools and materials provided to design and build a device that solves a specific problem or a solution to a specific problem.</td>
<td>-Events have causes that generate observable patterns.</td>
</tr>
</tbody>
</table>

**North Dakota Connection**

**Content Resources**
From Molecules to Organisms: Structures and Processes

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Describe patterns, through observation, of what plants and animals (including humans) need to survive.</th>
</tr>
</thead>
</table>

**Clarification Statement**
Examples of patterns could include that animals need to take in food, but plants make food; the different kinds of food needed by different types of animals; the requirement of plants to have light; and, that all living things need water.

**Assessment Boundary**

**Disciplinary Core Ideas**

**LS1.C: Organization for Matter and Energy Flow in Organisms**
- All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow.

**Science & Engineering Practices**

3. **Analyzing and Interpreting Data**
- Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions.

**Crosscutting Concepts**

**Patterns**
- Patterns in the natural and human designed world can be observed and used as evidence.

**North Dakota Connection**
ND Game and Fish, ND Natural Resource Conservation Services (ND NRCS), ND Department of Agriculture

**Content Resources**
**Earth's Systems**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use and share observations of local weather conditions to describe patterns over time.</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-ESS2-1</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**

Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days in different months.

**Assessment Boundary**

Assessment of quantitative observations limited to whole numbers and relative measures such as warmer/cooler.

**Disciplinary Core Ideas**

**ESS2.D: Weather and Climate**
- Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time.

**Science & Engineering Practices**

4. Analyzing and Interpreting Data
- Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions.

**Crosscutting Concepts**

Patterns
- Patterns in the natural world can be observed, used to describe phenomena, and used as evidence.

**North Dakota Connection**

ND Agricultural Weather Network (NDAWN), National Oceanic and Atmospheric Administration (NOAA), local meteorologist, National Weather Service

**Content Resources**
### Performance Standard

**K-ESS2-2**

Construct an argument supported by evidence for how plants and animals (including humans) can change their environment to meet their needs.

### Clarification Statement

Examples of plants and animals changing their environment could include beavers building dams, a squirrel digs in the ground to hide its food and tree roots can break concrete. Humans have developed means to heat and/or cool our homes and vehicles to protect ourselves from the elements.

### Assessment Boundary

### Disciplinary Core Ideas

**ESS2.E: Biogeology**
- Plants and animals can change their environment.

**ESS3.C: Human Impacts on Earth Systems**
- Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things.

### Science & Engineering Practices

7. Engaging in Argument from Evidence
- Construct an argument with evidence to support a claim.

### Crosscutting Concepts

Systems and System Models
- Systems in the natural and designed world have parts that work together.

### North Dakota Connection

ND Game and Fish, ND Natural Resource Conservation Services (ND NRCS), ND Water Commission, local zoo, ND Lignite Energy Council

### Content Resources
Earth and Human Activity

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Represent the relationship between the needs of different plants and animals (including humans) and the places they live using a model.</th>
</tr>
</thead>
</table>

Clarification Statement

Examples of relationships could include that deer eat buds, leaves, and grains, therefore, they may live in wooded areas and prairies. Grasses need sunlight, so they often grow in meadows. Plants, animals, and their surroundings make up a system. Models could be drawings, dioramas, and/or use of technology (e.g. iPad app: Draw and Tell).

Assessment Boundary

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESS3.A: Natural Resources</td>
<td>2. Developing and Using Models</td>
<td>Systems and System Models</td>
</tr>
<tr>
<td>-Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.</td>
<td>-Use a model to represent relationships in the natural world.</td>
<td>-Systems in the natural and designed world have parts that work together.</td>
</tr>
</tbody>
</table>

North Dakota Connection

ND Game and Fish, ND Natural Resource Conservation Services (ND NRCS), state parks

Content Resources
**Earth and Human Activity**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Ask questions to obtain information about the purpose of weather forecasting to prepare for and respond to weather.</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-ESS3-2</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**

Emphasize ways to prepare (e.g. shelter, clothing, food) for all types of weather (e.g. local seasonal weather: tornado sirens, blizzard warnings).

**Assessment Boundary**

**Disciplinary Core Ideas**

**ESS3.B: Natural Hazards**
- Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events.

**ET1.A: Defining and Delimiting an Engineering Problem**
- Asking questions, making observations, and gathering information are helpful in thinking about problems.

**Science & Engineering Practices**

1. **Asking Questions and Defining Problems**
   - Ask questions based on observations to find more information about the designed world.

8. **Obtaining, Evaluating, and Communicating Information**
   - Read grade-appropriate texts and/or use media to obtain scientific information to describe patterns in the natural world.

**Crosscutting Concepts**

**Cause and Effect**
- Events have causes that generate observable patterns.

**North Dakota Connection**

ND Agricultural Weather Network (NDAWN), National Oceanic and Atmospheric Administration (NOAA), local meteorologist, National Weather Service
# Earth and Human Activity

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-ESS3-3</td>
<td></td>
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</tbody>
</table>

**Clarification Statement**
Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include planting trees, reusing paper, and recycling cans and bottles.

**Assessment Boundary**

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
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<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things for sustainability.</td>
<td>-Communicate solutions with others in oral and/or written forms using models and/or drawings that provide detail about scientific ideas.</td>
<td>-Events have causes that generate observable patterns.</td>
</tr>
<tr>
<td>ET1.B: Developing Possible Solutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solutions to other people.</td>
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</tbody>
</table>

**North Dakota Connection**
ND Natural Resource Conservation Services (ND NRCS), ND Forest Service, ND Water Commission, ND Game and Fish

**Content Resources**
### K-2-ET1

#### Performance Standard K-2-ET1-1

Ask questions, make observations and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

#### Clarification Statement

Students can solve a given simple problem by asking questions, making observations, and gathering information.

#### Assessment Boundary

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ET1.A: Defining and Delimiting Engineering Problems</strong></td>
<td><strong>1. Asking Questions and Defining Problems</strong></td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>- A situation that people want to change or create can be approached as a problem to be solved through engineering.</td>
<td>- Ask questions based on observations to find more information about the natural and/or designed world(s).</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>- Asking questions, making observations, and gathering information are helpful in thinking about problems.</td>
<td>- Define a simple problem that can be solve through the development of a new or improved object or tool.</td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>- Before beginning to design a solution, it is important to clearly understand the problem.</td>
<td><strong>-</strong></td>
<td><strong>-</strong></td>
</tr>
</tbody>
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#### North Dakota Connection

Local engineering firms

#### Content Resources
## K-2-ET1

### Performance Standard

**K-2-ET1-2**

Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

### Clarification Statement

Create a model that will show how a shape of an object helps its function (e.g., build the tallest tower using multiple materials).

### Assessment Boundary

**Disciplinary Core Ideas**

**ET1.B: Developing Possible Solutions**
- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.

**Science & Engineering Practices**

2. **Developing and Using Models**
- Develop a simple model based on evidence to represent a proposed object or tool.

**Crosscutting Concepts**

- **Structure and Function**
  - The shape and stability of structures of natural and designed objects are related to their function(s).

### North Dakota Connection

Local engineering firms

### Content Resources
## Engineering & Technology

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-2-ET1-3</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**
Use data from Performance Standards K-2-ET1-1 and/or K-2-ET1-2.

**Assessment Boundary**

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ET1.C: Optimizing the Design Solution</strong></td>
<td><strong>4. Analyzing and Interpreting Data</strong></td>
<td>-Because there is always more than one possible solution to a problem, it is useful to compare and test designs.</td>
</tr>
<tr>
<td>-Because there is always more than one possible solution to a problem, it is useful to compare and test designs.</td>
<td>-Analyze tests of an object or tool to determine if it works as needed.</td>
<td></td>
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</tbody>
</table>

**North Dakota Connection**

**Content Resources**
## Waves and Their Applications in Technologies for Information Transfer

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Plan and conduct investigations to provide evidence that sound can make materials vibrate and that vibrating materials can make sound.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-PS4-1</td>
<td></td>
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</tbody>
</table>

### Clarification Statement
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.

### Assessment Boundary

### Disciplinary Core Ideas
<table>
<thead>
<tr>
<th>PS4.A: Wave Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Sound can make matter vibrate, and vibrating matter can make sound.</td>
</tr>
</tbody>
</table>

### Science & Engineering Practices
<table>
<thead>
<tr>
<th>3. Planning and Carrying Out Investigations</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Plan and conduct investigations collaboratively to produce evidence to answer a question.</td>
</tr>
</tbody>
</table>

### Crosscutting Concepts
<table>
<thead>
<tr>
<th>Cause and Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Simple tests can be designed to gather evidence to support or refute student ideas about causes.</td>
</tr>
</tbody>
</table>

### North Dakota Connection

### Content Resources
### Performance Standard 1-PS4-2
Construct an evidence-based account, through observation, that objects can be seen only when illuminated.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>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.</th>
</tr>
</thead>
</table>

#### Assessment Boundary

#### Disciplinary Core Ideas

- **PS4.B: Electromagnetic Radiation**
  - Objects can be seen if light is available to illuminate them or if they give off their own light.

#### Science & Engineering Practices

- **6. Constructing Explanations and Designing Solutions**
  - Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.

#### Crosscutting Concepts

- **Cause and Effect**
  - Simple tests can be designed to gather evidence to support or refute student ideas about causes.

#### North Dakota Connection

#### Content Resources
### Performance Standard 1-PS4-3
Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>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).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment does not include the speed of light.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS4.B: Electromagnetic Radiation</td>
<td>3. Planning and Carrying Out Investigations -Plan and conduct investigations collaboratively to produce evidence to answer a question.</td>
<td>Cause and Effect -Simple tests can be designed to gather evidence to support or refute student ideas about causes.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Resources</td>
</tr>
</tbody>
</table>
### Performance Standard 1-PS4-4

Design and build a device that uses light or sound to solve the problem of communicating over a distance.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Examples of devices could include a light source to send signals, paper cup and string &quot;telephones,&quot; and a pattern of drum beats to build understanding of how sound travels.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment does not include technological details for how communication devices work.</td>
</tr>
</tbody>
</table>

#### Disciplinary Core Ideas

**PS4.C: Information Technologies and Instrumentation**

-People also use a variety of devices to communicate (send and receive information) over long distances.

<table>
<thead>
<tr>
<th>Science &amp; Engineering Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. <strong>Constructing Explanations and Designing Solutions</strong></td>
</tr>
<tr>
<td>- Use tools and materials provided to design a device that solves a specific problem.</td>
</tr>
</tbody>
</table>

#### North Dakota Connection

**Content Resources**
From Molecules to Organisms: Structures and Processes

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Construct an evidence-based argument with the use of a drawing or a model that illustrates how structures of plants or animals help them survive in their habitat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-LS1-1</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**
An example could include how the parts of a turtle’s body help it survive (e.g. shell protects its body, webbed feet for swimming, claws for climbing).

**Assessment Boundary**

**Disciplinary Core Ideas**

**LS1.A: Structure and Function**
-All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow.

**LS1.D: Information Processing**
-Animals have body parts that capture and convey different kinds of information needed for growth and survival. Animals respond to these inputs with behaviors that help them survive. Plants also respond to some external inputs.

**Science & Engineering Practices**

2. **Developing and Using Models**
-Develop a simple model based on evidence.

6. **Constructing Explanations and Designing Solutions**
-Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.

7. **Engaging in Argument from Evidence**
-Construct an argument with evidence to support a claim.

**Crosscutting Concepts**

**Structure and Function**
-The shape and stability of structures and natural and designed objects are related to their function(s).

**Patterns**
-Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.

**North Dakota Connection**
-ND Game and Fish, ND Natural Resource Conservation Services (ND NRCS), ND University Systems

**Content Resources**
## From Molecules to Organisms: Structures and Processes

<table>
<thead>
<tr>
<th>Performance Standard 1-LS1-2</th>
<th>Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.</th>
</tr>
</thead>
</table>

### Clarification Statement
Examples of patterns of behaviors could include the signals that offspring make (such as crying, cheeping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring).

### Assessment Boundary

### Disciplinary Core Ideas
**LS1.B: Growth and Development of Organisms**
- Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive.

### Science & Engineering Practices
**8. Obtaining, Evaluating, and Communicating Information**
- Read grade-appropriate text and use media to obtain scientific information to determine patterns to the natural world.

### Crosscutting Concepts
**Patterns**
- Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.

### North Dakota Connection
ND Game and Fish, ND Natural Resource Conservation Services (ND NRCS), ND University Systems, local zoo

### Content Resources
### Heredity: Inheritance and Variation of Traits

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Construct an evidence-based account, through observation, that young plants and animals are alike, but not exactly like, their parents.</th>
</tr>
</thead>
</table>

#### Clarification Statement
Examples of patterns could include features plants or animals share. 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.

#### Assessment Boundary
Assessment does not include inheritance or animals that undergo metamorphosis or hybrids.

#### Disciplinary Core Ideas
- **LS3.A: Inheritance of Traits**
  - Young animals are very much, but not exactly like, their parents. Plants also are very much, but not exactly, like their parents.

- **LS3.B: Variation of Traits**
  - Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.

#### Science & Engineering Practices
- **6. Constructing Explanations and Designing Solutions**
  - Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.

#### Crosscutting Concepts
- **Patterns**
  - Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.

#### North Dakota Connection
- ND Game and Fish, ND Natural Resource Conservation Services (ND NRCS), ND University Systems

#### Content Resources
# Earth's Place in the Universe

<table>
<thead>
<tr>
<th>Performance Standard 1-ESS1-1</th>
<th>Describe patterns that can be predicted through observations of the sun, moon, and stars.</th>
</tr>
</thead>
</table>

**Clarification Statement**
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 (e.g. iPad apps).

**Assessment Boundary**
Assessment of star patterns is limited to stars being seen at night and not during the day.

**Disciplinary Core Ideas**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted.</td>
<td>4. Analyzing and Interpreting Data</td>
<td>Patterns</td>
</tr>
<tr>
<td>Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions.</td>
<td>-Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.</td>
<td></td>
</tr>
</tbody>
</table>

**North Dakota Connection**
ND University Systems, National Aeronautics and Space Administration (NASA), planetarium, Star Lab, Discovery Dome

**Content Resources**
Earth's Place in the Universe

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Make observations at different times of year to relate the amount of daylight to the time of year.</th>
</tr>
</thead>
</table>

Clarification Statement | Emphasis is on relative comparisons of the amount of daylight in different seasons due to the tilt of the Earth’s axis. |
Assessment Boundary | Assessment is limited to relative amounts of daylight, not quantifying the hours or time of daylight. |

Disciplinary Core Ideas | Science & Engineering Practices | Crosscutting Concepts |
-Seasonal patterns of sunrise and sunset can be observed, described, and predicted. | -Make observations (firsthand or from media) to collect data that can be used to make comparisons. | -Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. |

North Dakota Connection | NASA, National Weather Service |
Content Resources | |
## Engineering & Technology

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Ask questions, make observations and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>For example, students are challenged to create a structure that will protect them from the effects of the sun on the playground; students are challenged to create a house that will have sun exposure throughout the day.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Assessment Boundary</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
-Ask questions based on observations to find more information about the natural and/or designed world(s).  
-Define a simple problem that can be solve through the development of a new or improved object or tool. |                                                                                                                                 |

| North Dakota Connection | Content Resources |
# Engineering & Technology

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-2-ET1-2</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**

Draw or create a model that will show how a shape of an object helps it function (e.g. how a tree’s roots anchor it to the ground).

**Assessment Boundary**

**Disciplinary Core Ideas**

*ET1.B: Developing Possible Solutions*

- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solutions to other people.

**Science & Engineering Practices**

*2. Developing and Using Models*

- Develop a simple model based on evidence to represent a proposed object or tool.

**Crosscutting Concepts**

*Structure and Function*

- The shape and stability of structures of natural and designed objects are related to their function(s).

---

**North Dakota Connection**

**Content Resources**
### Engineering & Technology

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Students compare results with peers from a previous experiment. Consider using data from the previous experiment using different materials and their transparency.

**Assessment Boundary**

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **ET1.C: Optimizing the Design Solution**  
-Because there is always more than one possible solution to a problem, it is useful to compare and test designs. | **4. Analyzing and Interpreting Data**  
-Analyze tests of an object or tool to determine if it works as needed. | |

**North Dakota Connection**

**Content Resources**
### Performance Standard 2-PS1-1

Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS1.A: Structure and Properties of Matter -Different kinds of matter exist and many of them can be either solid, liquid or gas, depending on temperature. Matter can be described and classified by its observable properties.</td>
<td>3. Planning and Carrying Out Investigations -Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.</td>
<td>Patterns -Patterns in the natural and human designed world can be observed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
<th>ND Geological Survey – rocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Resources</td>
<td></td>
</tr>
</tbody>
</table>
Matter & Its Interactions

<table>
<thead>
<tr>
<th>Performance Standard 2-PS1-2</th>
<th>Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.</th>
</tr>
</thead>
</table>

**Clarification Statement**: Examples of properties could include, strength, flexibility, hardness, texture, and absorbency.

**Assessment Boundary**: Assessment of quantitative measurements is limited to length.

**Disciplinary Core Ideas**

**PS1.A: Structure and Properties of Matter**
- Different properties are suited to different purposes.

**Science & Engineering Practices**

**4. Analyzing and Interpreting Data**
- Analyze data from tests of an object or tool to determine if it works as intended.

**Crosscutting Concepts**

**Cause and Effect**
- Simple tests can be designed to gather evidence to support or refute student ideas about causes.

**North Dakota Connection**

ND Geological Survey - rocks

**Content Resources**
## Matter & Its Interactions

<table>
<thead>
<tr>
<th>Performance Standard 2-PS1-3</th>
<th>Make observations to construct an evidence-based account of how an object made of small set of pieces can be disassembled and made into a new object.</th>
</tr>
</thead>
</table>

### Clarification Statement
Examples of pieces could include blocks, building bricks, or other assorted small objects (Law of Conservation of Mass: matter can be neither created or destroyed, but just changes shape).

### Assessment Boundary

### Disciplinary Core Ideas
-Different properties are suited to different purposes.  
-A great variety of objects can be built up from a small set of pieces. | Science & Engineering Practices  
6. Constructing Explanations and Designing Solutions  
-Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. | Crosscutting Concepts  
Energy and Matter  
-Objects may break into smaller pieces and be put together into larger pieces or change shapes. |

### North Dakota Connection

### Content Resources

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16
## Matter & Its Interactions

<table>
<thead>
<tr>
<th>Performance Standard 2-PS1-4</th>
<th>Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.</th>
</tr>
</thead>
</table>

### Clarification Statement
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 burning paper.

### Assessment Boundary

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PS1.B: Chemical Reactions</strong></td>
<td>7. <strong>Engaging in Argument from Evidence</strong></td>
<td><strong>Cause and Effect</strong></td>
</tr>
<tr>
<td>- Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.</td>
<td>- Construct an argument with evidence to support a claim.</td>
<td>- Events have causes that generate observable patterns.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
<th>Lignite Energy Council - coal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content Resources</strong></td>
<td></td>
</tr>
</tbody>
</table>
## 2-LS2 Performance Standard 2-LS2-1

Plan and investigate to determine if plants need sunlight and water to grow.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment is limited to testing one variable at a time.</td>
</tr>
</tbody>
</table>

### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>LS2.A: Interdependent Relationships in Ecosystems</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Plants depend on water and light to grow.</td>
</tr>
</tbody>
</table>

### Science & Engineering Practices

<table>
<thead>
<tr>
<th>3. Planning and Carrying Out Investigations</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Plan and investigate collaboratively to produce data to serve as the basis for evidence to answer a question.</td>
</tr>
</tbody>
</table>

### Crosscutting Concepts

<table>
<thead>
<tr>
<th>Cause and Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Events have causes that generate observable patterns.</td>
</tr>
</tbody>
</table>

### North Dakota Connection

| ND Game and Fish – native plants, ND Natural Resource Conservation Services (ND NRCS), ND Department of Agriculture, ND University Systems |

### Content Resources
### Performance Standard

**2-LS2-2**

Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.

### Clarification Statement

Have various materials available to simulate how animals aid in pollination.

### Assessment Boundary

#### Disciplinary Core Ideas

- **LS2.A: Interdependent Relationships in Ecosystems**
  - Plants depend on animals for pollination or to move their seeds around.

- **ET1.B: Developing Possible Solutions**
  - Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.

#### Science & Engineering Practices

- **2. Developing and Using Models**
  - Develop a simple model based on evidence to represent a proposed object or tool.

#### Crosscutting Concepts

- **Structure and Function**
  - The shape and stability of structures of natural and designed objects are related to their function(s).

### North Dakota Connection

- ND Game and Fish, ND Natural Resource Conservation Services (ND NRCS), ND University Systems

### Content Resources
# Biological Evolution: Unity and Diversity

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Make observations of plants and animals to compare the diversity of life in different habitats.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-LS4-1</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**
Emphasis is on the diversity of living things in each of a variety of different habitats.

**Assessment Boundary**
Assessment does not include specific animal and plant names in specific habitats.

**Disciplinary Core Ideas**

<table>
<thead>
<tr>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LS4.D: Biodiversity and Humans</strong></td>
<td></td>
</tr>
<tr>
<td>-There are many kinds of living things in any area, and they exist in different places on land and in water.</td>
<td>3. Planning and Carrying Out Investigations</td>
</tr>
<tr>
<td>-Make observations (firsthand or from media) to collect data which can be used to make comparisons.</td>
<td></td>
</tr>
</tbody>
</table>

**North Dakota Connection**

**Content Resources**

## Earth’s Place in the Universe

<table>
<thead>
<tr>
<th>Performance Standard 2-ESS1-1</th>
<th>Use information from several sources to provide evidence that Earth events can occur quickly or slowly.</th>
</tr>
</thead>
</table>

### Clarification Statement
Examples of events and timescales could include volcanic explosions and earthquakes, which happen quickly and erosion of rocks, which occurs slowly.

