High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Standard K.PS2.A.1

Learning Goal	**Proficiency Scale**
Students can plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.	4: Student demonstrates advanced application and understanding of forces and interactions. 3: Student demonstrates mastery with the learning goal as evidenced by: ● developing a plan to investigate the relationship between the strength and direction of pushes and pulls and the motion of an object. ● describing the cause and effect relationship between pushes and pulls and object motion to be determined. ● comparing the effects of the motion of the objects caused by changes in the strength or direction of the pushes and pulls and recording their data. 2: Student demonstrates he/she is nearing proficiency by: ● predicting the effect of the push or pull on the motion of the object. ● describing the relative strengths of the push or pull that will be applied to the object to start or stop its motion or change its speed OR describing the relative directions of the push or pull that will be applied to the object. 1: Student demonstrates limited understanding of forces and interactions.

Learning Targets- Pushes and Pulls Unit

Science and Engineering Practice
With guidance, plan and conduct an investigation in collaboration with peers.

Disciplinary Core Ideas

- Understand pushes and pulls can have different strengths and directions.
- Compare how pushes and pulls can change the speed or direction of an object.
- Identify that a bigger push or pull makes things speed up or slow down more quickly.

Cross Cutting Concept

Generalize that a bigger push or pull makes things speed up and move more quickly than a smaller push or pull.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Standard K.PS2.A.2	
<u>Learning Goal</u> Students can 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.	**<u>Proficiency Scale</u>** 4: Student demonstrates advanced application and understanding of forces and interactions. 3: Student demonstrates mastery with the learning goal as evidenced by: ● organizing data using graphical or visual displays. ● describing relative changes in the speed or direction of the object caused by pushes or pulls from the design solution. ● describing, from the observed data, whether the push or pull from the design solution causes the intended change in speed or direction of motion of the object. 2: Student demonstrates he/she is nearing proficiency by: ● organizing data with guidance. ● describe how the pushes or pull from the design solution causes the change in the object's motion. 1: Student demonstrates limited understanding of forces and interactions.

Learning Targets- Pushes and Pulls Unit

Science and Engineering Practices

- Collect observational data on the motion of objects.
- Analyze observational data and categorize what made an object's motion change (i.e., go slower, go faster, go farther, change direction, stop).

Disciplinary Core Idea

- Describe the ways we can cause an object to change motion.

Cross Cutting Concept

Describe the effect of actions on an object to make it change motion (i.e., go slower, go faster, go farther, change direction, stop) and generalize the relationship between the force applied and resulting motion of an object.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Standard K.PS3.A.1	
Learning Goal Students can make observations to determine the effect of sunlight on Earth's surface.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of weather and climate. 3: Student demonstrates mastery with the learning goal as evidenced by: ● describing observations of the relative warmth of materials in the presence and absence of sunlight. ● identifying patterns of relative warmth or materials in sunlight and in shade. 2: Student demonstrates he/she is nearing proficiency by: ● describing that sunlight warms the earth. ● comparing the warmth of earth materials placed in sunlight and the same earth materials placed in shade. 1: Student demonstrates limited understanding of weather and climate.
Learning Targets- Weather and Climate Unit **Science and Engineering Practice** Collect observational data using relative terms (e.g., warmer, hotter, colder, cooler, brighter, darker, lighter) on the effect of sunlight on Earth's surface. **Disciplinary Core Idea** Recall that sunlight warms Earth's surface and that more sunlight means more warmth (e.g., it is generally warmer in the day than at night). **Cross Cutting Concept** Generalize that the shielding or reduction of direct sunlight will result in reducing the warming effect of sunlight and that, conversely, an increase in direct sunlight will result in increasing the warming effect.	

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Standard K.PS3.B.1

Learning Goal	**Proficiency Scale**
Students can use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.	4: Student demonstrates advanced application and understanding of weather and climate. 3: Student demonstrates mastery with the learning goal as evidenced by: ● designing and building a structure that reduces warming caused by the sun. ● describing whether the structure meets the expectations in terms of cause (structure blocks sunlight) and effect (less warming of the surface). 2: Student demonstrates he/she is nearing proficiency by: ● designing and building a structure with guidance and support. ● describing that the structure is expected to reduce warming for a designed area by providing shade. 1: Student demonstrates limited understanding of weather and climate.

Learning Targets- Weather and Climate Unit

Science and Engineering Practices
- Design and build a model device, using provided tools and materials, to reduce the warming effect of sunlight.
- Generate and compare multiple solutions to the engineering challenge.

Disciplinary Core Idea
Recall that sunlight warms Earth's surface

Cross Cutting Concept
Generalize that the shielding or reduction of direct sunlight will result in reducing the warming effect of sunlight and that, conversely, an increase in direct sunlight will result in increasing the warming effect.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Standard K.ESS2.D.1	
Learning Goal Students can use and share observations of local weather conditions to describe patterns over time.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of weather and climate. 3: Student demonstrates mastery with the learning goal as evidenced by: ● organizing data from given observations (firsthand or from media) about local weather conditions using graphical displays (pictures, charts, etc.). ● describing patterns and sharing that: ○ certain months have more days of some kinds of weather than do other months. ○ the differences in relative temperature over the course of a day are directly related to the time of day. 2: Student demonstrates he/she is nearing proficiency by: ● organizing data with guidance and support. ● identifying in the data: ○ the change in the relative temperature over the course of a day. ○ the relative number of days of different types of weather conditions in a month. 1: Student demonstrates limited understanding of weather and climate.
Learning Targets - Weather and Climate Unit **Science and Engineering Practice** Analyze observations (data points). **Disciplinary Core Idea** Make relevant local weather observations that include noticing the amount of sunlight, wind, snow/rain, and temperature, both throughout a day and/or across multiple days. **Cross Cutting Concept**	

Identify general patterns in the local weather data collected over a period of time.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Standard 1.PS3.A.1

<table>
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<u>Learning Goal</u>

Students can identify the source of energy that causes an increase in the temperature of an object.

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<u>Proficiency Scale</u>

4: Student demonstrates advanced application and understanding of energy.

3: Student demonstrates mastery with the learning goal as evidenced by:

- identifying a source of energy and explaining how the source can cause an increase in the temperature of an object
- describing, using evidence, that the Sun is a source of energy that can increase temperature

2: Student demonstrates he/she is nearing proficiency by:

- identifying a source of energy
- understanding that energy can increase the temperature of objects.

1: Student demonstrates limited understanding of energy

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</table>

<u>Learning Targets - Weather and Climate Unit</u>

Science and Engineering Practices

- Ask questions based on observations to find out more information about the natural and/or designed world.
- Ask and/or identify questions that can be answered by an investigation.
- Use information from observations to construct an evidence-based account for natural phenomena.

Disciplinary Core Ideas

- Energy sources that increase the temperature of objects (e.g., sun, stove, flame, light bulb, oven)
- The sun is the primary source of energy on Earth.
- Temperature is a measure of hot or cold.

Cross Cutting Concepts

- Energy can cause the temperature of an object to increase.
- Events have causes that generate observable patterns.
- Simple tests can be designed to gather evidence to support or refute student ideas about causes.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Standard K.LS1.C.1	
Learning Goal Students can use observations to describe patterns of what plants and animals (including humans) need to survive.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of plants and animals. 3: Student demonstrates mastery with the learning goal as evidenced by: ● organizing data from given observations (firsthand or from media) using graphical displays (pictures, charts, etc.). ● describing the patterns identified in the data provided to show evidence that: ○ plants and animals need light and water to live and grow. ○ animals get their food from plants, other animals, or both. 2: Student demonstrates he/she is nearing proficiency by: ● organizing data with guidance and support. ● identifying patterns in the data including: ○ all animals eat food. ○ all animals drink water. ○ plants cannot live or grow if there is no water or light. 1: Student demonstrates limited understanding of plants and animals.
Learning Targets - Plants and Animals Unit **Science and Engineering Practices** ● Collect observations and information on the needs of various plants and animals. ● Organize or classify collected observations into like survival categories (e.g., food sources, water sources, shelter, air). **Disciplinary Core Ideas** ● Understand the basic food source needs of animals. ● Understand that plants need water and light to live and grow.	