### Assessment Boundary
Assessment does not include quantitative measurements of timescales.

### Disciplinary Core Ideas & Crosscutting Concepts

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **ESS1.C: The History of Planet Earth**
-Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe. | **6. Constructing Explanations and Designing Solutions**
-Make observations from several sources to construct an evidence-based account for natural phenomena. | **Stability and Change**
-Things may change slowly or rapidly. |

### North Dakota Connection

<table>
<thead>
<tr>
<th>Content Resources</th>
</tr>
</thead>
</table>
### Earth’s Systems

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Compare and contrast multiple solutions designed to slow or prevent wind or water from changing the shape of the land.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>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.</th>
</tr>
</thead>
</table>

| **Assessment Boundary** |  |
|-------------------------|  |

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESS2.A: Earth Materials and Systems</strong></td>
<td><strong>6. Constructing Explanations and Designing Solutions</strong></td>
<td><strong>Stability and Change</strong></td>
</tr>
<tr>
<td>-Wind and water can change the shape of the land.</td>
<td>-Compare multiple solutions to a problem.</td>
<td>-Things may change slowly or rapidly.</td>
</tr>
<tr>
<td><strong>ET1.C: Optimizing the Design Solution</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Because there is always more than one possible solution to a problem, it is useful to compare and test designs.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
<th>ND Soil Conservation, ND Natural Resource Conservation Services (ND NRCS), ND Department of Agriculture</th>
</tr>
</thead>
</table>

| Content Resources |  |
## Performance Standard

**2-ESS2-2** Develop a model to represent the shapes and kinds of land and bodies of water in an area.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Assessment Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assessment does not include quantitative scaling in models.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESS2.B: Plate Tectonics and Large-Scale System Interactions</strong></td>
<td><strong>2. Developing and Using Models</strong></td>
<td><strong>Patterns</strong></td>
</tr>
<tr>
<td>-Maps show where things are located. One can map the shapes and kinds of land and water in any area.</td>
<td>-Develop a model to represent patterns in the natural world.</td>
<td>-Patterns in the natural world can be observed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
<th>Content Resources</th>
</tr>
</thead>
</table>
| ND Soil and Conservation, ND Natural Resource Conservation Services (ND NRCS), National Oceanic and Atmospheric Administration (NOAA), ND Geological Survey | }
## Earth’s Systems

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Obtain information to identify where water is found on Earth and that it can be solid or liquid.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-ESS2-3</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**
Multimedia sources (e.g. Google Earth) may be used to obtain the information.

**Assessment Boundary**

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESS2.C: The Roles of Water in Earth’s Surface Processes</td>
<td>8. Obtaining, Evaluating, and Communicating Information</td>
<td>Patterns</td>
</tr>
<tr>
<td>-Water is found in the ocean, rivers, lakes and ponds. Water exists as solid ice and in liquid form.</td>
<td>-Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question.</td>
<td>-Patterns in the natural and/or designed world can be observed.</td>
</tr>
</tbody>
</table>

**North Dakota Connection**
National Oceanic and Atmospheric Administration (NOAA), ND Geological Survey

**Content Resources**
## Engineering & Technology

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>K-2-ET1-1</strong></td>
<td></td>
</tr>
</tbody>
</table>

### Clarification Statement
Use the engineering design process.

### Assessment Boundary

### Disciplinary Core Ideas
**ET1.A: Defining and Delimiting Engineering Problems**
- A situation that people want to change or create can be approached as a problem to be solved through engineering.
- Asking questions, making observations, and gathering information are helpful in thinking about problems.
- Before beginning to design a solution, it is important to clearly understand the problem.

### Science & Engineering Practices
**1. Asking Questions and Defining Problems**
- Ask questions based on observations to find more information about the natural and/or designed world(s).
- Define a simple problem that can be solved through the development of a new or improved object or tool.

### Crosscutting Concepts

### North Dakota Connection

### Content Resources
## Performance Standard

**K-2-ET1-2**

Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

### Clarification Statement

Use the engineering design process.

### Disciplinary Core Ideas

**ET1.B: Developing Possible Solutions**
- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solutions to other people.

### Science & Engineering Practices

**2. Developing and Using Models**
- Develop a simple model based on evidence to represent a proposed object or tool.

### Crosscutting Concepts

**Structure and Function**
- The shape and stability of structures of natural and designed objects are related to their function(s).

### North Dakota Connection

### Content Resources
### Performance Standard
**K-2-ET1-3**
Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Use the engineering design process.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ET1.C: Optimizing the Design Solution</strong></td>
<td>4. Analyzing and Interpreting Data</td>
<td></td>
</tr>
<tr>
<td>-Because there is always more than one possible solution to a problem, it is useful to compare and test designs.</td>
<td>-Analyze data from tests of an object or tool to determine if it works as needed.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Resources</td>
<td></td>
</tr>
</tbody>
</table>
## Motion & Stability: Forces & Interactions

### Performance Standard 3-PS2-1
Plan and Conduct an investigation to prove the effects of balanced and unbalanced forces on the motion of an object.

### Clarification Statement
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.

### Assessment Boundary
Assessment is limited to one variable at a time: number, size, or direction of forces.

### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>PS2.A: Forces and Motion</th>
<th>PS2.B: Types of Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object’s speed or direction of motion.</td>
<td>-Objects in contact exert forces on each other.</td>
</tr>
</tbody>
</table>

### Science & Engineering Practices

<table>
<thead>
<tr>
<th>3. Planning and Carrying Out Investigations</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.</td>
</tr>
</tbody>
</table>

### Crosscutting Concepts

<table>
<thead>
<tr>
<th>Cause and Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Cause and effect relationships are routinely identified.</td>
</tr>
</tbody>
</table>

### North Dakota Connection
Apply unbalanced forces to North Dakota winters. Examples include cars sliding on ice, sleds on snow, ice skating, etc.

### Content Resources
## Motion & Stability: Forces & Interactions

<table>
<thead>
<tr>
<th>Performance Standard 3-PS2-2</th>
<th>Make observations and metric measurements of an object's motion to prove that a pattern can be used to predict future motion.</th>
</tr>
</thead>
</table>

### Clarification Statement
Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw.

### Assessment Boundary
Assessment includes observing and/or measuring input motion and predicting and/or measuring output motion of a repeating pattern of motion. Assessment does not include technical terms.

### Disciplinary Core Ideas
**PS2.A: Forces and Motion**
The patterns of an object’s motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, period, frequency, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.)

### Science & Engineering Practices
**3. Planning and Carrying Out Investigations**
- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.

### Crosscutting Concepts
**Patterns**
- Patterns of change can be used to make predictions.

### North Dakota Connection

### Content Resources
# Motion & Stability: Forces & Interactions

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Ask questions to determine cause and effect relationships of static electricity or magnetic interactions between two objects not in contact with each other.</th>
</tr>
</thead>
</table>

**Clarification Statement**
Examples of static electricity are the force on hair from an electrically charged balloon, a charged rod and pieces of paper; examples of a magnetic force are the force between two magnets, the force between an electromagnet and steel paperclips. Examples of cause and effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.

**Assessment Boundary**
Assessment is limited to forces produced by objects that can be manipulated by students.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS2.B: Types of Interactions</td>
<td>1. Asking Questions and Defining Problems</td>
<td>Cause and Effect</td>
</tr>
<tr>
<td>- Electric, and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.</td>
<td>- Ask questions that can be investigated based on patterns such as cause and effect relationships.</td>
<td>- Cause and effect relationships are routinely identified, tested, and used to explain change.</td>
</tr>
</tbody>
</table>

**North Dakota Connection**
Connect to the dry air in North Dakota winters. Examples include static electricity in bedding, clothing, and hair covered by a hat. Additional examples would be lightning in a summer storm.

**Content Resources**
## Motion & Stability: Forces & Interactions

<table>
<thead>
<tr>
<th>Performance Standard 3-PS2-4</th>
<th>Define a simple design problem that can be solved by applying scientific ideas about magnets.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clarification Statement</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Assessment Boundary</strong></td>
<td></td>
</tr>
</tbody>
</table>

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<tr>
<td><strong>PS2.B: Types of Interactions</strong></td>
<td>1. Asking Questions and Defining Problems</td>
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</tr>
<tr>
<td>- Electric, and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.</td>
<td>- Define a simple problem that can be solved through the development of a new or improved object or tool.</td>
<td></td>
</tr>
</tbody>
</table>

| North Dakota Connection       |                                                                                  |
| Content Resources             |                                                                                  |
3-LS1-1

From Molecules to Organisms: Structures and Processes

<table>
<thead>
<tr>
<th>Performance Standard 3-LS1-1</th>
<th>Develop models to describe that organisms have unique and diverse life cycles but all experience birth, growth, reproduction, and death.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Changes organisms go through during their life form a pattern.

**Assessment Boundary**

Assessment should include a variety of models of life cycles of many organisms. Assessment of plant life cycles is limited to those of flowering plants. Assessment does not include details of human reproduction.

**Disciplinary Core Ideas**

**LS1.B: Growth and Development of Organisms**

- Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles.

**Science & Engineering Practices**

2. Developing and Using Models

- Develop models to describe phenomena.

**Crosscutting Concepts**

Patterns

- Patterns of change can be used to make predictions.

**North Dakota Connection**

Consider contacting an expert at local vector controls and extension services, ND Game and Fish office, and colleges or universities etc. Example could include the life cycle of the mosquito.

**Content Resources**

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## Performance Standard

### 3-LS2-1

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Construct an argument that some animals form groups that help members survive.</th>
</tr>
</thead>
</table>

### Clarification Statement

Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size.

### Assessment Boundary

### Disciplinary Core Ideas

**LS2.D: Social Interactions and Group Behavior**
- Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size.

### Science & Engineering Practices

7. **Engaging an Argument from Evidence**
- Construct an argument with evidence, data, and/or a model.

### Crosscutting Concepts

**Cause and Effect**
- Cause and effect relationships are routinely identified and used to explain change.

### North Dakota Connection

Consider contacting an expert at local extension services, ND Game and Fish office, and colleges or universities etc.

### Content Resources
### Performance Standard 3-LS3-1

Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment does not include genetic mechanisms of inheritance and prediction of traits. Assessment is limited to non-human examples.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS3.A: Inheritance of Traits</td>
<td>4. Analyzing and Interpreting Data</td>
<td>Patterns</td>
</tr>
<tr>
<td>-Many characteristics of organisms are inherited from their parents.</td>
<td>-Analyze and interpret data to make sense of phenomena using logical reasoning.</td>
<td>-Similarities and differences in patterns can used to sort and classify natural phenomena.</td>
</tr>
<tr>
<td>LS3.B: Variation of Traits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Different organisms vary in how they look and function because they have different inherited information.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### North Dakota Connection

Consider the agriculture industry and how offspring such as calves may have the same traits as their parents. Examples include coat color, body shape, birth marks etc.

### Content Resources
### Biological Evolution: Unity & Diversity

<table>
<thead>
<tr>
<th>Performance Standard 3-LS4-2</th>
<th>Use evidence 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.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clarification Statement</strong></td>
<td>Examples of cause and effect relationships could be plants that have larger thorns than other plants may be less likely to be eaten by predators; and, animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring.</td>
</tr>
<tr>
<td><strong>Assessment Boundary</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Disciplinary Core Ideas</strong></td>
<td><strong>Science &amp; Engineering Practices</strong></td>
</tr>
</tbody>
</table>
| LS4.B: Natural Selection    | 6. **Constructing Explanations and Designing Solutions**                                                                                                                              | **Cause and Effect**  
   - Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.  
   - Use evidence (e.g. observations, patterns) to construct an explanation                                                                 |
| **North Dakota Connection** | Contact your local NDGF office. Consider contacting an expert at local extension services, ND Game and Fish office, and colleges or universities etc.                                            |
| **Content Resources**       |                                                                                                                                                                                                 |
### Heredity: Inheritance & Variations of Traits

**Performance Standard**  
3-LS3-2  
-use evidence to support the explanation that the expression of traits can be influenced by the environment.

**Clarification Statement**  
Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted. A person born healthy based on their genetics could suffer from the exposure to toxic chemicals.

**Assessment Boundary**

**Disciplinary Core Ideas**  
**LS3.A: Inheritance of Traits**  
-Other characteristics result from individuals’ interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment.

**LS3.B: Variation of Traits**  
-Environmental factors such as toxins may affect the traits that an organism develops.

**Science & Engineering Practices**  
6. **Constructing Explanations and Designing Solutions**  
-Use evidence (e.g., observations, patterns) to support an explanation.

**Crosscutting Concepts**  
**Cause and Effect**  
-Cause and effect relationships are routinely identified and used to explain change.

**North Dakota Connection**  
Examples could include the agricultural industry by comparing vegetation during a wet season versus a dry season. Genetically modified crops exist in an attempt to limit the effect of environmental conditions.

**Content Resources**
# Performance Standard 3-LS4-3

**Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.**

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS4.C: Adaptation</td>
<td>7. <em>Engaging in argument from evidence</em>&lt;br&gt;- Construct an argument with evidence.</td>
<td>Cause and Effect&lt;br&gt;- Cause and effect relationships are routinely identified and used to explain change.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
<th>Wetland destruction and urban sprawl can cause loss to habitats and wildlife.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Content Resources</th>
</tr>
</thead>
</table>
### Biological Evolution: Unity & Diversity

<table>
<thead>
<tr>
<th>Performance Standard 3-LS4-1</th>
<th>Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.</th>
</tr>
</thead>
</table>

**Clarification Statement**
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.

**Assessment Boundary**
Assessment does not include identification of specific fossils or present plants and animals. Assessment is limited to major fossil types and relative ages.

**Disciplinary Core Ideas**

<table>
<thead>
<tr>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Some kinds of plants and animals that once lived on Earth are no longer found anywhere. Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments.</td>
<td>-Analyze and interpret data to make sense of phenomena using logical reasoning.</td>
</tr>
<tr>
<td>North Dakota Connection</td>
<td>Scale, Proportion, and Quantity</td>
</tr>
<tr>
<td>Consider reaching out to oil, natural gas, and coal industries. Connect ND natural resources to fossilization.</td>
<td>-Observable phenomena that exists from very short to very long time periods.</td>
</tr>
</tbody>
</table>

**Content Resources**
Earth's Systems

**Performance Standard 3-ESS2-1**
Represent data in tables and graphical displays to describe and predict typical weather conditions expected during a particular season.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Examples of data could include average temperature, precipitation, and wind direction.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment of graphical displays is limited to pictographs and bar graphs. Assessment does not include climate change.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESS2.D: Weather and Climate</td>
<td>4. Analyzing and Interpreting Data</td>
<td>Patterns</td>
</tr>
<tr>
<td>-Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.</td>
<td>-Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationships.</td>
<td>-Patterns of change can be used to make predictions.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
<th>Collect weather data using the national weather service or National Oceanic and Atmospheric Administration (NOAA) to make predictions.</th>
</tr>
</thead>
</table>

Content Resources
### Earth's Systems

<table>
<thead>
<tr>
<th>Performance Standard 3-ESS2-2</th>
<th>Obtain and combine information to describe climates in different regions of the world.</th>
</tr>
</thead>
</table>

**Clarification Statement**
Examples of climate in different regions, how climate predicts weather conditions, and climate variations around the world.

**Assessment Boundary**

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESS2.D: Weather and Climate</strong></td>
<td><strong>8. Obtaining, Evaluating, and Communicating Information</strong></td>
<td><strong>Patterns</strong></td>
</tr>
<tr>
<td>-Climate describes a range of an area’s typical weather conditions and the extent to which those conditions vary over years.</td>
<td>-Obtain and combine information from books and other reliable media to explain phenomena.</td>
<td>-Patterns of change can be used to make predictions.</td>
</tr>
</tbody>
</table>

**North Dakota Connection**

**Content Resources**
# 3-ESS3-1

## Earth & Human Activity

<table>
<thead>
<tr>
<th>Performance Standard 3-ESS3-1</th>
<th>Evaluate the feasibility of a design solution that reduces the impacts of a weather-related hazard.</th>
</tr>
</thead>
</table>

### Clarification Statement
Examples of design solutions to weather-related hazards could include barriers to prevent flooding and wind resistant roofs.

### Assessment Boundary

### Disciplinary Core Ideas
**ESS3.B: Natural Hazards**
-A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.

### Science & Engineering Practices
**7. Engaging in Argument from Evidence**
-Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

### Crosscutting Concepts
**Cause and Effect**
-Cause and effect relationships are routinely identified, tested, and used to explain change.

### North Dakota Connection
North Dakota natural disasters include flooding, blizzard, wind damage, erosion, tornadoes etc.

### Content Resources
### Performance Standard 3-ET1-1

Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

### Clarification Statement

Refer to the Engineering Design Process in the link above for a visual flow chart. Design ideas may be quite simple. This could include an object, tool, process, or system either at home or school that may make life easier or more efficient. Identifying a problem impacting the student will be the most influential.

### Assessment Boundary

### Disciplinary Core Ideas

**ET1.A: Defining and Delimiting Problems**

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

### Science & Engineering Practices

**1. Asking Questions and Defining Problems**

- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

### Crosscutting Concepts

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### North Dakota Connection

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### Content Resources
### 3-ET1-2

#### Performance Standard

3-ET1-2

Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Refer to the Engineering Design Process in the link above for a visual flow chart.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
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<th>Crosscutting Concepts</th>
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</thead>
<tbody>
<tr>
<td><strong>ET1.B: Developing Possible Solutions</strong></td>
<td><strong>6. Constructing Explanations and Designing Solutions</strong></td>
<td></td>
</tr>
<tr>
<td>-Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.</td>
<td>-Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.</td>
<td></td>
</tr>
<tr>
<td>-At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| North Dakota Connection | Content Resources |
### Engineering & Technology

<table>
<thead>
<tr>
<th>Performance Standard 3-ET1-3</th>
<th>Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.</th>
</tr>
</thead>
</table>

#### Clarification Statement
Refer to the Engineering Design Process in the link above for a visual flow chart.

#### Assessment Boundary

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| ET1.B: Developing Possible Solutions  
-Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.  
ET1.C: Optimizing the Design Solution  
-Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. | 3. Planning and Carrying Out Investigations  
-Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. | |

#### North Dakota Connection

| Content Resources |
## Energy

### Performance Standard 4-PS3-1

| Performance Standard 4-PS3-1 | Use evidence to construct an explanation relating the speed of an object to the energy of that object. |

### Clarification Statement

Emphasis on relative speeds of objects and the connection between motion and energy.

### Assessment Boundary

Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.

### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>PS3.A: Definitions of Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>-The faster a given object is moving, the more energy it possesses.</td>
</tr>
</tbody>
</table>

### Science & Engineering Practices

<table>
<thead>
<tr>
<th>6. Constructing Explanations and Designing Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Use evidence (e.g. observations or patterns) to construct an explanation.</td>
</tr>
</tbody>
</table>

### Crosscutting Concepts

<table>
<thead>
<tr>
<th>Energy and Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Energy can be transferred in various ways and between objects.</td>
</tr>
</tbody>
</table>

### North Dakota Connection

Content Resources
<table>
<thead>
<tr>
<th>Performance Standard 4-PS3-2</th>
<th>Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.</th>
</tr>
</thead>
</table>

**Clarification Statement**
Emphasis on the transfer of energy whenever objects are moving. Examples of how sound, light, and heat can transfer energy.

**Assessment Boundary**
Assessment does not include quantitative measurements of energy.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Energy can be transferred from place to place by moving objects or through sound, light, or electric currents.</td>
<td>-Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.</td>
<td>-Energy can be transferred in various ways and between objects.</td>
</tr>
<tr>
<td><strong>PS3.B: Conservation of Energy and Energy Transfer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred causing a change in motion. In such collisions, some energy is also transferred to the surrounding air as heat or sound.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Energy can also be transferred from place to place by electric currents to produce motion, sound, heat, or light.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**North Dakota Connection**

**Content Resources**
**Energy**

<table>
<thead>
<tr>
<th>Performance Standard 4-PS3-3</th>
<th>Ask questions and predict outcomes about the changes in energy that occur when objects collide.</th>
</tr>
</thead>
</table>

**Clarification Statement**
Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.

**Assessment Boundary**
Assessment does not include quantitative measurements of energy.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PS3.A: Definitions of Energy</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents. |

| **PS3.B: Conservation of Energy and Energy Transfer** |
- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. |

| **PS3.C: Relationship Between Energy and Forces** |
- When objects collide, the contact forces transfer energy so as to change the objects’ motions. |

**1. Asking Questions and Defining Problems**
- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.

**Energy and Matter**
- Energy can be transferred in various ways and between objects.
4-PS3-4

**Energy**

<table>
<thead>
<tr>
<th>Performance Standard 4-PS3-4</th>
<th>Using the engineering design process build a device that converts energy from one form to another.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Examples of devices could include a greenhouse model such as a glass jar in direct sunlight, electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater (solar oven) that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device. Use engineering design process flow chart.

**Assessment Boundary**

Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PS3.B: Conservation of Energy and Energy Transfer</strong>&lt;br&gt;-Energy can also be transferred from place to place by electric currents, which can be used to produce motion, sound, heat, or light.</td>
<td><strong>6. Constructing Explanations and Designing Solutions</strong>&lt;br&gt;-Apply scientific ideas to solve design problems.</td>
<td><strong>Energy and Matter</strong>&lt;br&gt;-Energy can be transferred in various ways and between objects.</td>
</tr>
<tr>
<td><strong>PS3.D: Energy in Chemical Processes and Everyday Life</strong>&lt;br&gt;-The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**North Dakota Connection**

Wind turbines are manufactured and placed across North Dakota. Consider contacting your local electric cooperative for examples of solar cells being used for a variety of purposes.

**Content Resources**

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
<th>Wind turbines are manufactured and placed across North Dakota. Consider contacting your local electric cooperative for examples of solar cells being used for a variety of purposes.</th>
</tr>
</thead>
</table>
## Waves and Their Applications in Technologies for Information Transfer

<table>
<thead>
<tr>
<th>Performance Standard 4-PS4-1</th>
<th>Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.</th>
</tr>
</thead>
</table>

**Clarification Statement**
Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.

**Assessment Boundary**
Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.

### Disciplinary Core Ideas

#### PS4.A: Wave Properties
-Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach.
-Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).

### Science & Engineering Practices

#### 2. Developing and Using Models
-Develop a model using an analogy, example, or abstract representation to describe a scientific principle.

### Crosscutting Concepts

#### Patterns
-Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena.

### North Dakota Connection
Consider past events where extreme wave actions have resulted in damage to structures including moving large objects from the water. For example, Devils Lake and Lake Sakakawea.

### Content Resources
### Waves and Their Applications in Technologies for Information Transfer

<table>
<thead>
<tr>
<th>Performance Standard 4-PS4-3</th>
<th>Construct a code to convey information by researching past and present methods of transmitting information.</th>
</tr>
</thead>
</table>

#### Clarification Statement
Examples of past methods could include a string between two cans, Morse code, rotary dial telephones. Examples of current methods include fiber optics, digitized signals, wireless communication, blue tooth, and using code.org for exploration of computer coding patterns.

#### Assessment Boundary

#### Disciplinary Core Ideas
**PS4.C: Information Technologies and Instrumentation**
- Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa.

#### Science & Engineering Practices
**6. Constructing Explanations and Designing Solutions**
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

#### Crosscutting Concepts
**Patterns**
- Similarities and differences in patterns can be used to sort and classify designed products.