Cross Cutting Concept Make a generalization about the similar needs of all plants and similar needs of all animals and describe that pattern in the natural world.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Standard K.ESS2.E.1	
Learning Goal Students can construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of plants and animals. 3: Student demonstrates mastery with the learning goal as evidenced by: ● making a claim to be supported by evidence that plants and animals (including humans) can change the environment to meet their needs. ● supporting the claim and presenting an argument connecting various needs of plants and animals to show evidence about how plants/animals change their environments to meet their needs. ● The argument includes: ○ examples of how plants affect other parts of their system by changing their environments to meet their needs. ○ examples of how animals affect other parts of their systems by changing their environments to meet their needs. 2: Student demonstrates he/she is nearing proficiency by: ● making and supporting a claim with guidance and support. ● identifying and describing: ○ examples of plants changing their environments.

	○ examples of animals (including humans) changing their environments. ○ examples of plant and animal needs. 1: Student demonstrates limited understanding of plants and animals.

Learning Targets

Science and Engineering Practices

- Engage in an argument.
- Use relative evidence to support a claim.

Disciplinary Core Ideas

- Describe how plants and animals change their environment (e.g., squirrel digs in the ground, ants build anthills).
- Identify ways humans have altered the natural environment and recognize how plants and animals have changed the environment to meet their needs (e.g., tree roots break concrete, vines grow around fences, birds use some human-made materials to build nests).

Cross Cutting Concept

Describe the relationship (system) between plants and animals and their environment (natural or human-made).

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High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal K.ESS3.A.1

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<u>Learning Goal</u>

Students can use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live.

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<u>Proficiency Scale</u>

4: Student demonstrates advanced application and understanding of plants and animals.

3: Student demonstrates mastery with the learning goal as evidenced by:

- using a given model to represent and describe the relationships between the components including:
  - the relationships between the different plants and animals and the materials they need to survive.
  - the relationship between places where different plants and animals live and the resources those places provide.
  - the relationships between specific plants and animals and where they live.
- using a given model to describe that plants and animals, the places in which they live, and the resources found in those places are each part of a system, and that these parts of systems work together and allow living things to meet their needs.

2: Student demonstrates he/she is nearing proficiency by:

- identifying and describing the components in a given model representing:
  - different plants and animals (including humans).
  - the places where the different plants and animals live.
  - the things that plants and animals need.
- describing the relationship between the components with guidance and support

1: Student demonstrates limited understanding of plants and animals.

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Learning Targets

Science and Engineering Practices

- Use a model.
- Relate a model to relationships in nature.

Disciplinary Core Ideas

- Describe the needs of living things, both plants and animals (including humans).
- Identify that living things use their environment to meet their needs.
- Understand that humans use natural resources daily.

Cross Cutting Concept

Identify the mutual relationship between living things and their natural environment (i.e., deer eat buds and leaves and are therefore often found in forest, grasses need sun and are therefore often found in meadows).

<table>
<tr><td colspan="2">High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal K.ESS3.C.1</td></tr>
<tr><td><u>Learning Goal</u>

Students can communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.</td>
<td><u>Proficiency Scale</u>

4: Student demonstrates advanced application and understanding of plants and animals.

3: Student demonstrates mastery with the learning goal as evidenced by:

communicating information clearly about solutions in oral and/or written form.
communicating information about solutions that reduce the negative effects of humans on the local environment, including:

examples of things that people do to live comfortably and how those things can cause changes to the land, water, air, and/or living things in the local environment.
examples of choices that people can make to reduce negative impacts and the effects those choices have on the local environment.

2: Student demonstrates he/she is nearing proficiency by:

communicating information, with guidance and support, about solutions in oral and/or written form
describing information about:

how people affect the land, water, air, and/or living things in the local environment in positive and negative ways.
solutions that reduce the negative effects of humans on the local environment.

1: Student demonstrates limited understanding of plants and animals.</td></tr>
</table>

Learning Targets

Science and Engineering Practices
Communicate solutions with others in oral and/or written forms, using models and/or drawings that provide detail about scientific ideas.
Disciplinary Core Ideas

- Understand that humans impact the world around them.
- Create sketches, drawings, or physical models to communicate ideas for a problem's solutions.
- Identify ways to reduce human impact on land, water, air, and other living things.

Cross Cutting Concept
Identify the impact of human choices on the environment and the general observable patterns that are formed.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 1.LS1.A.1	
Learning Goal Students can use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of structure, function, and information processing. 3: Student demonstrates mastery with the learning goal as evidenced by: ● designing a device and describing the specific or required features in their designs and devices including: ○ the device provides a solution to the given human problem. ○ the device mimics plant and/or animal external parts, and/or information processing. 2: Student demonstrates he/she is nearing proficiency by: ● describing the given human problem to be solved by the design. ● explaining how external structures are used to help the plant and/or animal grow and/or survive. 1: Student demonstrates limited understanding of structure, function, and information processing.
Learning Targets - Life Science Unit **Science and Engineering Practices** ● Define a simple problem that can be solved through mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs. ● Design a solution to a given human problem by mimicking how plants and animals use their structures. ● Ask questions based on observations of how different plants and animals use their body parts in different ways to protect themselves. ● Develop a model to represent relationships in the natural world, such as animals' external parts and the animals' ability to move from place to place. ● Make observations (firsthand or from media) to construct an evidence-based account for how plant and animal structures (e.g., roots of plants,	

duck feet) help them survive and grow.

Disciplinary Core Ideas

- All organisms have external parts that they use to perform daily functions.
- Different animals use their body parts in different ways (e.g., see; hear; grasp objects; protect themselves; move from place to place; seek, find, and take in food, water, and air).
- Plants have different parts (e.g., roots, stems, leaves, flowers, fruits) that help them survive and grow.
- Animals have body parts that capture and convey different kinds of information needed for growth and survival.
- Animals respond to inputs with behaviors that help them survive. Plants also respond to external inputs.

Cross Cutting Concept

- The shape and stability of structures of natural and designed objects are related to their function(s).
- Describe simple tests that can be designed to gather evidence to support or refute student ideas about how different plant and animal parts contribute to survival.

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High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 1.LS3.A.1

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Learning Goal

Students who demonstrate understanding can make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.

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Proficiency Scale

4: Student demonstrates advanced application and understanding of inheritance and variation of traits..

3: Student demonstrates mastery with the learning goal as evidenced by:

- connecting the evidence of observed patterns in features to support that:
  - young plants and animals are very similar to their parents.
  - young plants and animals are not exactly the same as their parents.
  - similarities and differences in features are evidence that although individuals of the same type of animal or plant are recognizable as similar, they can also vary in many ways.

2: Student demonstrates he/she is nearing proficiency by:

- describing evidence from observations that:
  - there are key differences between different types of plants and animals.
  - young plants and animals of the same type have similar, but not identical features.
  - adult plants and animals of the same type have similar, but not identical features.

1: Student demonstrates limited understanding of inheritance and variation of traits.

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Learning Targets - Life Science Unit

Science and Engineering Practices

- Make observations (firsthand or from media [e.g., books, videos]) to collect data that can be used to make comparisons of parent and baby plants and animals.
- Read grade-appropriate texts and/or use media to obtain scientific information to determine patterns in and/or evidence about similarities in young plants and animals and their parents.

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- Make qualitative observations to compare and contrast parents and offspring.
- Observe the growth of a plant from seed to flowering plant.

Disciplinary Core Ideas

- Adult plants and animals can have young.
- Animals and plants of the same kind have the same structures (e.g., wings, number of legs, fur, leaf shape, flower).
- Young organisms are very much, but not exactly, like their parents and also resemble other organisms of the same kind.

Cross Cutting Concept

- Observe the pattern that parents and their young are alike, but not exactly alike (i.e., animals and plants).
- Observe the pattern that animals and plants of the same kind have the same structures.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 5.PS4.A.1	
Learning Goal Students can make observations to construct an evidence-based account that objects in darkness can be seen only when light is reflected off them or when they produce their own light.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of light waves. 3: Student demonstrates mastery with the learning goal as evidenced by: ● logically connecting the evidence to support and describe that: ○ the presence of light in a space causes objects to be able to be seen in that space. ○ objects cannot be seen if there is no light to illuminate them, but the same object in the same space can be seen if a light source is introduced. ○ the ability of an object to give off its own light causes the object to be seen in a space where there is no other light. 2: Student demonstrates he/she is nearing proficiency by: ● making observations about: ○ the appearance of objects in a space with no light. ○ the appearance of objects in a space with light. ○ the appearance of objects that give off light in a space with no other light. 1: Student demonstrates limited understanding of light waves.
Learning Targets - Light and Sound **Science and Engineering Practices** Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. **Disciplinary Core Ideas** Objects can be seen when light reflected from their surfaces enters our eyes. **Cross Cutting Concept** Simple tests can be designed to gather evidence to support or refute student ideas about causes.	