#### North Dakota Connection
Consider contacting local telephone companies for a demonstration on fiber optics.

#### Content Resources
From Molecules to Organisms: Structures and Processes

<table>
<thead>
<tr>
<th>Performance Standard 4-LS1-1</th>
<th>Construct an argument that plants, and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarification Statement</td>
<td>Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, skin, quills, horns, tusks, scales, etc.</td>
</tr>
<tr>
<td>Assessment Boundary</td>
<td>Assessment is limited to macroscopic structures within plant and animal systems.</td>
</tr>
</tbody>
</table>

### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>LS1.A: Structure and Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.</td>
</tr>
</tbody>
</table>

### Science & Engineering Practices

<table>
<thead>
<tr>
<th>7. Engaging in Argument from Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Construct an argument with evidence, data, and/or a model.</td>
</tr>
</tbody>
</table>

### Crosscutting Concepts

<table>
<thead>
<tr>
<th>Systems and System Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>-A system can be described in terms of its components and their interactions.</td>
</tr>
</tbody>
</table>

### North Dakota Connection

| Contact a taxidermist or the local game and fish for examples and possible demonstrations. |

### Content Resources

<p>| |</p>
<table>
<thead>
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<th></th>
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<tbody>
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</tr>
</tbody>
</table>
## Performance Standard

**4-LS1-2**

Form an explanation to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.

### Clarification Statement

Emphasis is on systems of information transfer. Examples include responses to stimuli such as a hot surface and pulling your hand away, animals running from predators, animals communicating with each other through signals to express danger, reproduction, and for food.

### Assessment Boundary

Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.

### Disciplinary Core Ideas

**LS1.D: Information Processing**
- Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal’s brain. Animals are able to use their perceptions and memories to guide their actions.

### Science & Engineering Practices

2. **Developing and Using Models**
- Use a model to test interactions concerning the functioning of a natural system.

### Crosscutting Concepts

**Systems and System Models**
- A system can be described in terms of its components and their interactions.

### North Dakota Connection

Consider contacting ND Game and Fish for more animal examples of responses to stimuli.

### Content Resources
Earth’s Place in the Universe

<table>
<thead>
<tr>
<th>Performance Standard 4-ESS1-1</th>
<th>Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.</th>
</tr>
</thead>
</table>

**Clarification Statement**

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.

**Assessment Boundary**

Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.

**Disciplinary Core Ideas**

**ESS1.C: The History of Planet Earth**
- Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed.

**Science & Engineering Practices**

6. Constructing Explanations and Designing Solutions
- Identify the evidence that supports particular points in an explanation.

**Crosscutting Concepts**

Patterns
- Patterns can be used as evidence to support an explanation.

**North Dakota Connection**

Theodore Roosevelt National Park show the layering of sediment by the exposure of the Badlands. Contact the state Geographic Alliance, Geological Society, and local Colleges and Universities for more resources. Local museums are also a valuable resource.

**Content Resources**
Earth & Space Science

<table>
<thead>
<tr>
<th>Performance Standard 4-ESS2-1</th>
<th>Make observations and metric measurements to provide evidence of the effects of weathering and the rate of erosion by water, ice, wind, or vegetation.</th>
</tr>
</thead>
</table>

**Clarification Statement**

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.

**Assessment Boundary**

Assessment is limited to a single form of weathering or erosion.

### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>ESS2.A: Earth Materials and Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Rainfall helps to shape the land and affects the types of living things found in a region. Water ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ESS2.E: Biogeology</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Living things affect the physical characteristics of their regions.</td>
</tr>
</tbody>
</table>

### Science & Engineering Practices

<table>
<thead>
<tr>
<th>3. Planning and Carrying Out Investigations</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.</td>
</tr>
</tbody>
</table>

### Crosscutting Concepts

<table>
<thead>
<tr>
<th>Cause and Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Cause and Effect relationships are routinely identified, tested, and used to explain change.</td>
</tr>
</tbody>
</table>

### North Dakota Connection

The exposure of the Badlands (Theodore Roosevelt National Park website) is due to weathering and erosion from flowing water and wind. Consider the soil conservation districts for presentations on preventing erosion. Much of ND has been shaped by glaciers. North Dakota Geological Survey.

### Content Resources
# Earth’s Systems

<table>
<thead>
<tr>
<th>Performance Standard 4-ESS2-2</th>
<th>Analyze and interpret data from maps to describe patterns of Earth’s features.</th>
</tr>
</thead>
</table>

## Clarification Statement
Maps can include topographic maps of Earth’s land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.

## Assessment Boundary

## Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>ESS2.B: Plate Tectonics and Large-Scale System Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth.</td>
</tr>
</tbody>
</table>

## Science & Engineering Practices

<table>
<thead>
<tr>
<th>4. Analyzing and Interpreting Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyze and interpret data to make sense of phenomena using logical reasoning.</td>
</tr>
</tbody>
</table>

## Crosscutting Concepts

<table>
<thead>
<tr>
<th>Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patterns can be used as evidence to support an explanation.</td>
</tr>
</tbody>
</table>

## North Dakota Connection

North Dakota has an abundance of topographical features of interest. Examples include the Red River and Mouse/Souris River which flow north due to elevation.

## Content Resources
## Earth and Human Activity

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.

**Assessment Boundary**

**Disciplinary Core Ideas**

**ESS3.A: Natural Resources**

- Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.

**Science & Engineering Practices**

**8. Obtaining, Evaluating, And Communicating Information**

- Obtain and combine information from books and other reliable media to explain phenomena.

**Crosscutting Concepts**

**Cause & Effect**

- Cause and effect relationships are routinely identified and used to explain change.

**North Dakota Connection**

Contact the North Dakota petroleum council, energy council, or lignite council for information on our natural resources.

**Content Resources**
Earth and Human Activity

| Performance Standard 4-ESS3-2 | Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans. |

Clarification Statement
- Examples of solutions could include designing flood control methods, earthquake, tornado, or hurricane resistant buildings, and improving predictions and forecasts.

Assessment Boundary

Disciplinary Core Ideas | Science & Engineering Practices | Crosscutting Concepts
---|---|---
ESS3.B: Natural Hazards -A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. | 6. Constructing Explanations and Designing Solutions -Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. | Cause and Effect -Cause and effect relationships are routinely identified, tested, and used to explain change. |

North Dakota Connection
- The national weather service could provide resources for predicting and managing natural disasters. ND has numerous concerns for natural disasters across the state.

Content Resources
### Performance Standard 4-ET1-1
Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Refer to the Engineering Design Process in the link above for a visual flow chart. They could include an object, tool, process, or system either at home or school that may make life easier or more efficient.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Disciplinary Core Ideas</strong></th>
<th><strong>Science &amp; Engineering Practices</strong></th>
<th><strong>Crosscutting Concepts</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>ET1.A: Defining and Delimiting Engineering Problems</td>
<td>1. <strong>Asking Questions and Defining Problems</strong> - Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.</td>
<td></td>
</tr>
</tbody>
</table>

**North Dakota Connection**

**Content Resources**
### Engineering & Technology

<table>
<thead>
<tr>
<th>Performance Standard 4-ET1-2</th>
<th>Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.</th>
</tr>
</thead>
</table>

**Clarification Statement**
Refer to the Engineering Design Process in the link above for a visual flow chart. This is a continuation of the previous standard.

**Assessment Boundary**

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ET1.B: Developing Possible Solutions</strong></td>
<td>-Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.</td>
<td><strong>6. Constructing Explanations and Designing Solutions</strong> -Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.</td>
</tr>
</tbody>
</table>

### North Dakota Connection

### Content Resources
### Performance Standard

**4-ET1-3**

Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

---

**Clarification Statement**

Refer to the Engineering Design Process in the link above for a visual flow chart. This is a continuation of the previous standard.

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**Assessment Boundary**

---

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ET1.B: Developing Possible Solutions</strong>&lt;br&gt; -Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.</td>
<td><strong>3. Planning and Carrying Out Investigations</strong>&lt;br&gt; -Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.</td>
<td></td>
</tr>
<tr>
<td><strong>ET1.C: Optimizing the Design Solution</strong>&lt;br&gt; -Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**North Dakota Connection**

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**Content Resources**

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# Matter and its Interactions

<table>
<thead>
<tr>
<th>Performance Standard 5-PS1-1</th>
<th>Develop a model to describe that matter is made of particles too small to be seen.</th>
</tr>
</thead>
</table>

**Clarification Statement**
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. Drawings of simple molecules such as water, sugar, carbon dioxide would be appropriate.

**Assessment Boundary**
Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.

## Disciplinary Core Ideas

| PS1.A: Structure and Properties of Matter -Matter of any type can be subdivided into particles that are too small to see, but the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. |
| Science & Engineering Practices -Use models to describe phenomena. |
| Crosscutting Concepts -Scale, Proportion, and Quantity -Natural objects exist from the very small to the immensely large. |

**North Dakota Connection**

**Content Resources**
**Matter and its Interactions**

<table>
<thead>
<tr>
<th>Performance Standard 5-PS1-2</th>
<th>Measure and graph metric quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total mass of matter is conserved.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Examples of reactions or changes could include dissolving, and mixing. Examples of physical changes could include ice melting into water. Distinguish between mass and weight. Weight is a measure of gravitational force on an object. Weight of an object can change depending upon gravitational force. Ex. Earth vs. the moon. Mass is the amount of matter in an object.

**Assessment Boundary**

**Disciplinary Core Ideas**

- **PS1.A: Structure and Properties of Matter**
  - The mass of matter is conserved when it changes form, even in transitions in which it seems to vanish.

- **PS1.B: Chemical Reactions**
  - No matter what reaction or change in properties occurs, the total mass of the substances does not change.

**Science & Engineering Practices**

- **5. Using Mathematical and Computational Thinking**
  - Measure (metric) and graph quantities such as mass to address scientific and engineering questions and problems.

**Crosscutting Concepts**

- **Scale, Proportion, and Quantity**
  - Metric units are used to measure and describe physical quantities such as mass, length, temperature, and volume.

**North Dakota Connection**

**Content Resources**
## Matter and its Interactions

<table>
<thead>
<tr>
<th>Performance Standard 5-PS1-3</th>
<th>Make observations and measurements to identify materials based on their properties.</th>
</tr>
</thead>
</table>

### Clarification Statement
Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include density, color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility.

### Assessment Boundary

### Disciplinary Core Ideas

**PS1.A: Structure and Properties of Matter**
- Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.)

### Science & Engineering Practices

**3. Planning and Carrying Out Investigations**
- Make observations and metric measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.

### Crosscutting Concepts

**Scale, Proportion, and Quantity**
- Metric units are used to measure and describe physical quantities such as weight, temperature, and volume.

### North Dakota Connection

### Content Resources
# Matter and its Interactions

## Performance Standard

<table>
<thead>
<tr>
<th>Performance Standard 5-PS1-4</th>
<th>Conduct an investigation to determine whether the mixing of two or more substances results in new substances.</th>
</tr>
</thead>
</table>

## Clarification Statement

Examples of mixtures, not new substances, could be mixing of salt or sugar and water. Examples of new substances include making gelatin, chocolate milk, cookies, and cakes.

## Assessment Boundary

## Disciplinary Core Ideas

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-When two or more different substances are mixed, a new substance with different properties may be formed.</td>
<td>3. Planning and Carrying Out Investigations&lt;br&gt;-Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.</td>
<td>Cause and Effect&lt;br&gt;-Cause and effect relationships are routinely identified and used to explain change.</td>
</tr>
</tbody>
</table>

## North Dakota Connection

## Content Resources
Performance Standard 5-PS3-1 | Use models to describe how energy from the sun is converted into food (used for body repair, growth, motion, and to maintain body warmth).

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Examples of models could include food webs, diagrams, and flow charts to illustrate flow of energy.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td></td>
</tr>
</tbody>
</table>

**Disciplinary Core Ideas**

**PS3.D: Energy in Chemical Processes and Everyday Life**
- The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water).

**LS1.C: Organization for Matter and Energy Flow in Organisms**
- Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. (secondary)

**Science & Engineering Practices**

2. Developing and Using Models
- Use models to describe phenomena.

**Crosscutting Concepts**

Energy and Matter
- Energy can be transferred in various ways and between objects.

**North Dakota Connection**
ND game and fish may have more information on energy transfer via food webs.

**Content Resources**
## From Molecules to Organisms: Structures and Processes

<table>
<thead>
<tr>
<th>Performance Standard 5-LS1-1</th>
<th>Support an argument that plants get the materials they need for growth chiefly from air and water.</th>
</tr>
</thead>
</table>

### Clarification Statement
Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil. Consider hydroponics or the growing of plants in water.

### Assessment Boundary

### Disciplinary Core Ideas
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-Plants acquire their material for growth from carbon dioxide, the sun, and water through the process of photosynthesis.</td>
<td>-Support an argument with evidence, data, or a model.</td>
</tr>
</tbody>
</table>

### Crosscutting Concepts
<table>
<thead>
<tr>
<th>Energy and Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Matter is transported into, out of, and within systems.</td>
</tr>
</tbody>
</table>

### North Dakota Connection
Without photosynthesis North Dakota would not be an agricultural state.

### Content Resources
# Ecosystems: Interaction, Energy, and Dynamics

<table>
<thead>
<tr>
<th>Performance Standard 5-LS2-1</th>
<th>Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.</th>
</tr>
</thead>
</table>

**Clarification Statement**
Examples of systems could include organisms, ecosystems (decay), and the Earth. Consider teaching the carbon cycle, nitrogen cycle, and water cycle. Crop rotation is often due to the amount of nitrogen in the soil. Soybeans and other legumes can pull nitrogen from the air and convert it into a usable form.

**Assessment Boundary**
Assessment does not include molecular explanations.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **LS2.A: Interdependent Relationships in Ecosystems**  
- The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plant parts and animals) and therefore operate as “decomposers.” Decomposition eventually restores (recycles) some materials back to the soil. A healthy ecosystem is a balanced ecosystem. Newly introduced species can damage the balance of an ecosystem.  
**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems**  
- Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. | **2. Developing and Using Models**  
- Develop a model to describe phenomena. | **Systems and System Models**  
- A system can be described in terms of its components and their interactions. |

**North Dakota Connection**
Consider contacting the ND soybean council. Soybeans and other legumes can pull nitrogen from the air and convert it to a form that can be used.

**Content Resources**
Earth’s Place in the Universe

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Support an argument that the apparent brightness of the sun and stars is due to their relative distances from the Earth.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-ESS1-1</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**
Examples of stars distance from Earth and their relative brightness.

**Assessment Boundary**
Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).

**Disciplinary Core Ideas**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth.</td>
<td>7. Engaging in Argument from Evidence -Support an argument with evidence, data, or a model.</td>
<td>Scale, Proportion, and Quantity -Natural objects exist from the very small to the immensely large.</td>
</tr>
</tbody>
</table>

**North Dakota Connection**
Consider reaching out to local colleges and universities for more information such as UND space studies program. Many have planetariums for public use.

**Content Resources**
Earth’s Place in the Universe

<table>
<thead>
<tr>
<th>Performance Standard 5-ESS1-2</th>
<th>Construct a graph to reveal patterns of daily changes in length (metric) and direction of shadows, length of day and night, and the seasonal appearance of some stars in the night sky.</th>
</tr>
</thead>
</table>

**Clarification Statement**
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.

**Assessment Boundary**
Assessment does not include causes of seasons.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESS1.B: Earth and the Solar System</strong></td>
<td><strong>4. Analyzing and Interpreting Data</strong></td>
<td><strong>Patterns</strong></td>
</tr>
<tr>
<td>-The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.</td>
<td>-Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.</td>
<td>-Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.</td>
</tr>
</tbody>
</table>

**North Dakota Connection**

**Content Resources**
## Earth’s Systems

### Performance Standard 5-ESS2-1
Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere (water cycle). The geosphere, hydrosphere, atmosphere, and biosphere are each a system.</td>
<td></td>
</tr>
</tbody>
</table>

**Assessment Boundary**

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESS2.A: Earth Materials and Systems</strong></td>
<td><strong>2. Developing and Using Models</strong></td>
<td><strong>Systems and System Models</strong></td>
</tr>
<tr>
<td>-Earth’s major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth’s surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.</td>
<td>-Develop a model using an example to describe a scientific principle.</td>
<td>-A system can be described in terms of its components and their interactions.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
<th>Content Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consider the water, nitrogen, or carbon cycle and relate to ND agriculture.</td>
<td></td>
</tr>
</tbody>
</table>
## Earth’s Systems

<table>
<thead>
<tr>
<th>Performance Standard 5-ESS2-2</th>
<th>Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.</th>
</tr>
</thead>
</table>

| Clarification Statement       | Emphasis on freshwater and salt water in oceans, glaciers, groundwater, and surface water.                                                                                                           |
| Assessment Boundary           | Assessment is limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere.                                                                                             |

| Disciplinary Core Ideas       | Science & Engineering Practices                                                                                           | Crosscutting Concepts                                                                                     |
| ESS2.C: The Roles of Water in Earth’s Surface Processes       | 5. Using Mathematical and Computational Thinking                                                                 | Scale, Proportion, and Quantity                                                                                   |
| -Nearly all of Earth’s available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. | -Describe and graph quantities such as area and volume to address scientific quantities.                           | -Metric system is used to measure and describe physical quantities such as length, mass, and volume.           |

| North Dakota Connection       | Consider contacting the ND petroleum council to collect information on the saltwater that is pumped from Earth’s interior at oil well sites. The ND geological society and state water commission (project WET) for more resources. |

| Content Resources             |                                                                                                                         |                                                                                                           |
# Earth and Human Activity

<table>
<thead>
<tr>
<th>Performance Standard 5-ESS3-1</th>
<th>Obtain and combine information about ways individual communities use science ideas to protect the Earth’s resources and environment.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clarification Statement</strong></td>
<td>Obtain and combine information about ways individual communities use science ideas to protect the Earth’s resources and environment.</td>
</tr>
<tr>
<td><strong>Assessment Boundary</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Disciplinary Core Ideas</strong></th>
<th><strong>Science &amp; Engineering Practices</strong></th>
<th><strong>Crosscutting Concepts</strong></th>
</tr>
</thead>
</table>
-Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. However, individuals and communities are doing things to help protect Earth’s resources and environments. | Systems and System Models  
-A system can be described in terms of its components and their interactions. |

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
<th>The NDSU extension service, NDGF for wildlife management, ND Geological Society and State Water Commission (project WET) for more resources. Land reclamation is a mission of the ND Lignite Council.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content Resources</strong></td>
<td></td>
</tr>
</tbody>
</table>
### Performance Standard 5-ET1-1

Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Refer to the Engineering Design Process in the link above for a visual flow chart. They could include an item/object either at home or school that may make life easier or more efficient.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clarification Statement</strong></td>
<td><strong>Science &amp; Engineering Practices</strong></td>
</tr>
<tr>
<td><strong>ET1.A: Defining and Delimiting Engineering Problems</strong></td>
<td><strong>1. Asking Questions and Defining Problems</strong></td>
</tr>
<tr>
<td>-Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.</td>
<td>-Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
<th>Content Resources</th>
</tr>
</thead>
</table>

### Performance Standard 5-ET1-2
Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Refer to the Engineering Design Process in the link above for a visual flow chart. This is a continuation of the previous standard.</th>
</tr>
</thead>
</table>

### Disciplinary Core Ideas
**ET1.B: Developing Possible Solutions**
- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.

<table>
<thead>
<tr>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6. Constructing Explanations and Designing Solutions</strong></td>
<td>- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.</td>
</tr>
</tbody>
</table>

### North Dakota Connection
Content Resources
## Engineering & Technology

<table>
<thead>
<tr>
<th>Performance Standard 5-ET1-3</th>
<th>Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.</th>
</tr>
</thead>
</table>

### Clarification Statement
Refer to the Engineering Design Process in the link above for a visual flow chart. This is a continuation of the previous standard.

### Assessment Boundary

### Disciplinary Core Ideas

**ET1.B: Developing Possible Solutions**
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.

**ET1.C: Optimizing the Design Solution**
- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

### Science & Engineering Practices

**3. Planning and Carrying Out Investigations**
- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.

### Crosscutting Concepts

### North Dakota Connection

### Content Resources
Middle school science standards can be identified by the icon. These standards are grouped by content domain.

- Earth and Space Science
- Life Science
- Physical Science
- Engineering Technology
### Earth’s Place in the Universe

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.</th>
</tr>
</thead>
</table>

#### Clarification Statement
- Examples of models can be physical, graphical, or conceptual.

#### Assessment Boundary

#### Disciplinary Core Ideas
- **ESS1.A: The Universe and its Stars**
  - Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.

- **ESS1.B: Earth and the Solar System**
  - This model of the solar system can explain eclipses of the sun and the moon. Earth’s spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.

#### Science & Engineering Practices
- 1. Asking questions and defining problems
- 2. Developing and using models
- 3. Planning and carrying out investigations
- 4. Analyzing and interpreting data
- 5. Using mathematical and computational thinking
- 6. Constructing explanations and designing solutions
- 7. Engaging in argument from evidence
- 8. Obtaining, evaluating, and communicating information

#### Crosscutting Concepts
- **Patterns**
  - Patterns can be used to identify cause and effect relationships.

#### North Dakota Connection
- University of North Dakota Aerospace Science, Valley City State University Medicine Wheel, Valley City State University Planetarium
### Performance Standard MS-ESS1-2

Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.

### Clarification Statement

Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students’ school or state).

### Assessment Boundary

Assessment does not include Kepler’s Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.

### Disciplinary Core Ideas

**ESS1.A: The Universe and Its Stars**
- Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.

**ESS1.B: Earth and the Solar System**
- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

### Science & Engineering Practices

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

### Crosscutting Concepts

- Systems and System Models
  - Models can be used to represent systems and their interactions.

### North Dakota Connection
<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Analyze and interpret data to determine scale properties of objects in the solar system.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object’s layers (such as crust and atmosphere), surface features (such as volcnoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.

**Assessment Boundary**

Assessment does not include recalling facts about properties of the planets and other solar system bodies.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **ESS1.B: Earth and the Solar System** | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | **Systems and System Models**  
Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to development of entire industries and engineered systems. |

**North Dakota Connection**
### Earth’s Place in the Universe

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>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.</th>
</tr>
</thead>
</table>

**Clarification Statement**

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 Earth’s major events could range from being very recent (such as the last Ice Age or the earliest fossils of Homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.

**Assessment Boundary**

Assessment does not include recalling the names of specific periods or epochs and events within them.

### Disciplinary Core Ideas

**ESS1.C: The History of Planet Earth**

- The geologic time scale interpreted from rock strata provides a way to organize Earth’s history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.

### Science & Engineering Practices

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

### Crosscutting Concepts

**Systems and System Models**

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

### North Dakota Connection

**MS-ESS2-1**

## Earth’s Systems

<table>
<thead>
<tr>
<th>Performance Standard MS-ESS2-1</th>
<th>Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth’s materials (e.g. rock cycle).

**Assessment Boundary**

Assessment does not include the identification and naming of minerals.

**Disciplinary Core Ideas**

- **ESS2.A: Earth’s Materials and Systems**
  - All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms.

**Science & Engineering Practices**

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

**Crosscutting Concepts**

- **Systems and System Models**
  - Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale.

**North Dakota Connection**

# Earth’s Systems

<table>
<thead>
<tr>
<th>Performance Standard MS-ESS2-2</th>
<th>Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying times and spatial scales.</th>
</tr>
</thead>
</table>

## Clarification Statement
Emphasis is on how processes change Earth’s surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.

## Assessment Boundary

## Disciplinary Core Ideas

|--------------------------------------|-------------------------------|-----------------------|
| -The planet’s systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth’s history and will determine its future. | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | Systems and System Models  
-Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. |

| ESS2.C: The Roles of Water in Earth’s Surface Processes | | |
| -Water’s movements cause weathering and erosion, which change the land’s surface features and create underground formations. | | |

## North Dakota Connection
North Dakota Geologic Survey, Sheyenne National Grasslands, North Dakota University Systems, Prairie Potholes, Theodore Roosevelt National Park, North Dakota river systems
# Earth’s Systems

<table>
<thead>
<tr>
<th>Performance Standard MS-ESS2-3</th>
<th>Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of past plate motions.</th>
</tr>
</thead>
</table>

**Clarification Statement**
Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).

**Assessment Boundary**
Paleomagnetic anomalies in oceanic and continental crust are not assessed.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| ESS1.C: The History of Planet Earth
  - Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches (secondary).
ESS2.B: Plate Tectonics and Large-Scale System Interactions
  - Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth’s plates have moved great distances, collided, and spread apart. | 1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. **Analyzing and interpreting data**
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information | Patterns
  - Patterns in rates of change and other numerical relationships can provide information about natural systems. |

**North Dakota Connection**
North Dakota Geologic Survey, North Dakota Geographic Alliance, North Dakota University Systems
# Earth’s Systems

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.

**Assessment Boundary**

A quantitative understanding of the latent heats of vaporization and fusion is not assessed.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESS2.C: The Roles of Water in Earth’s Surface Processes</strong></td>
<td><strong>1. Asking questions and defining problems</strong></td>
</tr>
<tr>
<td>Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. Global movements of water and its changes in form are propelled by sunlight and gravity.</td>
<td><strong>2. Developing and using models</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Science &amp; Engineering Practices</strong></th>
<th><strong>Crosscutting Concepts</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Asking questions and defining problems</strong></td>
<td><strong>Systems and System Models</strong></td>
</tr>
<tr>
<td><strong>2. Developing and using models</strong></td>
<td>-Within a natural system, the transfer of energy drives the motion and/or cycling of matter.</td>
</tr>
<tr>
<td><strong>3. Planning and carrying out investigations</strong></td>
<td><strong>3. Planning and carrying out investigations</strong></td>
</tr>
<tr>
<td><strong>4. Analyzing and interpreting data</strong></td>
<td><strong>4. Analyzing and interpreting data</strong></td>
</tr>
<tr>
<td><strong>5. Using mathematical and computational thinking</strong></td>
<td><strong>5. Using mathematical and computational thinking</strong></td>
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<td><strong>6. Constructing explanations and designing solutions</strong></td>
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</tr>
<tr>
<td><strong>7. Engaging in argument from evidence</strong></td>
<td><strong>7. Engaging in argument from evidence</strong></td>
</tr>
<tr>
<td><strong>8. Obtaining, evaluating, and communicating information</strong></td>
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</tr>
</tbody>
</table>

**North Dakota Connection**

North Dakota watersheds, ND Project Water Education for Teachers (WET)
**MS-ESS2-5**

### Earth’s Systems

<table>
<thead>
<tr>
<th>Performance Standard MS-ESS2-5</th>
<th>Use data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.</th>
</tr>
</thead>
</table>

**Clarification Statement**

- Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided for students to interpret (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (e.g., condensation).

**Assessment Boundary**

- Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.

**Disciplinary Core Ideas**

- **ESS2.C: The Roles of Water in Earth’s Surface Processes**
  - The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

- **ESS2.D: Weather and Climate**
  - Because these patterns are so complex, weather can only be predicted probabilistically.

**Science & Engineering Practices**

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

**Crosscutting Concepts**

- **Cause and Effect**
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems.

**North Dakota Connection**

- National Oceanic and Atmospheric Administration, National Weather Service
### Earth’s Systems

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>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.</th>
</tr>
</thead>
</table>

#### Clarification Statement

Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.

#### Assessment Boundary

#### Disciplinary Core Ideas

**ESS2.C: The Roles of Water in Earth’s Surface Processes**

- Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.

**ESS2.D: Weather and Climate**

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.

#### Science & Engineering Practices

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

#### Crosscutting Concepts

**Systems and System Models**

- Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy, matter, and information flows within systems.

#### North Dakota Connection
# Earth and Human Activity

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS-ESS3-1</td>
<td></td>
</tr>
</tbody>
</table>

## Clarification Statement

Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).

## Assessment Boundary

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESS3.A: Natural Resources</td>
<td>1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematical and computational thinking 6. <strong>Constructing explanations and designing solutions</strong> 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information</td>
<td><strong>Cause and Effect</strong> - Cause and effect relationships may be used to predict phenomena in natural or designed systems. All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.</td>
</tr>
</tbody>
</table>

## North Dakota Connection

North Dakota Geologic Survey, North Dakota Geographic Alliance, North Dakota University Systems, North Dakota Energy Industries
# MS-ESS3-2 Earth and Human Activity

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Analyze and interpret data on natural hazards to forecast future catastrophic events that necessitate the development of technologies to mitigate their effects.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS-ESS3-2</td>
<td></td>
</tr>
</tbody>
</table>

## Clarification Statement

Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can 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, blizzards, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can 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).

## Assessment Boundary

### Disciplinary Core Ideas

**ESS3.B: Natural Hazards**
- Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.

### Science & Engineering Practices

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

### Crosscutting Concepts

**Patterns**
- Graphs and charts can be used to identify patterns in data. The uses of technologies and any limitations on their use are driven by individual and societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time.

## North Dakota Connection

### Earth and Human Activity

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).

**Assessment Boundary**

**Disciplinary Core Ideas**

**ESS3.C: Human Impacts on Earth Systems**

-Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things. Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

**Science & Engineering Practices**

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

**Crosscutting Concepts**

**Cause and Effect**

-Relationships can be classified as casual or correlational, and correlation does not necessarily imply causation.

**North Dakota Connection**

Agricultural Industries, North Dakota Energy Industries, North Dakota conservation entities
## MS-ESS3-4
### Earth and Human Activity

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth’s systems.</th>
</tr>
</thead>
</table>

### Clarification Statement
Examples of evidence 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 can 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.

### Assessment Boundary

### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>ESS3.C: Human Impacts on Earth Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.</td>
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</tbody>
</table>

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
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8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

<table>
<thead>
<tr>
<th>Cause and Effect</th>
</tr>
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<tbody>
<tr>
<td>-Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td>
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</tbody>
</table>

### North Dakota Connection

| Agricultural Industries, North Dakota Energy Industries, North Dakota conservation entities |
**Earth and Human Activity**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Investigate factors that have caused changes in global temperatures over time.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS-ESS3-5</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**

Examples of factors include natural processes (such as changes in incoming solar radiation or volcanic activity) and human activities (such as fossil fuel combustion, cement production, and agricultural 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.

**Assessment Boundary**

**Disciplinary Core Ideas**

- ESS3.D: Global Climate Change
  - Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth’s mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.

**Science & Engineering Practices**

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

**Crosscutting Concepts**

- Structure and Function
  - Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

**North Dakota Connection**

**MS-LS1-1**

### From Molecules to Organisms: Structure and Processes

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Conduct an investigation to provide evidence that living things are unicellular or multicellular and may have different cell types.</th>
</tr>
</thead>
</table>

**Clarification Statement**

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.

**Assessment Boundary**

**Disciplinary Core Ideas**

**LS1.A: Structure and Function**

- All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).

**Science & Engineering Practices**

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

**Crosscutting Concepts**

**Systems and System Models**

- Phenomena that can be observed at one scale may not be observable at another scale.

**North Dakota Connection**
**From Molecules to Organisms: Structure and Processes**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop and use a model to describe the function of a cell as a whole and ways cell parts (organelles) contribute to the cell functions.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Emphasis is on the cell functioning as a whole system and the primary role of identified organelle of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.

**Assessment Boundary**

Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.

**Disciplinary Core Ideas**

**LS1.A: Structure and Function**

- Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.

**Science & Engineering Practices**

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

**Crosscutting Concepts**

**Systems and System Models**

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

**North Dakota Connection**
## From Molecules to Organisms: Structure and Processes

### Performance Standard MS-LS1-3

Use evidence to model how the body is a system of interacting subsystems composed of groups of cells.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.</td>
</tr>
</tbody>
</table>

### Disciplinary Core Ideas

**LS1.A: Structure and Function**

- In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.

### Science & Engineering Practices

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

### Crosscutting Concepts

**Systems and System Models**

- Systems may interact with other systems; they may have sub-systems and be part of larger complex systems.

### North Dakota Connection
### Performance Standard

**MS-LS1-4**

Use evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction.

### Clarification Statement

Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.

### Assessment Boundary

**Disciplinary Core Ideas**

- LS1.B: Growth and Development of Organisms
  - Animals engage in characteristic behaviors that increase the odds of reproduction. Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.

**Science & Engineering Practices**

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

**Crosscutting Concepts**

- Cause and Effect
  - Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
**MS-LS1-5**

### Performance Standard MS-LS1-5

Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

### Clarification Statement

Examples of local environmental conditions could include availability of food, light, space, and water (photosynthesis). Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could 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.

### Assessment Boundary

Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.

### Disciplinary Core Ideas

- **LS1.B: Growth and Development of Organisms**
  - Genetic factors as well as local conditions affect the growth of the adult plant.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
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### Crosscutting Concepts

- **Cause and Effect**
  - Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

### North Dakota Connection

- Agricultural Industries
### From Molecules to Organisms: Structure and Processes

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>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.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Emphasis is on tracing movement of matter and flow of energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment does not include details of the chemical reactions for photosynthesis.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. **Constructing explanations and designing solutions**  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | **TITLE?**  
-Matter is conserved because atoms are conserved in physical and chemical processes. |
| **PS3.D: Energy in Chemical Processes and Everyday Life** | -Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. |                                                                                       |

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
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</thead>
</table>
### MS-LS1-7

#### From Molecules to Organisms: Structure and Processes

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as it moves through an organism.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Assessment Boundary</th>
<th>Assessment does not include details of the chemical reactions for photosynthesis or respiration.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.</td>
<td>2. Developing and using models</td>
<td>-Matter is conserved because atoms are conserved in physical and chemical processes.</td>
</tr>
</tbody>
</table>

| -Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. | 5. Using mathematical and computational thinking | | 6. Constructing explanations and designing solutions |
| | 7. Engaging in argument from evidence | | 8. Obtaining, evaluating, and communicating information |

| North Dakota Connection | | | |
|-------------------------| | | |
### Performance Standard
**MS-LS2-1**

Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

### Clarification Statement
Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.

### Assessment Boundary

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | **Cause and Effect**  
-Cause and effect relationships may be used to predict phenomena in natural or designed systems. |

### North Dakota Connection
Ecosystems: Interactions, Energy, and Dynamics

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.

**Assessment Boundary**

**Disciplinary Core Ideas**

**LS2.A: Interdependent Relationships in Ecosystems**

-Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

**Science & Engineering Practices**

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

**Crosscutting Concepts**

Patterns

- Patterns can be used to identify cause and effect relationships.

**North Dakota Connection**

Resources may include the Habitats of North Dakota book series.
**Performance Standard**

**MS-LS2-3**

Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment does not include the use of chemical reactions to describe the processes.</td>
</tr>
</tbody>
</table>

**Disciplinary Core Ideas**

**LS2.B: Cycle of Matter and Energy Transfer in Ecosystems**

- Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

<table>
<thead>
<tr>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Asking questions and defining problems</td>
<td>Systems and System Models</td>
</tr>
<tr>
<td>2. Developing and using models</td>
<td>-The transfer of energy can be tracked as energy flows through a designed or natural system.</td>
</tr>
<tr>
<td>3. Planning and carrying out investigations</td>
<td></td>
</tr>
<tr>
<td>4. Analyzing and interpreting data</td>
<td></td>
</tr>
<tr>
<td>5. Using mathematical and computational thinking</td>
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<tr>
<td>6. Constructing explanations and designing solutions</td>
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<tr>
<td>8. Obtaining, evaluating, and communicating information</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
</tr>
</thead>
</table>
### Ecosystems: Interactions, Energy, and Dynamics

<table>
<thead>
<tr>
<th>Performance Standard MS-LS2-4</th>
<th>Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.</th>
</tr>
</thead>
</table>

#### Clarification Statement
Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.

#### Assessment Boundary

#### Disciplinary Core Ideas
- **LS2.C: Ecosystem Dynamics, Functioning, and Resilience**
  - Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

#### Science & Engineering Practices
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. **Engaging in argument from evidence**
8. Obtaining, evaluating, and communicating information

#### Crosscutting Concepts
- **Cause and Effect**
  - Small changes in one part of a system might cause large changes in another part.

---

**North Dakota Connection**
# Ecosystems: Interactions, Energy, and Dynamics

## Performance Standard

**MS-LS2-5**

Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

### Clarification Statement

Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.

### Assessment Boundary

---

### Disciplinary Core Ideas

**LS2.C: Ecosystem Dynamics, Functioning, and Resilience**

-Biodiversity describes the variety of species found in Earth’s terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem’s biodiversity is often used as a measure of its health.

**LS4.D: Biodiversity and Humans**

-Changes in biodiversity can influence humans’ resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.

### Science & Engineering Practices

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

### Crosscutting Concepts

**Cause and Effect**

-Small changes in one part of a system might cause large changes in another part. The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time. Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

### North Dakota Connection

North Dakota wetlands, North Dakota Soil Conservation
Heredity: Inheritance and Variation of Traits

**Performance Standard**

**MS-LS3-1**

Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

**Clarification Statement**

Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.

**Assessment Boundary**

Assessment does not include specific changes in the molecular level, mechanisms for protein synthesis, or specific types of mutations.

**Disciplinary Core Ideas**

**LS3.A: Inheritance of Traits**
- Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual.

**LS3.B: Variation of Traits**
- Genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.

**Science & Engineering Practices**

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

**Crosscutting Concepts**

**Systems and System Models**
- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

**North Dakota Connection**
### MS-LS3-2

#### Heredity: Inheritance and Variation of Traits

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>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.</th>
</tr>
</thead>
</table>

#### Clarification Statement

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 variation (mitosis, meiosis, and binary fission).

#### Assessment Boundary

#### Disciplinary Core Ideas

**LS1.B: Growth and Development of Organisms**
- Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring.

**LS3.A: Inheritance of Traits**
- Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes inherited.

**LS3.B: Variation of Traits**
- In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene.

#### Science & Engineering Practices

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

#### Crosscutting Concepts

**Cause and Effect**
- Cause and effect relationships may be used to predict phenomena in natural systems.

#### North Dakota Connection

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### Natural Selection and Adaptations

**Performance Standard**

**MS-LS4-1**

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.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment does not include the names of individual species or geological eras in the fossil record.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LS4.A: Evidence of Common Ancestry and Diversity</strong></td>
<td></td>
<td><strong>Patterns</strong></td>
</tr>
</tbody>
</table>
| The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. **Analyzing and interpreting data**  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | - Graphs and charts can be used to identify patterns in data. Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. |

# Natural Selection and Adaptations

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>MS-LS4-2</th>
<th>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.</th>
</tr>
</thead>
</table>

## Clarification Statement
Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures (examples could include bone structure comparisons of different organisms).

## Assessment Boundary

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | Patterns  
-Patterns can be used to identify cause and effect relationships. |

## North Dakota Connection
**Natural Selection and Adaptations**

<table>
<thead>
<tr>
<th>Performance Standard MS-LS4-3</th>
<th>Analyze displays of pictorial data to compare patterns of similarities and differences in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures (examples may include fish, pigs, and chickens).

**Assessment Boundary**

Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.

**Disciplinary Core Ideas**

**Science & Engineering Practices**

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

**Crosscutting Concepts**

Patterns  
- Graphs and charts can be used to identify patterns in data.

**North Dakota Connection**
# Natural Selection and Adaptations

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>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.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clarification Statement</strong></td>
<td>Emphasis is on using simple probability statements and proportional reasoning to construct explanations.</td>
</tr>
<tr>
<td><strong>Assessment Boundary</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Disciplinary Core Ideas</strong></td>
<td><strong>Science &amp; Engineering Practices</strong></td>
</tr>
</tbody>
</table>
| LS4.B: Natural Selection | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | Cause and Effect  
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. |
| North Dakota Connection | | |
Natural Selection and Adaptations

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.</th>
</tr>
</thead>
</table>

**Clarification Statement**
Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.

**Assessment Boundary**

**Disciplinary Core Ideas**

**LS4.B: Natural Selection**
-In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.

**Science & Engineering Practices**
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**Cause and Effect**
-Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineering systems.

**North Dakota Connection**
North Dakota University Systems, Garrison Dam National Fish Hatchery, North Dakota Game and Fish Department
Natural Selection and Adaptations

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.</th>
</tr>
</thead>
</table>

Clarification Statement  
Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.

Assessment Boundary  
Assessment does not include Hardy-Weinberg calculations.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **LS4.C: Adaptation**   | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating Information | **Cause and Effect**  
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. |

North Dakota Connection
### Matter and Interaction

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop models to describe the atomic composition of simple molecules and extended structures.</th>
</tr>
</thead>
</table>

#### Clarification Statement

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. Examples of molecular-level models could include drawings, 3-D ball and stick structures, or computer representations showing different molecules with different types of atoms.

#### Assessment Boundary

Assessment does not include valance 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 structures is not required.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | Systems and System Models  
-Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. |

| North Dakota Connection |
### Matter and Interaction

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Analyze and interpret data on the properties of substances before and after an interaction has occurred to determine if a chemical reaction has occurred.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS-PS1-2</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**

Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.

**Assessment Boundary**

Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.

### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.</td>
<td>1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematical and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information</td>
<td>Patterns - Macroscopic patterns are related to the nature of microscopic and atomic-level structure.</td>
</tr>
</tbody>
</table>

**PS1.B: Chemical Reactions**

- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

### North Dakota Connection
**MS-PS1-3**  
**Matter and Interaction**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Gather and analyze information to describe that synthetic materials come from natural resources and impact society.</th>
</tr>
</thead>
</table>

**Clarification Statement**  
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.

**Assessment Boundary**  
Assessment is limited to qualitative information.

**Disciplinary Core Ideas**  
**PS1.A: Structure and Properties of Matter**  
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

**PS1.B: Chemical Reactions**  
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

**Science & Engineering Practices**
1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**
**Structure and Function**  
- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

**North Dakota Connection**  
Petroleum-based products, ethanol plants, coal gasification
**Performance Standard**
**MS-PS1-4**

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.

---

**Clarification Statement**

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 drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.

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**Assessment Boundary**

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**Disciplinary Core Ideas**

- **PS1.A: Structure and Properties of Matter**
  - The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

- **PS3.A: Definitions of Energy**
  - Heat refers to the energy transferred due to the temperature difference between two objects. The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule. The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material.

---

**Science & Engineering Practices**

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

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**Crosscutting Concepts**

- **Cause and Effect**
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems.

---

**North Dakota Connection**

- **North Dakota Energy Industries**

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# Matter and Interaction

<table>
<thead>
<tr>
<th>Performance Standard MS-PS1-5</th>
<th>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.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Assessment Boundary</th>
<th>Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PS1.B: Chemical Reactions</strong></td>
<td>1. Asking questions and defining problems</td>
<td><strong>TITLE?</strong></td>
</tr>
<tr>
<td>- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change.</td>
<td>2. Developing and using models</td>
<td>- Matter is conserved because atoms are conserved in physical and chemical processes.</td>
</tr>
<tr>
<td>3. Planning and carrying out investigations</td>
<td>4. Analyzing and interpreting data</td>
<td>5. Using mathematical and computational thinking</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
<th></th>
<th></th>
</tr>
</thead>
</table>

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### Matter and Interaction

<table>
<thead>
<tr>
<th>Performance Standard MS-PS1-6</th>
<th>Design a project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Emphasis is on the design, controlling the transfer of energy to the environment, and modification of the device using factors such as type and concentration of a substance.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS1.B: Chemical Reactions</td>
<td></td>
<td>Systems and System Models</td>
</tr>
<tr>
<td>-Some chemical reactions release energy, others store energy.</td>
<td>1. Asking questions and defining problems</td>
<td>-The transfer of energy can be tracked as energy flows through a designed or natural system.</td>
</tr>
<tr>
<td>ET1.B: Developing Possible Solutions</td>
<td>2. Developing and using models</td>
<td></td>
</tr>
<tr>
<td>ET1.C: Optimizing the Design Solution</td>
<td>3. Planning and carrying out investigations</td>
<td></td>
</tr>
<tr>
<td>-Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process. The iterative process of testing the most promising solutions and modifying what is proposed based on the test results leads to greater refinement and ultimately to an optimal solution.</td>
<td>4. Analyzing and interpreting data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Using mathematical and computational thinking</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Constructing explanations and designing solutions</td>
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</tr>
<tr>
<td></td>
<td>7. Engaging in argument from evidence</td>
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</tr>
<tr>
<td></td>
<td>8. Obtaining, evaluating, and communicating information</td>
<td></td>
</tr>
</tbody>
</table>

| North Dakota Connection | |
|-------------------------| |
**Motion and Stability: Forces and Interactions**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.</th>
</tr>
</thead>
</table>

**Clarification Statement**
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.

**Assessment Boundary**
Assessment is limited to vertical or horizontal interactions in one dimension.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. |
| 6. **Constructing explanations and designing solutions** | 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information | |

**North Dakota Connection**
# Performance Standard

**MS-PS2-2**  
Plan an investigation using Newton's First and Second Laws to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

## Clarification Statement

Emphasis is on balanced (Newton’s First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton’s Second Law), frame of reference, and specification of units.

## Assessment Boundary

Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.

## Disciplinary Core Ideas

**PS2.A: Forces and Motion**  
-The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. A larger force causes a larger change in motion. All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

## Science & Engineering Practices

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

## Crosscutting Concepts

**Structure and Function**  
-Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

## North Dakota Connection

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# Motion and Stability: Forces and Interactions

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Interpret data to determine the factors that affect the strength of electric and magnetic forces.</th>
</tr>
</thead>
</table>

### Clarification Statement
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.

### Assessment Boundary
Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.

### Disciplinary Core Ideas
- **PS2.B: Types of Interactions**
  - Electric and magnetic (emagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.

### Science & Engineering Practices
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts
- **Cause and Effect**
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems.

### North Dakota Connection
### Performance Standard

**MS-PS2-4**

Use evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.

### Clarification Statement

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.

### Assessment Boundary

Assessment does not include Newton’s Law of Gravitation or Kepler’s Laws.