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 1.PS4.C.1	
Learning Goal Students can use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of light and sound waves. 3: Student demonstrates mastery with the learning goal as evidenced by: ● designing and building a device that is able to send or receive information over a given distance and uses light or sound to communicate. 2: Student demonstrates he/she is nearing proficiency by: ● describing a given problem involving people communicating over long distances. ● designing and building, with guidance, a device that uses light or sound to solve the given problem. 1: Student demonstrates limited understanding of light and sound waves.

Learning Targets - Light and Sound

Science and Engineering Practices
- Define a simple problem that can be solved through the development of a new or improved object or tool.
- Make observations to construct an evidence-based account of devices that can help people communicate over long distances.
- Communicate design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas.
- With guidance, students use tools and materials to design and build a device that uses light or sound to solve the given problem.

Disciplinary Core Ideas
- Objects can only be seen if there is light to illuminate them or they give off their own light.
- Objects made of different materials allow light to pass through them in different ways.
- Materials can block light and create shadows.
- Materials (e.g., mirror, aluminum foil) can change the direction of the light.
- People use a variety of devices to communicate over long distances to send and/or receive information.

Cross Cutting Concept
Objects are related to their function(s).

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 1.PS4.A.1 and 2.PS4.A.1	
Learning Goal Students can plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of light and sound waves. 3: Student demonstrates mastery with the learning goal as evidenced by: ● developing an investigation plan and describing the evidence that will result from the investigation including: ○ observations that sounds can cause materials to vibrate. ○ observations that vibrating materials can cause sounds. ○ how the data will support evidence to support or refute ideas about the relationship between vibrating materials and sound. 2: Student demonstrates he/she is nearing proficiency by: ● describing how materials can be made to vibrate to make sound. ● describing what sounds can be used to make materials vibrate. ● describing how to determine that a material is vibrating. 1: Student demonstrates limited understanding of light and sound waves.
Learning Targets - Light and Sound **Science and Engineering Practices** ● With guidance, predict, plan and conduct simple investigations to observe the vibrations of various materials producing sounds. ● Record information from observations that sound can make matter vibrate and vibrating matter can make sound. ● With guidance, use qualitative data to compare two alternative solutions to a problem (e.g., sound makes matter vibrate / vibrations make sound). **Disciplinary Core Ideas** ● Observe that sound can make materials (matter) vibrate. ● Observe that vibrating materials (matter) can make sound.	

Cross Cutting Concept

- Vibrations make sound, and sounds make vibrations.
- Events have causes that generate observable patterns in creating sound.
- Simple tests can be designed to gather evidence to support or refute student ideas about the cause and effect relationship of vibrations and sound.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 1.ESS1.A.2	
Learning Goal Students can use observations of the sun, moon, and stars to describe patterns that can be predicted.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of patterns and cycles in space. 3: Student demonstrates mastery with the learning goal as evidenced by: ● identifying and describing patterns in the organized data, including: ○ stars are not seen in the sky during the day, but they are seen in the sky during the night. ○ the sun is at different positions in the sky at different times of the day, appearing to rise in one part of the sky in the morning and appearing to set in another part of the sky in the evening. ○ the moon can be seen during the day and at night, but the sun can only be seen during the day ○ the moon is at a different position in the sky at different times of the day or night, appearing to rise in one part of the sky and appearing to set in another part of the sky. ● using the identified patterns of the motions and appearance of objects in the sky to provide evidence that future appearances of those objects can be predicted. 2: Student demonstrates he/she is nearing proficiency by: ● using graphical displays to organize data from given observations with guidance and support including: ○ objects visible in the sky during the day. ○ objects visible in the sky during the night. ○ the position of the sun in the sky at various times during the day. ○ the position of the moon in the sky at various times during the day or night. 1: Student demonstrates limited understanding of patterns and cycles in space.