### Disciplinary Core Ideas

**PS2.B: Types of Interactions**

- Gravitational forces are always attractive.
- There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.

### Science & Engineering Practices

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

### Crosscutting Concepts

**Systems and System Models**

- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.
# Motion and Stability: Forces and Interactions

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Conduct an investigation to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.</th>
</tr>
</thead>
</table>

**Clarification Statement**

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.

**Assessment Boundary**

Assessment is limited to electric and magnetic fields and is limited to qualitative evidence for the existence of fields.

## Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>PS2.B: Types of Interactions</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| - Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). | 1. Asking questions and defining problems  
2. Developing and using models  
3. **Planning and carrying out investigations**  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | **Cause and Effect**  
-Cause and effect relationships may be used to predict phenomena in natural or designed systems. |

## North Dakota Connection
### Performance Standard
**MS-PS3-1**

Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and/or the speed of an object.

### Clarification Statement
Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a whiffle ball versus a tennis ball.

### Assessment Boundary

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
- Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. |

<p>| North Dakota Connection |</p>
<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Using a model describe how the different amounts of potential energy in a system changes when the object's distance changes.</th>
</tr>
</thead>
</table>

| Clarification Statement | 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: Either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves and the Earth, 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. |

| Assessment Boundary | Assessment is limited to two objects and electric, magnetic, and gravitational interactions. |

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS3.C: Relationship Between Energy and Forces</td>
<td>-When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.</td>
<td></td>
</tr>
</tbody>
</table>

| North Dakota Connection | |

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### Performance Standard
**MS-PS3-3**
Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup (scientific principles could include the science and engineering practices or the engineering design process).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment does not include calculating the total amount of thermal energy transferred.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PS3.A: Definitions of Energy</strong></td>
<td>- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.</td>
<td></td>
</tr>
<tr>
<td><strong>PS3.B: Conservation of Energy and Energy Transfer</strong></td>
<td>- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.</td>
<td></td>
</tr>
<tr>
<td><strong>ET1.A: Defining and Delimiting an Engineering Problem</strong></td>
<td>- The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful.</td>
<td></td>
</tr>
</tbody>
</table>
| **ET1.B: Developing Possible Solutions** | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating Information | **TITLE?**  
- Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup. Scientific principles could include the science and engineering practices or the engineering design process. |

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
<th>North Dakota Energy Industries</th>
</tr>
</thead>
</table>

---

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**MS-PS3-4**

### ENERGY

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Investigate to determine the relationships among the energy transferred, the type of matter, mass, and change in the average kinetic energy of the particles as measured by the temperature of the sample.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clarification Statement</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Assessment Boundary</strong></td>
<td>Assessment does not include calculating the total amount of thermal energy transferred.</td>
</tr>
</tbody>
</table>

**Disciplinary Core Ideas**

**PS3.A: Definitions of Energy**
- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

**PS3.B: Conservation of Energy and Energy Transfer**
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

**Science & Engineering Practices**

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

**Crosscutting Concepts**

**Title?**
- Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

**North Dakota Connection**
### Performance Standard
**MS-PS3-5**

Construct and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Examples of empirical evidence used in arguments may include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment does not include calculations of energy.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
</tr>
</thead>
</table>
| **PS3.B: Conservation of Energy and Energy Transfer**    | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating Information |

| Crosscutting Concepts | TITLE?  
- Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). |

| North Dakota Connection | |

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### Performance Standard
**MS-PS4-1**

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.

### Clarification Statement
Emphasis is on describing waves with both qualitative and quantitative thinking.

### Assessment Boundary
Assessment does not include electromagnetic waves and is limited to standard repeating waves.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **PS4.A: Wave Properties**
- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. | 1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. **Using mathematical and computational thinking**
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information | **Patterns**
- Graphs and charts can be used to identify patterns in data.

### North Dakota Connection
### Performance Standard MS-PS4-2

Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment is limited to qualitative applications pertaining to light and mechanical waves.</td>
</tr>
</tbody>
</table>

#### Disciplinary Core Ideas

**PS4.A: Wave Properties**
- A sound wave needs a medium through which it is transmitted.

**PS4.B: Electromagnetic Radiation**
- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object’s material and the frequency (color) of the light. The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

#### Science & Engineering Practices

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

#### Crosscutting Concepts

**Structure and Function**
- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

### North Dakota Connection
### MS-PS4-3

**Waves and their Applications in Technologies for Information Transfer**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Evaluate how different forms of technology utilize different signals.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS-PS4-3</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**

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.

**Assessment Boundary**

Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **PS4.C: Information Technologies and Instrumentation** | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating Information | **Structure and Function**  
- Structures can be designed to serve particular functions. Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. Advances in technology influence the progress of science and science has influenced advances in technology. |
| **-Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.** | | |

**North Dakota Connection**

North Dakota power, telephone, and cable companies
### Performance Standard MS-ET1-1

Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>This standard may be integrated into any performance standard. Suggested ecological topics may include deforestation, overpopulation, water quality, air quality, erosion, or toxic spills.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| ET1.A: Defining and Delimiting Engineering Problems | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | TITLE?  
All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. |

<p>| North Dakota Connection | |</p>
<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Evaluate competing design solutions using systematic process to determine how well they meet the criteria and constraints of the problem.</th>
</tr>
</thead>
</table>

**Clarification Statement**
This standard may be integrated into any performance standard. This is a continuation of the previous standard.

**Assessment Boundary**

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ET1.B: Developing Possible Solutions</strong></td>
<td>1. Asking questions and defining problems</td>
<td>8. Obtaining, evaluating, and communicating information</td>
</tr>
<tr>
<td>-There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.</td>
<td>2. Developing and using models</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Planning and carrying out investigations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Analyzing and interpreting data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Using mathematical and computational thinking</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Constructing explanations and designing solutions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Engaging in argument from evidence</td>
<td></td>
</tr>
</tbody>
</table>

**North Dakota Connection**
**Engineering & Technology**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.</th>
</tr>
</thead>
</table>

**Clarification Statement**

This standard may be integrated into any performance standard. This is a continuation of the previous standard.

**Assessment Boundary**

**Disciplinary Core Ideas**

- **ET1.B: Developing Possible Solutions**
  - A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. Models of all kinds are important for testing solutions.

- **ET1.C: Optimizing the Design Solution**
  - The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.

**Science & Engineering Practices**

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

**Crosscutting Concepts**

- **Cause and Effect**
  - Relationships can be classified as casual or correlational, and correlation does not necessarily imply causation.

**North Dakota Connection**
## Engineering & Technology

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>MS-ET1-4</th>
<th>Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>This standard may be integrated into any performance standard. This is a continuation of the previous standard.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Assessment Boundary</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ET1.B: Developing Possible Solutions</strong></td>
<td>1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematical and computational thinking</td>
<td><strong>Cause and Effect</strong> -Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td>
</tr>
</tbody>
</table>

| North Dakota Connection |
High school standards (grades 9-12) are listed by discipline:

- Life Science
- Physical Science
- Earth & Space Science
- Engineering & Technology

The standards are also defined for the following courses:

- Biology
- Chemistry
- Earth & Space Science
- Environmental Science
- Physical Science
- Physics
- Anatomy & Physiology
These standards are organized according to how they apply to typical courses offered across the state of North Dakota. The organization of these standards is meant to serve as a guideline for curriculum development. Individual school districts will be responsible for selecting standards appropriate for elective courses not listed above. The Engineering & Technology standards are to be integrated across all science courses.
<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>HS-LS1-1</th>
<th>Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarification Statement</td>
<td>Emphasis is on the conceptual understanding that DNA sequences determine the amino acid sequence and thus protein structure.</td>
<td></td>
</tr>
<tr>
<td>Assessment Boundary</td>
<td>Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis</td>
<td></td>
</tr>
</tbody>
</table>

**Disciplinary Core Ideas**

**LS1.A: Structure and Function**
- Systems of specialized cells within organisms help them perform the essential functions of life.
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
   - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**Structure and Function**
- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

**North Dakota Connection**
**Performance Standard HS-LS1-2**  
Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

**Clarification Statement**  
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 could be 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.

**Assessment Boundary**  
Assessment does not include interactions and functions at the molecular or chemical reaction level.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **LS1.A: Structure and Function**  
-Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. | 1. Asking questions and defining problems  
2. Developing and using models  
- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating Information | **Systems and System Models**  
-Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. |

**North Dakota Connection**
### FROM MOLECULES TO ORGANISM: STRUCTURES AND PROCESSES

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Examples of investigations could include heart rate response to exercise, cell transport, etc.

**Assessment Boundary**

Assessment does not include the cellular processes involved in the feedback mechanism.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LS1.A: Structure and Function</strong></td>
<td>1. Asking questions and defining problems 2. Developing and using models 3. <strong>Planning and carrying out investigations</strong>  - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data and refine the design accordingly. 4. Analyzing and interpreting data 5. Using mathematical and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information</td>
<td><strong>Stability and Change</strong>  - Feedback (negative or positive) can stabilize or destabilize a system.</td>
</tr>
</tbody>
</table>

**North Dakota Connection**
### Performance Standard
**HS-LS1-4**

| Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. |

---

### Clarification Statement

Emphasis is on conceptual understanding that mitosis passes on genetically identical materials via replication, not on the details of each phase in mitosis.

### Assessment Boundary

Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.

### Disciplinary Core Ideas

**LS1.B: Growth and Development of Organisms**

- In multicellular organisms, individual cells grow and then divide via a process called mitosis allowing the organism to grow. Each parent cell passing identical genetic material to both daughter cells. Cellular division and differentiation produce and maintain a complex organism.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
   - Use a model based on evidence to illustrate the relationships between systems or between components of a system.
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Systems and System Models**

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

### North Dakota Connection

- [Link to North Dakota Science Standards](https://www.nd.gov/education/standards/ndss-core-standards-science)
Performance Standard  
**HS-LS1-5**  
Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>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 could include diagrams, chemical equations, and conceptual models.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment does not include specific biochemical steps.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
2. Developing and using models  
• Use a model based on evidence to illustrate the relationships between systems or between components of a system.  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | Energy and Matter  
-Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. |

North Dakota Connection
**FROM MOLECULES TO ORGANISM: STRUCTURES AND PROCESSES**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen may combine with other elements to form large carbon-based molecules.</th>
</tr>
</thead>
</table>

**Clarification Statement**
Emphasis is on using evidence from models and simulations to support explanations.

**Assessment Boundary**
Assessment does not include the details of the specific chemical reactions or identification of macromolecules.

**Disciplinary Core Ideas**
-Sugar molecules contain carbon, hydrogen, and oxygen. These building blocks are used to form large molecules. Chemical elements are recombined in different ways to form different products.

**Science & Engineering Practices**
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
   - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**
Energy and Matter
-Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

**North Dakota Connection**
FROM MOLECULES TO ORGANISM: STRUCTURES AND PROCESSES

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.</th>
</tr>
</thead>
</table>

**Clarification Statement**
Emphasis is on the conceptual understanding of the inputs and outputs of the processes of aerobic and anaerobic cellular respiration. Examples of models could include diagrams, chemical equations, conceptual models and/or laboratory investigations.

**Assessment Boundary**
Assessment should not include identification of the steps or specific processes involved in cellular respiration.

**Disciplinary Core Ideas**
**LS1.C: Organization for Matter and Energy Flow in Organisms**
- Chemical elements are recombined in different ways to form different products. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken, and new compounds are formed that can transport energy.

**Science & Engineering Practices**
1. Asking questions and defining problems
2. Developing and using models
   - Use a model based on evidence to illustrate the relationships between systems or between components of a system.
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**
**Energy and Matter**
- Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.

**North Dakota Connection**
**ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use mathematical and/or computational models to support explanations of factors that affect carrying capacity of ecosystems at different scales.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS-LS2-1</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**

Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from computer simulations or historical data sets.

**Assessment Boundary**

Assessment does not include deriving mathematical equations to make comparisons.

**Disciplinary Core Ideas**

**LS2.A: Interdependent Relationships in Ecosystems**

-Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
   - Use mathematical and/or computational representations of phenomena or design solutions to support explanations.
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

Scale, Proportion, and Quantity
-The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

**North Dakota Connection**

ND Game and Fish, ND Colleges and Universities, Natural Resource Conservation Service, USFWS
### Performance Standard

**HS-LS2-2**  
Use evidence from mathematical representations to explain factors that affect population dynamics and biodiversity.

### Clarification Statement

Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.

### Assessment Boundary

Assessment is limited to provided data.

### Disciplinary Core Ideas

**LS2.A: Interdependent Relationships in Ecosystems**
-Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease.

**LS2.C: Ecosystem Dynamics, Functioning, and Resilience**
-Interactions within an ecosystem can keep its organisms relatively constant under stable conditions. A change in the ecosystem can create a change in populations.

### Science & Engineering Practices

1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. **Using mathematical and computational thinking**  
   - Use mathematical representations of phenomena or design solutions to support and revise explanations.  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

Scale, Proportion, and Quantity  
-Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

### North Dakota Connection

ND Game and Fish, ND Colleges and Universities, Natural Resource Conservation Service, Forestry Service, Invasive species management: Aquatic nuisance species (e.g. zebra mussels), leafy spurge management, CRP mismanagement decreasing plant diversity.
**ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

<table>
<thead>
<tr>
<th>Performance Standard HS-LS2-3</th>
<th>Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.</th>
</tr>
</thead>
</table>

**Clarification Statement**
Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.

**Assessment Boundary**
Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.

**Disciplinary Core Ideas**
- Photosynthesis and cellular respiration provide most of the energy for life processes.

**Science & Engineering Practices**
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
   - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**
- **Energy and Matter**
  - Energy drives the cycling of matter within and between systems.

**North Dakota Connection**
### HS-LS2-4

**ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.</th>
</tr>
</thead>
</table>

#### Clarification Statement
Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.

#### Assessment Boundary
Assessment is limited to conceptual reasoning to describe the cycling of matter and flow of energy.

#### Disciplinary Core Ideas

**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems**
- The chemical elements that make up the molecules of organisms pass through food webs (10% rule) and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.

#### Science & Engineering Practices
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
   - Use mathematical representations of phenomena or design solutions to support claims.
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

#### Crosscutting Concepts
**Energy and Matter**
- Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.

#### North Dakota Connection
Tillage on cropland, drought effects, disturbance releases, fires, etc. ND Connection: NDSU Research stations, extension; NRCS
### ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.</th>
</tr>
</thead>
</table>

**Clarification Statement**
Examples of models could include simulations and mathematical models.

**Assessment Boundary**
Assessment does not include the specific chemical steps of photosynthesis and respiration.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** | 1. Asking questions and defining problems  
2. Developing and using models  
   - Develop a model based on evidence to illustrate the relationships between systems or components of a system.  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | **Systems and System Models**  
- Models can be used to simulate systems and interactions — including energy, matter and information flows — within and between systems at different scales. |

**North Dakota Connection**
ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS

| Performance Standard HS-LS2-6 | 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. |

| Clarification Statement | Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise, that occur at different rates. |

| Assessment Boundary | Assessment is limited to provided data. |

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| LS2.C: Ecosystem Dynamics, Functioning, and Resilience | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
   • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.  
8. Obtaining, evaluating, and communicating information | Stability and Change  
-Much of science deals with constructing explanations of how things change and how they remain stable. |

| North Dakota Connection | ND Game and Fish, ND Colleges and Universities, Natural Resource Conservation Service, Forestry Service |
### Performance Standard HS-LS2-7
Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Examples of human activities can include urbanization, building dams, and dissemination of invasive species.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| LS2.C: Ecosystem Dynamics, Functioning, and Resilience | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
   - Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations landscapes of recreational or inspirational value.  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | Stability and Change  
-Much of science deals with constructing explanations of how things change and how they remain stable. |
| LS4.D: Biodiversity and Humans | -Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). |                                                                                       |

| North Dakota Connection | ND Rivers, Devils Lake, ND Game and Fish, ND Colleges and Universities, Natural Resource Conservation Service, Forestry Service, River Keepers |                                                                                       |
**ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Evaluate the evidence for the role of group behavior on individual and species’ chances to survive and reproduce.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.

**Assessment Boundary**

**Disciplinary Core Ideas**

LS2.D: Social Interactions and Group Behavior
- Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.

<table>
<thead>
<tr>
<th>Science &amp; Engineering Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Asking questions and defining problems</td>
</tr>
<tr>
<td>2. Developing and using models</td>
</tr>
<tr>
<td>3. Planning and carrying out investigations</td>
</tr>
<tr>
<td>4. Analyzing and interpreting data</td>
</tr>
<tr>
<td>5. Using mathematical and computational thinking</td>
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<tr>
<td>6. Constructing explanations and designing solutions</td>
</tr>
</tbody>
</table>
| 7. Engaging in argument from evidence  
  • Evaluate the evidence behind currently accepted explanations to determine the merits of arguments. |
| 8. Obtaining, evaluating, and communicating information |

**Crosscutting Concepts**

Cause and Effect
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

**North Dakota Connection**

ND Game and Fish, USFWS
**Performance Standard HS-LS3-1**

Construct an explanation to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

**Clarification Statement**

Emphasis should be on traits including completely dominant, codominant, incompletely dominant, and sex-linked traits. Examples can include pedigrees, karyotypes, genetic disorders, Punnett squares, dihybrid crosses.

**Assessment Boundary**

Assessment focuses on the conceptual understanding of meiosis.

**Disciplinary Core Ideas**

**LS1.A: Structure and Function**

- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins.

**LS3.A: Inheritance of Traits**

- DNA make up genes that are sections on chromosomes which are the instructions for forming individual characteristics (traits). All cells of an organism have the same genetic content. Gene expression is regulated in different ways.

**Science & Engineering Practices**

1. Asking questions and defining problems
   - Ask questions that arise from examining models or a theory to clarify relationships.

2. Developing and using models

3. Planning and carrying out investigations

4. Analyzing and interpreting data

5. Using mathematical and computational thinking

6. Constructing explanations and designing solutions

7. Engaging in argument from evidence

8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**Cause and Effect**

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

**North Dakota Connection**
**Performance Standard**  
**HS-LS3-2**  
Make and defend a claim based on evidence that inheritable genetic variations result from various factors.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Emphasis is on (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. Emphasis is also on using data to support arguments for the way variation occurs.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assessment Boundary</strong></td>
<td>Assessment focuses on the conceptual understanding of meiosis.</td>
</tr>
</tbody>
</table>

**Disciplinary Core Ideas**  
**LS3.B: Variation of Traits**  
-Sexual reproduction (meiosis) creates variation through crossing over and independent assortment. Mutations may occur during DNA replication resulting in genetic variation or due to environmental factors. The variation and distribution of traits observed depends on both genetic and environmental factors.

**Science & Engineering Practices**  
1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
   - Make and defend a claim based on evidence about the natural world that reflects scientific knowledge and student-generated evidence.  
   - Obtaining, evaluating, and communicating information

**Crosscutting Concepts**  
**Cause and Effect**  
-Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

**North Dakota Connection**
**HEREDITY: INHERITANCE AND VARIATION OF TRAITS**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Emphasis is on distribution and variation of traits in a population and the use of mathematics to describe the distribution. Examples can include calculations of frequencies in Punnett squares, graphical representations.

**Assessment Boundary**

Assessment does not include Hardy-Weinberg calculations or chi square test.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LS3.B: Variation of Traits</strong>&lt;br&gt;-The variation and distribution of traits observed depends on both genetic and environmental factors.</td>
<td>1. Asking questions and defining problems&lt;br&gt;2. Developing and using models&lt;br&gt;3. Planning and carrying out investigations&lt;br&gt;4. Analyzing and interpreting data&lt;br&gt;   • Apply concepts of statistics and probability to scientific and engineering questions and problems, using digital tools when feasible.&lt;br&gt;5. Using mathematical and computational thinking&lt;br&gt;6. Constructing explanations and designing solutions&lt;br&gt;7. Engaging in argument from evidence&lt;br&gt;8. Obtaining, evaluating, and communicating information</td>
<td><strong>Scale, Proportion, and Quantity</strong>&lt;br&gt;-Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).</td>
</tr>
</tbody>
</table>

**North Dakota Connection**
### BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Analyze and interpret scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Biological evolution is defined as changes in the traits of populations of organisms over time. Emphasis is on a conceptual understanding of the role each line of evidence (e.g., similarities in DNA sequences, order of appearance of structure during embryological development, cladograms, homologous and vestigial structures, fossil records) demonstrates as related to common ancestry and biological evolution.

**Assessment Boundary**

**Disciplinary Core Ideas**

**LS4.A: Evidence of Common Ancestry and Diversity**

- Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. **Obtaining, evaluating, and communicating information**
   - Communicate scientific information in multiple formats.

**Crosscutting Concepts**

**Patterns**

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

**North Dakota Connection**

ND Fossils, ND Heritage Museum
### BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Construct an explanation based on evidence that the process of biological evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Emphasis is on using evidence to explain the influence each of the four factors has on the 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 could include mathematical models such as simple distribution graphs and proportional reasoning.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Assessment Boundary</th>
<th>Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LS4.B: Natural Selection</strong>&lt;br&gt;-Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information — that is, trait variation — that leads to differences in performance among individuals.</td>
<td><strong>1. Asking questions and defining problems</strong>&lt;br&gt;<strong>2. Developing and using models</strong>&lt;br&gt;<strong>3. Planning and carrying out investigations</strong>&lt;br&gt;<strong>4. Analyzing and interpreting data</strong>&lt;br&gt;<strong>5. Using mathematical and computational thinking</strong>&lt;br&gt;<strong>6. Constructing explanations and designing solutions</strong>&lt;br&gt;- Construct an explanation based on valid and reliable evidence obtained from a variety of sources and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.</td>
<td><strong>Cause and Effect</strong>&lt;br&gt;-Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes.</td>
</tr>
<tr>
<td><strong>LS4.C: Adaptation</strong>&lt;br&gt;-Evolution is a consequence of the interaction of four factors: (1) Variations, (2) Overpopulation, (3) Adaptations, (4) Descent with modification.</td>
<td><strong>7. Engaging in argument from evidence</strong>&lt;br&gt;<strong>8. Obtaining, evaluating, and communicating information</strong></td>
<td></td>
</tr>
</tbody>
</table>

| North Dakota Connection | ND Fossils, ND Heritage Museum |
**BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use mathematical models to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.</th>
</tr>
</thead>
</table>

**Clarification Statement**
- Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.

**Assessment Boundary**
- Assessment is limited to graphical analysis. Assessment does not include allele frequency calculations.

### Disciplinary Core Ideas
- **LS4.B: Natural Selection**
  - The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.

- **LS4.C: Adaptation**
  - Adaptation also means that the distribution of traits in a population can change when conditions change.

### Science & Engineering Practices
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
   - Apply concepts of statistics and probability to scientific and engineering questions and problems, using digital tools when feasible.
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts
- **Patterns**
  - Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
Performance Standard HS-LS4-4 | Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

**Clarification Statement**

Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.

**Assessment Boundary**

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **LS4.C: Adaptation**   | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
   - Apply concepts of statistics and probability to scientific and engineering questions and problems, using digital tools when feasible.  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information  | **Cause and Effect**  
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. |

**North Dakota Connection**

Salt-tolerant plants and animals in sodic/saline depressions. Animals and plants adapted to cold winters. Department of Fish & Wildlife, Natural Resource Conservation Service, ND Colleges and Universities.
### Performance Standard
**HS-LS4-5**
Evaluate the evidence supporting claims that changes in environmental conditions may result in increases in the number of individuals of some species, the emergence of new species over time, and the extinction of other species.

### Clarification Statement
Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.

### Assessment Boundary

#### Disciplinary Core Ideas
- **LS4.C: Adaptation**
  - Changes in the physical environment contribute to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline — and sometimes the extinction — of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species’ evolution is lost.

#### Science & Engineering Practices
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
   - Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.
8. Obtaining, evaluating, and communicating information

#### Crosscutting Concepts
- **Cause and Effect**
  - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

### North Dakota Connection
### Performance Standard HS-LS4-6

**Design and revise a solution to mitigate adverse impacts of human activity on biodiversity.**

| Clarification Statement | Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species. |

**Assessment Boundary**

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Changes in the physical environment lead to changes in species diversity and distribution.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LS4.D: Biodiversity and Humans</strong></td>
<td>6. Constructing explanations and designing solutions</td>
<td>- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</td>
</tr>
<tr>
<td>- Human activity has adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ETS1.B: Developing Possible Solutions</strong></td>
<td>7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information</td>
<td></td>
</tr>
<tr>
<td>- When evaluating solutions, such as restoration, conservation, and preservation, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.</td>
<td></td>
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</tbody>
</table>

**North Dakota Connection**

Restoration of ecosystems, such as prairies and wetlands, Department of Fish & Wildlife, Natural Resource Conservation Service, ND Colleges and Universities, Local, regional and state governments. Reclamation of coal mines, US Bureau of Reclamation.
CHEMISTRY
<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>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.</th>
</tr>
</thead>
</table>

**Clarification Statement**

**Physical Science:** Examples of properties that could be predicted from patterns could include metals, nonmetals, metalloids, number of valence electrons, types of bonds formed, or atomic mass. Emphasis is on main group elements.

**Chemistry:** Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, atomic radius, atomic mass, or reactions with oxygen. Emphasis is on main group elements and qualitative understanding of the relative trends of ionization energy and electronegativity.

**Assessment Boundary**

Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.

**Disciplinary Core Ideas**

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
   - Use a model to predict the relationships between systems or between components of a system.
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Patterns**

-Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

**North Dakota Connection**
**Performance Standard HS-PS1-2**

**Construct 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.**

**Clarification Statement**

**Physical Science:** Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or hydrogen and oxygen. Reaction classification includes synthesis, decomposition, single displacement, double displacement, and acid-base.

**Chemistry:** Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or carbon and hydrogen. Reaction classification aids in the prediction of products (e.g. synthesis, decomposition, single displacement, double displacement, and acid-base).

**Assessment Boundary**

Identification of the main types of chemical reactions (single replacement, double replacement, synthesis, decomposition, composition).

**Disciplinary Core Ideas**

**PS1.A: Structure and Properties of Matter**

- The periodic table orders elements horizontally by the number of protons in the atom’s nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

**PS1.B: Chemical Reactions**

- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
   - Construct and revise an explanation based on valid and reliable evidence.
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

**North Dakota Connection**
## MATTER AND ITS INTERACTIONS

<table>
<thead>
<tr>
<th>Performance Standard HS-PS1-3</th>
<th>Plan and conduct an investigation to gather evidence to compare the structure of substances at the macro scale to infer the strength of electrical forces between particles.</th>
</tr>
</thead>
</table>

### Clarification Statement

**Chemistry:** 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 macro properties of substances could include the melting point and boiling point, vapor pressure, and surface tension. Quantitative calculations are beyond the scope of this standard.

### Assessment Boundary

### Disciplinary Core Ideas

**PS1.A: Structure and Properties of Matter**
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
   - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence.
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Patterns**
- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

### North Dakota Connection
### Matter and Its Interactions

| Performance Standard HS-PS1-4 | 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. |

| Clarification Statement | Chemistry: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved. |

| Assessment Boundary | Assessment does not include bond energy calculations. |

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>- A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.</td>
<td>2. Developing and using models</td>
<td>- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.</td>
</tr>
<tr>
<td>PS1.B: Chemical Reactions</td>
<td>3. Planning and carrying out investigations</td>
<td>-</td>
</tr>
<tr>
<td>- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.</td>
<td>4. Analyzing and interpreting data</td>
<td></td>
</tr>
<tr>
<td>5. Using mathematical and computational thinking</td>
<td>6. Constructing explanations and designing solutions</td>
<td></td>
</tr>
<tr>
<td>7. Engaging in argument from evidence</td>
<td>8. Obtaining, evaluating, and communicating information</td>
<td></td>
</tr>
</tbody>
</table>

| North Dakota Connection |
### MATTER AND ITS INTERACTIONS

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Apply scientific principles and evidence to provide an explanation about the effects of the reacting particles on the rate at which a reaction occurs.</th>
</tr>
</thead>
</table>

| Clarification Statement | Physical Science: Emphasis is on relating factors such as temperature and concentration to reaction rate qualitatively.  
Chemistry: Emphasis is on relating factors such as temperature and concentration to reaction rate quantitatively. Catalysts and inhibitors in a qualitative understanding. |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|

<table>
<thead>
<tr>
<th>Assessment Boundary</th>
<th>Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **PS1.B: Chemical Reactions** |asking questions and defining problems  
developing and using models  
planning and carrying out investigations  
analyzing and interpreting data  
using mathematical and computational thinking  
applying scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.  
engaging in argument from evidence  
obtaining, evaluating, and communicating information | **Patterns**  
different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. |

| North Dakota Connection | Pipeline chemistry, water treatment, power plant scrubbers |  

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<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.</th>
</tr>
</thead>
</table>

**Clarification Statement**

**Chemistry:** Emphasis is on the application of Le Chatelier’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. This standard includes one variable at a time and does not include calculating equilibrium constants and concentrations.

**Assessment Boundary**

**Disciplinary Core Ideas**

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
   - Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**North Dakota Connection**
# HS-PS1-7

## MATTER AND ITS INTERACTIONS

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.</th>
</tr>
</thead>
</table>

### Clarification Statement

**Physical Science:** Emphasis is on using mathematical ideas as they relate to balancing reactions to communicate the proportional relationships between masses of atoms in the reactants and the products. Emphasis is on assessing students’ use of mathematical thinking and not on memorization. **Chemistry:** Emphasis is on using mathematical ideas as they relate to balancing reactions and stoichiometry to communicate the proportional relationships between masses of atoms in the reactants and the products. Emphasis is on assessing students’ use of mathematical thinking and not on memorization.

### Assessment Boundary

Assessment is limited to balancing chemical equations. Assessment does not include complex reactions.

### Disciplinary Core Ideas

**PS1.B: Chemical Reactions**

-The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
   - Use mathematical representations of phenomena to support claims.
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Energy and Matter**

-The total amount of energy and matter in closed systems is conserved.

### North Dakota Connection

<table>
<thead>
<tr>
<th>169</th>
<th></th>
</tr>
</thead>
</table>

ND Science Standards
### Performance Standard HS-PS1-8
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.

**Clarification Statement**

**Physical Science:** Emphasis is only qualitative understanding between fission and fusion.

**Chemistry:** Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations as well as alpha, beta, and gamma radioactive decays.

**Assessment Boundary**
Assessment is limited to qualitative understanding of fission and fusion.

### Disciplinary Core Ideas
**PS1.C: Nuclear Processes**
- Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
   - Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Construction explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts
**Energy and Matter**
- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.
HS-PS2-6

MOTION AND STABILITY: FORCES AND INTERACTIONS

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Chemistry: 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.

**Assessment Boundary**

**Disciplinary Core Ideas**

PS2.B: Types of Interactions
- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
   - Communicate scientific and technical information (e.g., about the process of development and the design and performance of a proposed process or system) in multiple formats (including oral, graphical, textual and mathematical).

**Crosscutting Concepts**

Structure and Function
- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

**North Dakota Connection**
Performance Standard

**HS-PS3-1**

Create a mathematical 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 and out of the system are known.

**Clarification Statement**

**Physical Science:** Emphasis is on basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and potential energy.

**Chemistry:** Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations, systems of two or three components, and thermal energy.

**Physics:** Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations; systems of two or three components; and thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.

**Assessment Boundary**

Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and potential energy.

**Disciplinary Core Ideas**

**PS3.A: Definitions of Energy**
-A system’s total energy is conserved within its system and surroundings.

**PS3.B: Conservation of Energy and Energy Transfer**
-Energy cannot be created or destroyed, but it can be transferred. Mathematical expressions, including potential and kinetic energy, allow the concept of conservation of energy to be used to describe a system. The availability of energy limits what can occur in any system.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
   - Create a computational model or simulation of a phenomenon, designed device, process, or a system
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**Systems and System Models**
-Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

**North Dakota Connection**
<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop and use models to illustrate that energy is associated with motion and relative position of particles (objects).</th>
</tr>
</thead>
</table>

### Clarification Statement

**Physical Science:** Emphasis is on energy associated with the different states of matter.  
**Chemistry:** Emphasis on phenomena relating to the Kinetic Molecular Theory in all phases of matter. Possible models include diagrams, drawings, descriptions, and computer simulations.  
**Physics:** Emphasis on phenomena relating to the Kinetic Molecular Theory in all phases of matter. Possible models include diagrams, drawings, descriptions, and computer simulations.

### Assessment Boundary

Does not include quantitative calculations and limited to energy associated with solids, liquids, and gases.

### Disciplinary Core Ideas

**PS3.A: Definitions of Energy**
- Energy cannot be created or destroyed, but it can be transferred.  
- Energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.  
- Energy can be modeled as a combination of energy associated with the motion and relative position of particles. In some cases, the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

### Science & Engineering Practices

1. Asking questions and defining problems  
2. Developing and using models  
   - Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Energy and Matter**
- Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.

### North Dakota Connection
## HS-PS3-3

### PERFORMANCE STANDARD

**HS-PS3-3**  
Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

### CLARIFICATION STATEMENT

**Physical Science:** Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, generators, and types of circuits.

**Chemistry:** Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Examples of devices in chemistry could include hot/cold packs and batteries.

**Physics:** Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Examples of devices in physics could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and electric motors.

### ASSESSMENT BOUNDARY

Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.

### DISCIPLINARY CORE IDEAS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.</td>
<td>- Although energy cannot be destroyed, it can be converted to less useful forms.</td>
<td>- Criteria and constraints also include satisfying any requirements set by society.</td>
</tr>
</tbody>
</table>

### SCIENCE & ENGINEERING PRACTICES

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

### CROSSCUTTING CONCEPTS

**Energy and Matter**  
- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

### NORTH DAKOTA CONNECTION

North Dakota wind energy, Garrison Dam, ND Solar Farms
**Performance Standard HS-PS3-4**

Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

**Clarification Statement**

**Physical Science/Chemistry/Physics:** Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes conceptually (Chemistry & Physics includes quantitative analysis). Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.

**Assessment Boundary**

Assessment is limited to investigations based on materials and tools provided to students and is limited to qualitative only.

### Disciplinary Core Ideas

**PS3.B: Conservation of Energy and Energy Transfer**

- Energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.

**PS3.D: Energy in Chemical Processes**

- Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding environment.

**ETS1.A: Defining and Delimiting an Engineering Problem**

- Criteria and constraints also include satisfying any requirements set by society.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
   - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements.
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**Systems and System Models**

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

### North Dakota Connection
**HS-PS4-1**

**WAVES AND THEIR APPLICATIONS IN TECHNOLOGIES FOR INFORMATION TRANSFER**

<table>
<thead>
<tr>
<th>Performance Standard HS-PS4-1</th>
<th>Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.</th>
</tr>
</thead>
</table>

**Clarification Statement**

**Physical Science/Chemistry/Physics**: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.

**Assessment Boundary**

Assessment is limited to algebraic relationships and describing those relationships qualitatively. (Physical science limited to qualitative only)

**Disciplinary Core Ideas**

**PS4.A: Wave Properties**

- The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
   - Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**Cause and Effect**

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

**North Dakota Connection**
<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Construct an explanation using evidence to support the idea that electromagnetic radiation can be described by a wave model and a particle model.</th>
</tr>
</thead>
</table>

**Clarification Statement**

Chemistry/Physics: 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.

**Assessment Boundary**

Assessment does not include using quantum theory

**Disciplinary Core Ideas**

**PS4.A: Wave Properties**
-Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only.)

**PS4.B: Electromagnetic Radiation**
-Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
   - Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

Systems and System Models
-Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions-including energy, matter, and information flows—within and between systems at different scales.

**North Dakota Connection**
EARTH & SPACE SCIENCE
## Performance Standard
### HS-ESS1-1

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 in the form of radiation.

### Clarification Statement

**Earth Science:** Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun’s core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun’s radiation varies due to sudden solar flares (“space weather”), the 11-year sunspot cycle, and non-cyclic variations over centuries.

### Assessment Boundary

Assessment does not include details of the atomic and sub-atomic processes involved with the sun’s nuclear fusion.

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### Disciplinary Core Ideas

**ESS1.A: The Universe and Its Stars**
- The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.

**PS3.D: Energy in Chemical Processes and Everyday Life**
- Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary)

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
   - Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Scale, Proportion, and Quantity**
- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

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**North Dakota Connection**
## EARTH’S PLACE IN THE UNIVERSE

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Construct an explanation for the observed expansion of the known universe based on astronomical evidence of light spectra, motion of distant galaxies, cosmic background radiation, and composition of matter in the universe.</th>
</tr>
</thead>
</table>

### Clarification Statement

**Earth Science:** Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, which led to the formulation of the Big Bang and other theories.

### Assessment Boundary

### Disciplinary Core Ideas

**ESS1.A: The Universe and Its Stars**
- The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.
- Nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.

**PS4.B: Electromagnetic Radiation**
- Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary)

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking

### Crosscutting Concepts

**Energy and Matter**
- Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems.

### North Dakota Connection
### HS-ESS1-3

#### EARTH’S PLACE IN THE UNIVERSE

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Communicate scientific ideas about the way stars, over their life cycle, produce elements.</th>
</tr>
</thead>
</table>

#### Clarification Statement

| Earth Science: 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. |

#### Assessment Boundary

| Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed. |

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **ESS1.A: The Universe and Its Stars** | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
   • Construct an explanation based on valid and reliable evidence  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | **Energy and Matter**  
-In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. |

**North Dakota Connection**
## HS-ESS1-4

### EARTH’S PLACE IN THE UNIVERSE

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Earth Science/Physics: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Mathematical representations for the gravitational attraction of bodies and Kepler’s laws of orbital motions should not deal with more than two bodies, nor involve calculus.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESS1.A: The Universe and Its Stars</td>
<td>1. Asking questions and defining problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Developing and using models</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Planning and carrying out investigations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Analyzing and interpreting data</td>
<td></td>
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<tr>
<td></td>
<td>5. Using mathematical and computational thinking</td>
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</tr>
<tr>
<td></td>
<td>• Use mathematical or computational representations of phenomena to describe explanations.</td>
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<td>6. Constructing explanations and designing solutions</td>
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<td></td>
<td>7. Engaging in argument from evidence</td>
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<tr>
<td></td>
<td>8. Obtaining, evaluating, and communicating information</td>
<td></td>
</tr>
<tr>
<td>Scale, Proportion, and Quantity</td>
<td>Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).</td>
<td></td>
</tr>
</tbody>
</table>

| North Dakota Connection |
**Performance Standard HS-ESS1-5**  
Evaluate 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.

**Clarification Statement**

**Earth Science/Geology:** Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages of oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and 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).

**Assessment Boundary**

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **ESS1.C: The History of Planet Earth**  
-Continental rocks are generally much older than the rocks of the ocean floor. | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. **Engaging in argument from evidence**  
- Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments.  
8. Obtaining, evaluating, and communicating information | **Patterns**  
- Empirical evidence is needed to identify patterns. |
| **ESS2.B: Plate Tectonics and Large-Scale System Interactions**  
-Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth’s surface and provides a framework for understanding its geologic history. | |
| **PS1.C: Nuclear Processes**  
-Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. | |

**North Dakota Connection**

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### HS-ESS1-6

#### EARTH’S PLACE IN THE UNIVERSE

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>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.</th>
</tr>
</thead>
</table>

**Clarification Statement**

**Earth Science/Geology:** Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth. Examples of evidence include the absolute ages of ancient materials (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.

**Assessment Boundary**

**Disciplinary Core Ideas**

- ESS1.C: The History of Planet Earth
  - Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little. Studying these objects can provide information about Earth’s formation and early history.

- PS1.C: Nuclear Processes
  - Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. **Constructing explanations and designing solutions**
   - Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

- **Stability and Change**
  - Much of science deals with constructing explanations of how things change and how they remain stable.

**North Dakota Connection**

184
### Earth’s Systems

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>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.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Earth Science: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment does not include memorization of the details of the formation of specific geographic features of Earth’s surface.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESS2.A: Earth Materials and Systems</td>
<td>1. Asking questions and defining problems 2. Developing and using models  • Using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematical and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information</td>
<td>Stability and Change - Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.</td>
</tr>
<tr>
<td>ESS2.B: Plate Tectonics and Large-Scale System Interactions</td>
<td>- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth’s surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth’s crust.</td>
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</table>

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
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<tbody>
<tr>
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<tr>
<td>Performance Standard</td>
<td>Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.</td>
</tr>
</tbody>
</table>

**Clarification Statement**

**Earth Science/Environmental Science:** Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could 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.

**Assessment Boundary**

**Disciplinary Core Ideas**

- ESS2.A: Earth Materials and Systems
  - Earth’s systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

- ESS2.D: Weather and Climate
  - The foundation for Earth’s global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
   - Introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

- Stability and Change
  - Feedback (negative or positive) can stabilize or destabilize a system.

**North Dakota Connection**

Wildfires in the west affect air quality, sunlight reaching the soil surface, and temperatures in ND. Land use changes in response to Federal programs, such as the Conservation Reserve Program. Effects of changing climate, such as shifts in the pathway of the Jetstream. U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA)
**HS-ESS2-3**

### Earth’s Systems

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop a model based on evidence of Earth’s interior to describe the cycling of matter by thermal convection.</th>
</tr>
</thead>
</table>

**Clarification Statement**

**Earth Science**: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth’s three-dimensional structure obtained from seismic waves, records of the rate of change of Earth’s magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth’s layers from high-pressure laboratory experiments.

**Assessment Boundary**

**Disciplinary Core Ideas**

**ESS2.A: Earth Materials and Systems**
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth’s surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust.

**ESS2.B: Plate Tectonics and Large-Scale System Interactions**
- The radioactive decay of unstable isotopes continually generates new energy within Earth’s crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
   - Developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**Energy and Matter**
- Energy drives the cycling of matter within and between systems.

**North Dakota Connection**
**Performance Standard HS-ESS2-4**

Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate.

---

**Clarification Statement**

*Earth Science*: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; and 10-100s of thousands of years: changes to Earth’s orbit and the orientation of its axis.

**Assessment Boundary**

Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.

---

**Disciplinary Core Ideas**

**ESS1.B: Earth and the Solar System**
- Cyclical changes in the shape of Earth’s orbit, along with changes in the tilt of the planet’s axis of rotation have altered the intensity and distribution of sunlight falling on the earth.

**ESS2.A: Earth Materials and System**
- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun’s energy output or Earth’s orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities.

**ESS2.D: Weather and Climate**
- The foundation for Earth’s global climate systems is the electromagnetic radiation from the sun.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
   - Using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**Cause and Effect**
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

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**North Dakota Connection**


## Earth’s Systems

### Performance Standard

**HS-ESS2-5**

Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

### Clarification Statement

**Earth Science/Environmental Science:** 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 include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations 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).

### Assessment Boundary

**Disciplinary Core Ideas**

**ESS2.C: The Roles of Water in Earth’s Surface Processes**

- The abundance of liquid water on Earth’s surface and its unique combination of physical and chemical properties are central to the planet’s dynamics. These properties include water’s exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
   - Builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**Structure and Function**

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

### North Dakota Connection
## Earth’s Systems

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.</th>
</tr>
</thead>
</table>

### Clarification Statement

**Earth Science/Environmental Science:** Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.

### Assessment Boundary

### Disciplinary Core Ideas

- **ESS2.D: Weather and Climate**
  - Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
   - Using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

- **Energy and Matter**
  - The total amount of energy and matter in closed systems is conserved.

### North Dakota Connection
## HS-ESS2-7

### Performance Standard

**HS-ESS2-7**

Construct an argument based on evidence about the simultaneous coevolution of Earth’s systems and life on Earth.

### Clarification Statement

**Earth Science:** Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth’s other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth’s surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.

### Assessment Boundary

Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth’s other systems.

### Disciplinary Core Ideas

- **ESS2.D: Weather and Climate**
  - Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.

- **ESS2.E Biogeology**
  - The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth’s surface and the life that exists on it.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions

### Crosscutting Concepts

- **Stability and Change**
  - Much of science deals with constructing explanations of how things change and how they remain stable.

### North Dakota Connection
### EARTH AND HUMAN ACTIVITY

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>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.</th>
</tr>
</thead>
</table>

#### Clarification Statement

**Earth Science/Environmental Science:** Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.

#### Assessment Boundary

#### Disciplinary Core Ideas

**ESS3.A: Natural Resources**
- Resource availability has guided the development of human society.

**ESS3.B: Natural Hazards**
- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.

#### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
   - Construct an explanation based on valid and reliable evidence
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

#### Crosscutting Concepts

**Cause and Effect**
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

#### North Dakota Connection

ND receives less water from precipitation than is lost to the atmosphere in the form of evaporation and transpiration. This is compensated for in industry, including agriculture, by sourcing groundwater and surface water from rivers (which essentially bring water from out-of-state into ND). Also, the west of ND is drier than the east. As a result, crops are grown east, while in the west of ND, cattle ranching is more prevalent. ND Department of Health (Water Division), Agricultural extension, Natural Resources Conservation Service (NRCS), US Army Corps of Engineers
**HS-ESS3-2**

**EARTH AND HUMAN ACTIVITY**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th><strong>Earth Science/Environmental Science</strong>: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.</th>
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<table>
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<tr>
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<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESS3.A: Natural Resources</strong>&lt;br&gt;-Resource availability has guided the development of human society.</td>
<td>1. Asking questions and defining problems&lt;br&gt;2. Developing and using models&lt;br&gt;3. Planning and carrying out investigations&lt;br&gt;4. Analyzing and interpreting data&lt;br&gt;5. Using mathematical and computational thinking&lt;br&gt;6. Constructing explanations and designing solutions&lt;br&gt;7. Engaging in argument from evidence&lt;br&gt;• Evaluate competing design solutions to a real-world problem&lt;br&gt;8. Obtaining, evaluating, and communicating information</td>
<td><strong>Influence of Science, Engineering, and Technology on Society and the Natural World</strong>&lt;br&gt;-Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. Analysis of costs and benefits is a critical aspect of decisions about technology.</td>
</tr>
</tbody>
</table>

| **ESS3.B: Natural Hazards**<br>-Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. | | |

| North Dakota Connection | **No-till, minimum till practices in agriculture, coal mining, oil and gas exploration, solar and wind energy. NRCS, Ag extension, ND Dept. of Health, ND lignite council, oil and gas companies, alternative energy companies.** | | | |
## HS-ESS3-3

### EARTH AND HUMAN ACTIVITY

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Analyze the relationships among management of natural resources, the sustainability of human populations, and biodiversity through the use of a computational simulation.</th>
</tr>
</thead>
</table>

### Clarification Statement

**Earth Science/Environmental Science:** Examples of factors that affect the management of natural resources include costs of resource extraction, processing, and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.

### Assessment Boundary

Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.

### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>Science &amp; Engineering Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESS3.A: Natural Resources</strong></td>
</tr>
<tr>
<td>- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.</td>
</tr>
<tr>
<td><strong>ETS1.B: Developing Possible Solutions</strong></td>
</tr>
<tr>
<td>- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stability and Change</strong></td>
</tr>
<tr>
<td>- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.</td>
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</tbody>
</table>

### North Dakota Connection

No-till, minimum till practices in agriculture, coal mining, oil and gas exploration, solar and wind energy. Natural Resources Conservation Service (NRCS), Ag extension, ND Dept. of Health, ND lignite council, oil and gas companies, alternative energy companies.
### EARTH AND HUMAN ACTIVITY

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS-ESS3-4</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**

Earth Science/Environmental Science: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future 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).

**Assessment Boundary**

**Disciplinary Core Ideas**

- **ESS3.A: Natural Resources**
  - Resource availability has guided the development of human society.

- **ESS3.B: Natural Hazards**
  - Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
   - Construct an explanation based on valid and reliable evidence
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

- Cause and Effect
  - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

**North Dakota Connection**

ND receives less water from precipitation than is lost to the atmosphere in the form of evaporation and transpiration. This is compensated for in industry, including agriculture, by sourcing groundwater and surface water from rivers (which essentially bring water from out-of-state into ND). Also, the west of ND is drier than the east. As a result, crops are grown east, while in the west of ND, cattle ranching is more prevalent. ND Department of Health (Water Division), Agriculture extension, Natural Resources Conservation Service (NRCS), US Army Corps of Engineers
### Performance Standard

**HS-ESS3-5**

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 systems.

### Clarification Statement

**Earth Science/Environmental Science:** Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).

### Assessment Boundary

Assessment is limited to one example of a climate change and its associated impacts.

### Disciplinary Core Ideas

**ESS3.D: Global Climate Change**

- Even though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
   - Analyze data using computational models in order to make valid and reliable scientific claims
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Stability and Change**

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

### North Dakota Connection

Connect the effects of climate change on ND land uses. International Panel for Climate Change, National Oceanic and Atmospheric Administration (NOAA), Natural Resources Conservation Service (NRCS)
# HS-ESS3-6

## EARTH AND HUMAN ACTIVITY

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use data from computational representations to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.</th>
</tr>
</thead>
</table>

### Clarification Statement

**Earth Science/Environmental Science:** Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere.

### Assessment Boundary

Assessment does not include running computational representations but is limited to using the published results of scientific computational models.

### Disciplinary Core Ideas

#### ESS2.D: Weather and Climate
- Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise for the foreseeable future.

#### ESS3.D: Global Climate Change
- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
   - Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Systems and System Models**
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

### North Dakota Connection

Effects of climate change on ND land uses, International Panel for Climate Change, National Oceanic and Atmospheric Administration (NOAA), National Resources Conservation Service (NRCS)
ENVIRONMENTAL SCIENCE
**HS-LS1-2**

**FROM MOLECULES TO ORGANISM: STRUCTURES AND PROCESSES**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.</th>
</tr>
</thead>
</table>

**Clarification Statement**

*Earth Science/Environmental Science:* 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 could be 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.

**Assessment Boundary**

Assessment does not include interactions and functions at the molecular or chemical reaction level.

**Disciplinary Core Ideas**

<table>
<thead>
<tr>
<th>Science &amp; Engineering Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Asking questions and defining problems</td>
</tr>
<tr>
<td>2. Developing and using models</td>
</tr>
<tr>
<td>3. Planning and carrying out investigations</td>
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<tr>
<td>4. Analyzing and interpreting data</td>
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<tr>
<td>5. Using mathematical and computational thinking</td>
</tr>
<tr>
<td>6. Constructing explanations and designing solutions</td>
</tr>
<tr>
<td>7. Engaging in argument from evidence</td>
</tr>
<tr>
<td>8. Obtaining, evaluating, and communicating information</td>
</tr>
</tbody>
</table>

**Crosscutting Concepts**

*Systems and System Models*  
- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

**North Dakota Connection**
## ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use mathematical and/or computational models to support explanations of factors that affect carrying capacity of ecosystems at different scales.</th>
</tr>
</thead>
</table>

### Clarification Statement

**Earth Science/Environmental Science:** Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from computer simulations or historical data sets.

### Assessment Boundary

Assessment does not include deriving mathematical equations to make comparisons.

### Disciplinary Core Ideas

- **LS2.A: Interdependent Relationships in Ecosystems**
  - Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. **Using mathematical and computational thinking**
   - Use mathematical representation of phenomena or design solutions to support and revise explanations.
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

- **Scale, Proportion, and Quantity**
  - The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

### North Dakota Connection

Leafy spurge in rangeland reduces carrying capacity, e.g. cattle numbers, also zebra mussels and carp. ND Fish and Game, ND Colleges and Universities, Natural Resource Conservation Service (NRCS).
### Performance Standard

**HS-LS2-2**

Use evidence from mathematical representations to explain factors that affect population dynamics and biodiversity.

### Clarification Statement

**Earth Science/Environmental Science:** Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.

### Assessment Boundary

Assessment is limited to provided data.

### Disciplinary Core Ideas

**LS2.A: Interdependent Relationships in Ecosystems**

-Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease.

**LS2.C: Ecosystem Dynamics, Functioning, and Resilience**

-Interactions within an ecosystem can keep its organisms relatively constant under stable conditions. A change in the ecosystem can create a change in populations.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
   - Use mathematical representation of phenomena or design solutions to support and revise explanations.
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Scale, Proportion, and Quantity**

-Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

### North Dakota Connection

Leafy spurge in rangeland reduces carrying capacity, e.g. cattle numbers, also zebra mussels and carp. ND Fish and Game, ND Colleges and Universities, Natural Resource Conservation Service, Forestry Service (NRCS).
**HS-LS2-3**  
**ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.</th>
</tr>
</thead>
</table>

**Clarification Statement**  
Earth Science/Environmental Science: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.

**Assessment Boundary**  
Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| LS2.B: Cycles of Matter and Energy Transfer in Ecosystems | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
   - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, and peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | Energy and Matter  
- Energy drives the cycling of matter within and between systems. |

**North Dakota Connection**
Performance Standard | Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
--- | ---

**Clarification Statement**

**Earth Science/Environmental Science:** Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.

**Assessment Boundary**

Assessment is limited to conceptual reasoning to describe the cycling of matter and flow of energy.

**Disciplinary Core Ideas**  
**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems**  
- The chemical elements that make up the molecules of organisms pass through food webs (10% rule) and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.

**Science & Engineering Practices**

1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. **Using mathematical and computational thinking**  
   - Use mathematical representations of phenomena or design solutions to support claims.  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**Energy and Matter**  
- Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.

**North Dakota Connection**
### ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Earth Science/Environmental Science: Examples of models could include simulations and mathematical models.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment does not include the specific chemical steps of photosynthesis and respiration.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| LS2.B: Cycles of Matter and Energy Transfer in Ecosystems | 1. Asking questions and defining problems 2. Developing and using models  
  - Develop a model based on evidence to illustrate the relationships between systems or components of a system. 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematical and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information | Systems and System Models  
- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions — including energy, matter and information flows — within and between systems at different scales. |

| North Dakota Connection | | |
**Performance Standard HS-LS2-6**

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.

**Clarification Statement**

**Earth Science/Environmental Science:** Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise, that occur at different rates.

**Assessment Boundary**

Assessment is limited to provided data.

**Disciplinary Core Ideas**

**LS2.C: Ecosystem Dynamics, Functioning, and Resilience**

- Interactions within an ecosystem can keep its organisms relatively constant under stable conditions. A change in the ecosystem can create a change in populations.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
   - Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**Stability and Change**

- Much of science deals with constructing explanations of how things change and how they remain stable.

**North Dakota Connection**

ND Fish and Game, ND Colleges and Universities, Natural Resource Conservation Service (NRCS), Forestry Service
### Performance Standard

**HS-LS2-7**

**ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

| Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. |

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### Clarification Statement

**Earth Science/Environmental Science:** Examples of human activities can include urbanization, building dams, and dissemination of invasive species.

### Assessment Boundary

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### Disciplinary Core Ideas

**LS2.C: Ecosystem Dynamics, Functioning, and Resilience**

- Human activity in the environment can disrupt an ecosystem. — including habitat destruction, pollution, introduction of invasive species, overexploitation, climate change, restoration, conservation, and preservation.

**LS4.D: Biodiversity and Humans**

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
   - Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations landscapes of recreational or inspirational value.
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Stability and Change**

- Much of science deals with constructing explanations of how things change and how they remain stable.

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### North Dakota Connection

**ND Fish and Game, ND Colleges and Universities, Natural Resource Conservation Service (NRCS), Forestry Service, River Keepers**
**ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Evaluate the evidence for the role of group behavior on individual and species’ chances to survive and reproduce.</th>
</tr>
</thead>
</table>

| Clarification Statement | Earth Science/Environmental Science: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming. |

| Assessment Boundary |

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| LS2.D: Social Interactions and Group Behavior | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
   - Evaluate the evidence behind currently accepted explanations to determine the merits of arguments.  
8. Obtaining, evaluating, and communicating information | Cause and Effect  
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. |

| North Dakota Connection | ND Fish and Game, ND Colleges and Universities, Natural Resource Conservation Service (NRCS) |
**BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Evaluate the evidence supporting claims that changes in environmental conditions may result in increases in the number of individuals of some species, the emergence of new species over time, and the extinction of other species.</th>
</tr>
</thead>
</table>

**Clarification Statement**

**Earth Science/Environmental Science:** Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.

**Assessment Boundary**

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
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</tr>
</thead>
</table>

**North Dakota Connection**

Increasing demand for water. Reduction in wetlands and prairies due to agricultural activities and increased demand for water. Department of Fish & Wildlife, Natural Resources Conservation (NRCS), ND Colleges and Universities, local, regional and state governments.
## BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY

### Performance Standard
**HS-LS4-6**

**Design and revise a solution to mitigate adverse impacts of human activity on biodiversity.**

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Earth Science/Environmental Science: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.</th>
</tr>
</thead>
</table>

### Assessment Boundary

### Disciplinary Core Ideas

| LS4.C: Adaptation | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
   - Create or revise a simulation of a phenomenon, designed device, process, or system.  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

<table>
<thead>
<tr>
<th>LS4.D: Biodiversity and Humans</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| - Human activity has adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. | Cause and Effect  
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. |

### ETS1.B: Developing Possible Solutions

- When evaluating solutions, such as restoration, conservation, and preservation, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

### North Dakota Connection

| Restoration of ecosystems, such as prairies and wetlands. Department of Fish & Wildlife, Natural Resources Conservation Service (NRCS), ND Colleges and Universities, local, regional and state governments. Reclamation of coal mines, US Bureau of Reclamation. | 209 |
**Earth’s Systems**

| Performance Standard | Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. |

**Clarification Statement**

*Earth Science/Environmental Science: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could 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.*

**Assessment Boundary**

**Disciplinary Core Ideas**

**ESS2.A: Earth Materials and Systems**
- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

**ESS2.D: Weather and Climate**
- The foundation for Earth’s global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's reradiation into space.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
   - Introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**Stability and Change**
- Feedback (negative or positive) can stabilize or destabilize a system.

**North Dakota Connection**

Wildfires in the west affect air quality, sunlight reaching the soil surface, and temperatures in ND. Land use changes in response to Federal programs, such as the Conservation Reserve Program. Effects of changing climate, such as shifts in the pathway of the Jetstream. U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA).
Earth’s Systems

**Performance Standard**

| HS-ESS2-5 | Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. |

**Clarification Statement**

Earth Science/Environmental Science: 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 include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations 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).

**Assessment Boundary**

**Disciplinary Core Ideas**

- ESS2.C: The Roles of Water in Earth’s Surface Processes
  - The abundance of liquid water on Earth’s surface and its unique combination of physical and chemical properties are central to the planet’s dynamics. These properties include water’s exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
   - Builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

Structure and Function
- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

**North Dakota Connection**

Extensive snow cover delays warming in spring. Ice formation speeds up erosion of rocks, increases sediment formation. Formation of ND landscape due to Ice Ages. U.S. Geological Survey (USGS), use of stream tables to demonstrate meandering of rivers and formation of other river characteristics, like sorting of sediments.
# Earth’s Systems

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.</th>
</tr>
</thead>
</table>

**Clarification Statement**

**Earth Science/Environmental Science:** Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.

**Assessment Boundary**

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **ESS2.D: Weather and Climate** | 1. Asking questions and defining problems  
2. Developing and using models  
• Using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | **Energy and Matter**  
- The total amount of energy and matter in closed systems is conserved. |

**North Dakota Connection**

General lack of trees in ND impacts Carbon-cycling. Programs, such as i-Tree.
**Performance Standard**

**HS-ESS3-1**

**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.**

<table>
<thead>
<tr>
<th>Clarification Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Science/Environmental Science: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.</td>
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<table>
<thead>
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<th>Assesment Boundary</th>
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</thead>
<tbody>
<tr>
<td>Disciplinary Core Ideas</td>
</tr>
<tr>
<td><strong>ESS3.A: Natural Resources</strong></td>
</tr>
<tr>
<td>-Resource availability has guided the development of human society.</td>
</tr>
<tr>
<td><strong>ESS3.B: Natural Hazards</strong></td>
</tr>
<tr>
<td>-Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.</td>
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<table>
<thead>
<tr>
<th>North Dakota Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>ND receives less water from precipitation than is lost to the atmosphere in the form of evaporation and transpiration. This is compensated for in industry, including agriculture, by sourcing groundwater and surface water from rivers (which essentially bring water from out-of-state into ND). Also, the west of ND is drier than the east. As a result, crops are grown east, while in the west of ND, cattle ranching is more prevalent. ND Department of Health (Water Division), Ag extension, Natural Resources Conservation Service (NRCS), US Army Corps of Engineers.</td>
</tr>
</tbody>
</table>
# EARTH AND HUMAN ACTIVITY

## Performance Standard

**HS-ESS3-2**

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

### Clarification Statement

Earth Science/Environmental Science: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.

### Assessment Boundary

<table>
<thead>
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<tbody>
<tr>
<td>ESS3.A: Natural Resources - Resource availability has guided the development of human society.</td>
</tr>
<tr>
<td>ESS3.B: Natural Hazards - Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.</td>
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<thead>
<tr>
<th>Science &amp; Engineering Practices</th>
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<tbody>
<tr>
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<td>5. Using mathematical and computational thinking</td>
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<tr>
<td>6. Constructing explanations and designing solutions</td>
</tr>
<tr>
<td>7. Engaging in argument from evidence</td>
</tr>
<tr>
<td>- Evaluate competing design solutions to a real-world problem</td>
</tr>
<tr>
<td>8. Obtaining, evaluating, and communicating information</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influence of Science, Engineering, and Technology on Society and the Natural World</td>
</tr>
<tr>
<td>- Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.</td>
</tr>
<tr>
<td>- Analysis of costs and benefits is a critical aspect of decisions about technology.</td>
</tr>
</tbody>
</table>

### North Dakota Connection

No-till, minimum till practices in agriculture, coal mining, oil and gas exploration, solar and wind energy. NRCS, Ag extension, ND Dept. of Health, ND lignite council, oil and gas companies, alternative energy companies.
### Performance Standard HS-ESS3-3

Analyze the relationships among management of natural resources, the sustainability of human populations, and biodiversity through the use of a computational simulation.

### Clarification Statement

**Earth Science/Environmental Science:** Examples of factors that affect the management of natural resources include costs of resource extraction, processing and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.

### Assessment Boundary

Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.

### Disciplinary Core Ideas

| ESS3.A: Natural Resources | 1. Asking questions and defining problems
| 2. Developing and using models
| 3. Planning and carrying out investigations
| 4. Analyzing and interpreting data
| 5. Using mathematical and computational thinking
| 6. Constructing explanations and designing solutions
| 7. Engaging in argument from evidence
| 8. Obtaining, evaluating, and communicating information

| ETS1.B: Developing Possible Solutions | Stability and Change
| - When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.
| - Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

### North Dakota Connection

No-till, minimum till practices in agriculture, coal mining, oil and gas exploration, solar and wind energy. Natural Resources Conservation Service (NRCS), Ag extension, ND Dept. of Health, ND lignite council, oil and gas companies, alternative energy companies.
## Performance Standard

**HS-ESS3-4**

Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

### Clarification Statement

**Earth Science/Environmental Science:** Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future 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).

### Assessment Boundary

### Disciplinary Core Ideas

- **ESS3.C: Human Impacts on Earth Systems**  
  - Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

- **ETS1.B: Developing Possible Solutions**  
  - When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
   - Design or refine a solution to a complex real-world problem
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

- **Stability and Change**  
  - Feedback (negative or positive) can stabilize or destabilize a system.

### North Dakota Connection

- No-till, minimum till practices in agriculture, coal mining, oil and gas exploration, solar and wind energy. Natural Resources Conservation Service (NRCS), Ag extension, ND Dept. of Health, ND lignite council, oil and gas companies, alternative energy companies.
**Performance Standard**  
**HS-ESS3-5**

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 systems.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Science/Environmental Science: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment is limited to one example of a climate change and its associated impacts.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESS3.D: Global Climate Change</strong></td>
</tr>
<tr>
<td>- Even though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Science &amp; Engineering Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Asking questions and defining problems</td>
</tr>
<tr>
<td>2. Developing and using models</td>
</tr>
<tr>
<td>3. Planning and carrying out investigations</td>
</tr>
<tr>
<td>4. Analyzing and interpreting data</td>
</tr>
<tr>
<td>- Analyze data using computational models in order to make valid and reliable scientific claims</td>
</tr>
<tr>
<td>5. Using mathematical and computational thinking</td>
</tr>
<tr>
<td>6. Constructing explanations and designing solutions</td>
</tr>
<tr>
<td>7. Engaging in argument from evidence</td>
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<table>
<thead>
<tr>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stability and Change</strong></td>
</tr>
<tr>
<td>- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.</td>
</tr>
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<table>
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<tr>
<th>North Dakota Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effects of climate change on ND land uses. International Panel for Climate Change, National Oceanic and Atmospheric Administration (NOAA), Natural Resources Conservation Service (NRCS).</td>
</tr>
</tbody>
</table>
## EARTH AND HUMAN ACTIVITY

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use data from computational representations to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS-ESS3-6</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**

Earth Science/Environmental Science: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere.

**Assessment Boundary**

Assessment does not include running computational representations but is limited to using the published results of scientific computational models.

**Disciplinary Core Ideas**

**ESS2.D: Weather and Climate**
- Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise for the foreseeable future.

**ESS3.D: Global Climate Change**
- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
   - Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

Systems and System Models
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

**North Dakota Connection**

Effects of climate change on ND land uses. International Panel for Climate Change, National Oceanic and Atmospheric Administration (NOAA), Natural Resources Conservation Service (NRCS).
PHYSICAL SCIENCE
### MATTER AND ITS INTERACTIONS

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>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.</th>
</tr>
</thead>
</table>

#### Clarification Statement

| Physical Science: | Examples of properties that could be predicted from patterns could include metals, nonmetals, metalloids, number of valence electrons, types of bonds formed, or atomic mass. Emphasis is on main group elements. |
| Chemistry: | Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, atomic radius, atomic mass, or reactions with oxygen. Emphasis is on main group elements and qualitative understanding of the relative trends of ionization energy and electronegativity. |

#### Assessment Boundary

Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.

#### Disciplinary Core Ideas

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
   - Use a model to predict the relationships between systems or between components of a system.
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

#### North Dakota Connection
### HS-PS1-2

**MATTER AND ITS INTERACTIONS**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Construct 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.</th>
</tr>
</thead>
</table>

**Clarification Statement**

**Physical Science:** Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or hydrogen and oxygen. Reaction classification includes synthesis, decomposition, single displacement, double displacement, and acid-base.

**Chemistry:** Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or carbon and hydrogen. Reaction classification aids in the prediction of products (e.g. synthesis, decomposition, single displacement, double displacement, and acid-base).

**Assessment Boundary**

Identification of the main types of chemical reactions (single replacement, double replacement, synthesis, decomposition, composition).

**Disciplinary Core Ideas**

**PS1.A: Structure and Properties of Matter**
- The periodic table orders elements horizontally by the number of protons in the atom’s nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

**PS1.B: Chemical Reactions**
- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
   - Construct and revise an explanation based on valid and reliable evidence
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**Patterns**
- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

**North Dakota Connection**
MATTER AND ITS INTERACTIONS

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Apply scientific principles and evidence to provide an explanation about the effects of the reacting particles on the rate at which a reaction occurs.</th>
</tr>
</thead>
</table>

**Clarification Statement**

**Physical Science:** Emphasis is on relating factors such as temperature and concentration to reaction rate qualitatively.

**Chemistry:** Emphasis is on relating factors such as temperature and concentration to reaction rate quantitatively. Catalysts and inhibitors in a qualitative understanding.

**Assessment Boundary**

Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.

### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>PS1.B: Chemical Reactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.</td>
</tr>
</tbody>
</table>

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
   - Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Patterns**

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

### North Dakota Connection
### MATTER AND ITS INTERACTIONS

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Physical Science: Emphasis is on using mathematical ideas as they relate to balancing reactions to communicate the proportional relationships between masses of atoms in the reactants and the products. Emphasis is on assessing students’ use of mathematical thinking and not on memorization. Chemistry: Emphasis is on using mathematical ideas as they relate to balancing reactions and stoichiometry to communicate the proportional relationships between masses of atoms in the reactants and the products. Emphasis is on assessing students’ use of mathematical thinking and not on memorization.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Assessment Boundary</th>
<th>Assessment is limited to balancing chemical equations. Assessment does not include complex reactions.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>

| North Dakota Connection | |
|-------------------------| |
### MATTER AND ITS INTERACTIONS

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>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.</th>
</tr>
</thead>
</table>

### Clarification Statement

**Physical Science:** Emphasis is only qualitative understanding between fission and fusion.  
**Chemistry:** Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations as well as alpha, beta, and gamma radioactive decays.

### Assessment Boundary

Assessment is limited to qualitative understanding of fission and fusion.

### Disciplinary Core Ideas

**PS1.C: Nuclear Processes**
- Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
   - Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Energy and Matter**
- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

### North Dakota Connection
### Motion and Stability: Forces and Interactions

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.</th>
</tr>
</thead>
</table>

#### Clarification Statement

Physical Science and Physics: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force in one dimension.

#### Assessment Boundary

Assessment is limited to one dimensional motion and to macroscopic objects moving at non-relativistic speeds.

#### Disciplinary Core Ideas

**PS2.A: Forces and Motion**

- Newton’s second law accurately predicts changes in the motion of macroscopic objects.

#### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
   - Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

#### Crosscutting Concepts

**Cause and Effect**
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

#### North Dakota Connection
## Performance Standard

**HS-PS2-2**

Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

### Clarification Statement

| Physical Science | Emphasis is on the quantitative calculations of momentum and the qualitative meaning of conservation of momentum. |
| Physics | Emphasis is on the quantitative calculations of momentum and the qualitative meaning of conservation of momentum. Physics includes the quantitative calculations of conservation of momentum, including inelastic & elastic collisions. |

### Assessment Boundary

Assessment is limited to systems of two macroscopic bodies moving in one dimension.

### Disciplinary Core Ideas

**PS2.A: Forces and Motion**

- Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.
- If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
   - Use mathematical representations of phenomena to describe explanations.
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Systems and System Models**

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.
# MOTION AND STABILITY: FORCES AND INTERACTIONS

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Apply scientific principles, such as Newton's 1st &amp; 3rd Laws, and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.</th>
</tr>
</thead>
</table>

## Clarification Statement

<table>
<thead>
<tr>
<th>Physical Science: 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 football helmet or a parachute.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics: Physics includes algebraic manipulations.</td>
</tr>
</tbody>
</table>

## Assessment Boundary

Assessment is limited to qualitative evaluations.

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Momentum is conserved within the system and the surroundings.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ETS1.A: Defining and Delimiting an Engineering Problem</td>
<td>6. Constructing explanations and designing solutions  • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.</td>
<td></td>
</tr>
<tr>
<td>-Criteria and constraints also include satisfying any requirements set by society, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ETS1.C: Optimizing the Design Solution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Criteria may need to be broken down into simpler ones that can be approached systematically.</td>
<td></td>
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</tr>
</tbody>
</table>

## North Dakota Connection
**Performance Standard**  
**HS-PS3-1**  
Create a mathematical 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 and out of the system are known.

**Clarification Statement**
- **Physical Science**: Emphasis is on basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and potential energy.
- **Chemistry**: Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations, systems of two or three components, and thermal energy.
- **Physics**: Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations; systems of two or three components; and thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.

**Assessment Boundary**
Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and potential energy.

**Disciplinary Core Ideas**

|-----------------------------|--------------------------------|-----------------------|
| - A system’s total energy is conserved within its system and surroundings. | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
   - Create a computational model or simulation of a phenomenon, designed device, process, or a system  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | Systems and System Models  
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. |

**PS3.B: Conservation of Energy and Energy Transfer**
- Energy cannot be created or destroyed, but it can be transferred.
- Mathematical expressions, including potential and kinetic energy, allow the concept of conservation of energy to be used to describe a system.
- The availability of energy limits what can occur in any system.

**North Dakota Connection**
### HS-PS3-2

#### ENERGY

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop and use models to illustrate that energy is associated with motion and relative position of particles (objects).</th>
</tr>
</thead>
</table>

#### Clarification Statement

| Physical Science: Emphasis is on energy associated with the different states of matter. |
| Chemistry: Emphasis on phenomena relating to the Kinetic Molecular Theory in all phases of matter. Possible models include diagrams, drawings, descriptions, and computer simulations. |
| Physics: Emphasis on phenomena relating to the Kinetic Molecular Theory in all phases of matter. Possible models include diagrams, drawings, descriptions, and computer simulations. |

#### Assessment Boundary

Does not include quantitative calculations and limited to energy associated with solids, liquids, and gases.

#### Disciplinary Core Ideas

**PS3.A: Definitions of Energy**

- A system’s total energy is conserved within its system and surroundings
- Energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.

Energy can be modeled as a combination of energy associated with the motion and relative position of particles. In some cases, the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

#### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
   - Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

#### Crosscutting Concepts

**Energy and Matter**

- Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.

#### North Dakota Connection

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### Performance Standard
**HS-PS3-3**

**Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.**

### Clarification Statement

**Physical Science:** Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, generators, and types of circuits.

**Chemistry:** Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Examples of devices in chemistry could include hot/cold packs and batteries.

**Physics:** Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Examples of devices in physics could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and electric motors.

### Assessment Boundary

Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.

### Disciplinary Core Ideas

- **PS3.A: Definitions of Energy**
  - Energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.

- **PS3.D: Energy in Chemical Processes**
  - Although energy cannot be destroyed, it can be converted to less useful forms.

- **ETS1.A: Defining and Delimiting an Engineering Problem**
  - Criteria and constraints also include satisfying any requirements set by society.

### Science & Engineering Practices

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

### Crosscutting Concepts

**Energy and Matter**
- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

### North Dakota Connection
### Performance Standard
#### HS-PS3-4

Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

### Clarification Statement

**Physical Science/Chemistry/Physics:** Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes conceptually (Chemistry & Physics includes quantitative analysis). Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.

### Assessment Boundary

Assessment is limited to investigations based on materials and tools provided to students and is limited to qualitative only.

### Disciplinary Core Ideas

- **PS3.B: Conservation of Energy and Energy Transfer**
  - Energy cannot be created or destroyed, but it can be transferred.
  - Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution.

- **PS3.D: Energy in Chemical Processes**
  - Although energy cannot be destroyed, it can be converted to less useful forms.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. **Planning and carrying out investigations**
   - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Systems and System Models**
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

### North Dakota Connection
# Waves and their Applications in Technologies for Information Transfer

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Physical Science/Chemistry/Physics: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td>Assessment is limited to algebraic relationships and describing those relationships qualitatively. (Physical science limited to qualitative only)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Developing and using models</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Planning and carrying out investigations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Analyzing and interpreting data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Using mathematical and computational thinking</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Constructing explanations and designing solutions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Engaging in argument from evidence</td>
<td></td>
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<tr>
<td></td>
<td>8. Obtaining, evaluating, and communicating information</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cause and Effect - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</td>
<td></td>
</tr>
</tbody>
</table>

| North Dakota Connection |
### HS-PS2-1

**MOTION AND STABILITY: FORCES AND INTERACTION**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.</th>
</tr>
</thead>
</table>

**Clarification Statement**

**Physical Science and Physics:** Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force in one dimension.

**Assessment Boundary**

Assessment is limited to one dimensional motion and to macroscopic objects moving at non-relativistic speeds.

### Disciplinary Core Ideas

- **PS2.A: Forces and Motion**
  - Newton’s second law accurately predicts changes in the motion of macroscopic objects.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
   - Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

- **Cause and Effect**
  - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

### North Dakota Connection
# MOTION AND STABILITY: FORCES AND INTERACTION

## Performance Standard

| HS-PS2-2 | Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. |

## Clarification Statement

**Physical Science:** Emphasis is on the quantitative calculations of momentum and the qualitative meaning of conservation of momentum.

**Physics:** Emphasis is on the quantitative calculations of momentum and the qualitative meaning of conservation of momentum. Physics includes the quantitative calculations of conservation of momentum, including inelastic & elastic collisions.

## Assessment Boundary

Assessment is limited to systems of two macroscopic bodies moving in one dimension.

## Disciplinary Core Ideas

**PS2.A: Forces and Motion**
- Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.

## Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. **Using mathematical and computational thinking**
   - Use mathematical representations of phenomena to describe explanations.
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

## Crosscutting Concepts

**Systems and System Models**
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.

## North Dakota Connection

### MOTION AND STABILITY: FORCES AND INTERACTION

#### Performance Standard

**HS-PS2-3**  
Apply scientific principles, such as Newton's 1st & 3rd Laws, and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

#### Clarification Statement

**Physical Science**: 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 football helmet or a parachute.  
**Physics**: Physics includes algebraic manipulations.

#### Assessment Boundary

Assessment is limited to qualitative evaluations.

#### Disciplinary Core Ideas

**PS2.A: Forces and Motion**  
- If a system interacts with objects outside itself, the total momentum of the system can change; any such change is balanced by changes in the momentum of objects outside the system.

**ETS1.A: Defining and Delimiting an Engineering Problem**  
- Satisfy any requirements set by society, such as issues of risk mitigation.
  - **ETS1.C: Optimizing the Design Solution**  
- Criteria may need to be broken down into simpler ones that can be approached systematically.

#### Science & Engineering Practices

1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
   - Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information

#### Crosscutting Concepts

**Cause and Effect**  
- Systems can be designed to cause a desired effect.
### MOTION AND STABILITY: FORCES AND INTERACTION

**Performance Standard**  
**HS-PS2-4**  
Use mathematical representations of Newton’s Law of Gravitation and Coulomb’s Law to describe and predict the gravitational and electrostatic forces between objects.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th><strong>Physics:</strong> Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields for systems with two objects.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment Boundary</td>
<td></td>
</tr>
</tbody>
</table>

### Disciplinary Core Ideas

**PS2.B: Types of Interactions**

- Newton’s law of universal gravitation and Coulomb’s law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.

### Science & Engineering Practices

1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
   - Use mathematical representations of phenomena to describe explanations.  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Patterns**

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

### North Dakota Connection
## MOTION AND STABILITY: FORCES AND INTERACTION

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>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.</th>
</tr>
</thead>
</table>

### Clarification Statement

**Physics:** Evidence of changes within a circuit can be represented numerically, graphically, or algebraically using Ohm’s law.

### Assessment Boundary

### Disciplinary Core Ideas

**PS2.B: Types of Interactions**

- Using Newton’s law of universal gravitation and Coulomb’s law to describe and predict the effects of gravitational and electrostatic forces between objects. Forces at a distance are explained by fields that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.

**PS3.A: Definitions of Energy**

- “Electrical energy” may mean energy stored in a battery or energy transmitted by electric currents. (secondary)

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
   - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Cause and Effect**

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

### North Dakota Connection
### Performance Standard HS-PS3-1

Create a mathematical 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 and out of the system are known.

### Clarification Statement

<table>
<thead>
<tr>
<th>Physical Science</th>
<th>Chemistry</th>
<th>Physics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emphasis</strong> is on basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and potential energy.</td>
<td><strong>Emphasis</strong> is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations, systems of two or three components, and thermal energy.</td>
<td><strong>Emphasis</strong> is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations; systems of two or three components; and thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.</td>
</tr>
</tbody>
</table>

### Assessment Boundary

Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and potential energy.

### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>PS3.A: Definitions of Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>- A system’s total energy is conserved within the system and its surroundings.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PS3.B: Conservation of Energy and Energy Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Energy cannot be created or destroyed, but it can be transferred.</td>
</tr>
<tr>
<td>- Mathematical expressions, including potential and kinetic energy, allow the concept of conservation of energy to be used to describe a system.</td>
</tr>
<tr>
<td>The availability of energy limits what can occur in any system.</td>
</tr>
</tbody>
</table>

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
   - Create a computational model or simulation of a phenomenon, designed device, process, or a system
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

<table>
<thead>
<tr>
<th>Systems and System Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.</td>
</tr>
</tbody>
</table>

### North Dakota Connection

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### HS-PS3-2

#### ENERGY

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Develop and use models to illustrate that energy is associated with motion and relative position of particles (objects).</th>
</tr>
</thead>
</table>

| Clarification Statement | Physical Science: Emphasis is on energy associated with the different states of matter.  
Chemistry: Emphasis on phenomena relating to the Kinetic Molecular Theory in all phases of matter. Possible models include diagrams, drawings, descriptions, and computer simulations.  
Physics: Emphasis on phenomena relating to the Kinetic Molecular Theory in all phases of matter. Possible models include diagrams, drawings, descriptions, and computer simulations. |
|------------------------|----------------------------------------------------------------------------------------------------------------|

| Assessment Boundary | Does not include quantitative calculations and limited to energy associated with solids, liquids, and gases. |

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| PS3.A: Definitions of Energy | 1. Asking questions and defining problems  
2. Developing and using models  
   - Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | Energy and Matter  
- Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. |

| North Dakota Connection |
**Performance Standard HS-PS3-3**

Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
</tr>
</thead>
</table>
| **Physical Science**: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, generators, and types of circuits.  
**Chemistry**: Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Examples of devices in chemistry could include hot/cold packs and batteries.  
**Physics**: Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Examples of devices in physics could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and electric motors. |

<table>
<thead>
<tr>
<th>Assessment Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
</tr>
</thead>
</table>
| **PS3.A: Definitions of Energy**  
- Energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.  
**PS3.D: Energy in Chemical Processes**  
- Although energy cannot be destroyed, it can be converted to less useful forms.  
**ETS1.A: Defining and Delimiting an Engineering Problem**  
- Criteria and constraints also include satisfying any requirements set by society. |

<table>
<thead>
<tr>
<th>Science &amp; Engineering Practices</th>
</tr>
</thead>
</table>
| 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
- 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.  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information |

<table>
<thead>
<tr>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **Energy and Matter**  
- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. |

<table>
<thead>
<tr>
<th>North Dakota Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Dakota wind energy</td>
</tr>
</tbody>
</table>
### Performance Standard
**HS-PS3-4**

Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

### Clarification Statement

**Physical Science/Chemistry/Physics:** Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes conceptually (Chemistry & Physics includes quantitative analysis). Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.

### Assessment Boundary

Assessment is limited to investigations based on materials and tools provided to students and is limited to qualitative only.

### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>PS3.B: Conservation of Energy and Energy Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Energy cannot be created or destroyed, but it can be transferred.</td>
</tr>
<tr>
<td>- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PS3.D: Energy in Chemical Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Although energy cannot be destroyed, it can be converted to less useful forms.</td>
</tr>
</tbody>
</table>

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
   - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

**Systems and System Models**
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

### North Dakota Connection
**Energy**

**Performance Standard HS-PS3-5**

Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

<table>
<thead>
<tr>
<th>Clarification Statement</th>
<th>Physics: 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. Limited to systems containing two objects.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assessment Boundary</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Disciplinary Core Ideas**

- **PS3.C: Relationship Between Energy and Forces**
  - When two objects interacting through a field change relative position, the energy stored in the field is changed.

<table>
<thead>
<tr>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Asking questions and defining problems</td>
<td><strong>Cause and Effect</strong></td>
</tr>
<tr>
<td>2. Developing and using models</td>
<td>- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.</td>
</tr>
<tr>
<td>- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.</td>
<td></td>
</tr>
<tr>
<td>3. Planning and carrying out investigations</td>
<td></td>
</tr>
<tr>
<td>4. Analyzing and interpreting data</td>
<td></td>
</tr>
<tr>
<td>5. Using mathematical and computational thinking</td>
<td></td>
</tr>
<tr>
<td>6. Constructing explanations and designing solutions</td>
<td></td>
</tr>
<tr>
<td>7. Engaging in argument from evidence</td>
<td></td>
</tr>
<tr>
<td>8. Obtaining, evaluating, and communicating information</td>
<td></td>
</tr>
</tbody>
</table>

**North Dakota Connection**

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## WAVES AND THEIR APPLICATIONS IN TECHNOLOGIES FOR INFORMATION TRANSFER

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS-PS4-1</td>
<td></td>
</tr>
</tbody>
</table>

### Clarification Statement

**Physical Science/Chemistry/Physics:** Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.

### Assessment Boundary

Assessment is limited to algebraic relationships and describing those relationships qualitatively. (Physical science limited to qualitative only)

### Disciplinary Core Ideas

- **PS4.A: Wave Properties**
  - The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.

### Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
   - Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

- **Cause and Effect**
  - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

### North Dakota Connection
### WAVES AND THEIR APPLICATIONS IN TECHNOLOGIES FOR INFORMATION TRANSFER

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Construct an explanation using evidence to support the idea that electromagnetic radiation can be described by a wave model and a particle model.</th>
</tr>
</thead>
</table>

**Clarification Statement**

**Chemistry/Physics:** 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.

**Assessment Boundary**

Assessment does not include using quantum theory

## Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>PS4.A: Wave Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PS4.B: Electromagnetic Radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.</td>
</tr>
</tbody>
</table>

## Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
   - Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
8. Obtaining, evaluating, and communicating information

## Crosscutting Concepts

**Systems and System Models**

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows— within and between systems at different scales.

### North Dakota Connection
### Performance Standard
**HS-PS4-3**

Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

### Clarification Statement
**Physics:** Emphasis is on the idea that photons associated with different frequencies of light have different energies. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.

### Assessment Boundary
Assessment is limited to qualitative descriptions.

### Disciplinary Core Ideas
**PS4.B: Electromagnetic Radiation**
- When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.

### Science & Engineering Practices
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
   - Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible

### Crosscutting Concepts
**Cause and Effect**
- Cause and effect relationships can be suggested and predicted for complex natural and human designs systems by examining what is known about smaller scale mechanisms within the system.

### North Dakota Connection
**WAVES AND THEIR APPLICATIONS IN TECHNOLOGIES FOR INFORMATION TRANSFER**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>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.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS-PS4-4</td>
<td></td>
</tr>
</tbody>
</table>

**Clarification Statement**

**Physics:** Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology. Focus in on qualitative information and does not include band theory.

**Assessment Boundary**

**Disciplinary Core Ideas**

**PS3.D: Energy in Chemical Processes**
- Solar cells capture the sun’s energy and produce electrical energy.

**PS4.A: Wave Properties**
- Information can be digitized and then stored in computer memory and sent over long distances as wave pulses.

**PS4.B: Electromagnetic Radiation**
- Photovoltaic materials emit electrons when they absorb light of a high-enough frequency.

**PS4.C: Information Technologies and Instrumentation**
- Technologies based on waves are part of everyday experiences and are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
   - Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

**Crosscutting Concepts**

**Cause and Effect**
- Systems can be designed to cause a desired effect.

**North Dakota Connection**
ANATOMY & PHYSIOLOGY
### Performance Standard

**Performance Standard HS-LS1-2**

Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

### Clarification Statement

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 could be 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.

### Assessment Boundary

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **LS1.A: Structure and Function**
  - Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. | 1. Asking questions and defining problems
  2. Developing and using models
    - Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.
  3. Planning and carrying out investigations
  4. Analyzing and interpreting data
  5. Using mathematical and computational thinking
  6. Constructing explanations and designing solutions
  7. Engaging in argument from evidence
  8. Obtaining, evaluating, and communicating information | **Systems and System Models**
  - Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

### North Dakota Connection
### Performance Standard
**HS-LS1-3**
Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

### Clarification Statement
Examples of investigations could include heart rate response to exercise, cell transport, etc.

### Assessment Boundary

### Disciplinary Core Ideas
**LS1.A: Structure and Function**
- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.

### Science & Engineering Practices
1. Asking questions and defining problems
2. Developing and using models
3. **Planning and carrying out investigations**
   - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the and refine the design accordingly.
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts
**Stability and Change**
- Feedback (negative or positive) can stabilize or destabilize a system.

### North Dakota Connection
### HS-LS1-3

**ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.</th>
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</thead>
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<tr>
<th>Clarification Statement</th>
<th>Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in the human body. It is not necessary include the specific chemical processes of either aerobic or anaerobic respiration.</th>
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<tr>
<th>Assessment Boundary</th>
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<tr>
<th>Disciplinary Core Ideas</th>
<th>Science &amp; Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LS2.B: Cycles of Matter and Energy Transfer in Ecosystems</strong>&lt;br&gt;-Photosynthesis and cellular respiration provide most of the energy for life processes.</td>
<td>1. Asking questions and defining problems&lt;br&gt;2. Developing and using models&lt;br&gt;3. Planning and carrying out investigations&lt;br&gt;4. Analyzing and interpreting data&lt;br&gt;5. Using mathematical and computational thinking&lt;br&gt;<strong>6. Constructing explanations and designing solutions</strong>&lt;br&gt;• Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, and peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.&lt;br&gt;7. Engaging in argument from evidence&lt;br&gt;8. Obtaining, evaluating, and communicating information</td>
<td><strong>Energy and Matter</strong>&lt;br&gt;-Energy drives the cycling of matter within and between systems.</td>
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| North Dakota Connection |
ENGINEERING & TECHNOLOGY
### HS-ET1-1

#### Performance Standard

**HS-ET1-1**

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

### Clarification Statement

Course and grade level placement of this standard will be determined locally.

### Assessment Boundary

**Disciplinary Core Ideas**

**ET1.A: Defining and Delimiting Engineering Problems**

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

**Science & Engineering Practices**

1. Asking questions and defining problems
   - Builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting Concepts**

**Connections to Engineering, Technology, and Applications of Science Influence of Society and the Natural World**

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

### North Dakota Connection
## Engineering & Technology

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.</th>
</tr>
</thead>
</table>

### Clarification Statement
Course and grade level placement of this standard will be determined locally.

### Assessment Boundary

### Disciplinary Core Ideas
**ET1.C: Optimizing the Design Solution**
- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.

### Science & Engineering Practices
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
   - Builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories.
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### Crosscutting Concepts

### North Dakota Connection
### Engineering & Technology

<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.</th>
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| ET1.B: Developing Possible Solutions  
-When evaluating solutions, it is important to consider a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. | 1. Asking questions and defining problems  
2. Developing and using models  
3. Planning and carrying out investigations  
4. Analyzing and interpreting data  
5. Using mathematical and computational thinking  
6. Constructing explanations and designing solutions  
- Builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories.  
7. Engaging in argument from evidence  
8. Obtaining, evaluating, and communicating information | Connections to Engineering, Technology, and Applications of Science Influence of Science, Engineering, and Technology on Society and the Natural World  
-New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. |

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<td>Performance Standard</td>
<td>Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.</td>
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<td><strong>ET1.B: Developing Possible Solutions</strong></td>
<td>1. Asking questions and defining problems</td>
<td>Systems and System Models</td>
</tr>
<tr>
<td>- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.</td>
<td>2. Developing and using models</td>
<td>- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions — including energy, matter, and information flows — within and between systems at different scales.</td>
</tr>
<tr>
<td>3. Planning and carrying out investigations</td>
<td>4. Analyzing and interpreting data</td>
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<tr>
<td>5. Using mathematical and computational thinking</td>
<td>5. <strong>Builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.</strong></td>
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