Learning Targets - Space Systems

Science and Engineering Practices

- Make observations and collect data that can be used to make comparisons and predict patterns of the sun and moon during the day.
- Ask questions based on observations to find more information about the patterns of the sun, moon, and stars.
- Make predictions based on observations of the sun, moon, and stars.
- Use observations to describe patterns and/or relationships of the sun, moon, and stars to answer scientific questions.

Disciplinary Core Ideas

- Patterns of movement of the sun, moon, and stars as seen from Earth can be observed, described, and predicted.
- The sun is observed at different positions in the sky at different times of the day (e.g., rises in the morning, sets in the evening, high in the sky at midday, moves east to west).
- The moon is observed at different positions in the sky at different times during the day and/or night.

Cross Cutting Concept

- Make predictions using patterns (e.g., day/night, movement and position of sun and moon, observable during day and/or night).
- Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal K.ESS1.B.1	
Learning Goal Students who demonstrate understanding can make observations at different times of year to relate the amount of daylight to the time of year.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of patterns and cycles in space. 3: Student demonstrates mastery with the learning goal as evidenced by: ● making and recording observations about the relative length of the day in different seasons to reveal the pattern between the amount of daylight at different times of the year. 2: Student demonstrates he/she is nearing proficiency by: ● describing the data with guidance and support including observations of relative length of the day throughout the year. 1: Student demonstrates limited understanding of patterns and cycles in space.
Learning Targets - Space Systems Unit **Science and Engineering Practices** ● Collect and analyze observations (data points). ● Interpret data to make generalizations about seasons and amount of daylight in Missouri. **Disciplinary Core Ideas** Recall that different seasons result in longer or shorter amounts of daylight, depending on the time of year ("Have you noticed that you can play outside longer in the summer than in the winter?") and describe those amounts in relative terms (e.g., more, few, less). **Cross Cutting Concept** Describe the observable pattern that can be seen between the seasons and the amount of daylight.	

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 1.ESS1.A.1	
Learning Goal Students can describe the presence of the sun, moon, and stars in the sky over time.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of the universe and its stars. 3: Student demonstrates mastery with the learning goal as evidenced by: ● using pictures, models, and/or drawings to describe objects visible in the sky during the day and during the night 2: Student demonstrates he/she is nearing proficiency by: ● understands that the sun and moon move to different positions in the sky. 1: Student demonstrates limited understanding of the universe and its stars.

Learning Targets - Space Systems Unit

Science and Engineering Practices

- Make observations of the sun and moon during the day.
- Communicate information with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about the presence of the sun, moon, and stars in the sky over time.

Disciplinary Core Ideas

- The sun is observed at different positions in the sky at different times of the day (e.g., rises in the morning, sets in the evening, high in the sky at midday, moves from east to west).
- The moon is observed at different positions in the sky at different times during the day or night.
- Stars (other than the sun) are not observable in the sky during the day but are observed during the night.
- The moon can be observed during the day and during the night, but the sun can only be observed during the day.

Cross Cutting Concept

- Describe patterns in the presence of objects in the sky (e.g., sun, moon, stars) over time.
- Events have causes that generate observable patterns (e.g., the sun is visible only during the day, the moon is visible during day and night, stars are visible during the night).

- Some things stay the same while other things change (e.g., the sun during the day, the moon during the day or night).

<table>
<tr><td colspan="2">High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 2.LS2.A.2</td></tr>
<tr><td><u>Learning Goal</u>

Students can develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.</td>
<td><u>Proficiency Scale</u>

4: Student demonstrates advanced application and understanding of interdependent relationships in ecosystems.

3: Student demonstrates mastery with the learning goal as evidenced by:

developing a simple model that includes:

relevant structures of the animal.
relevant structures of the plant.
pollen or seeds from plants.

describing the relationships between components, including evidence that the developed model mimics how plant and animal structures interact to move pollen or disperse seeds.

2: Student demonstrates he/she is nearing proficiency by:

developing a simple model with guidance and support that includes:

relevant structures of the animal.
relevant structures of the plant.
pollen or seeds from plants.

identifying the relevant components of their model, including those components that mimic the natural structure of an animal that helps it disperse seeds or mimic the natural structure of an animal that helps it pollinate plants.

1: Student demonstrates limited understanding of interdependent relationships in ecosystems.</td></tr>
</table>

Learning Targets - Ecosystems Unit

Science and Engineering Practices

- Develop a simple model based on evidence to represent a proposed object or tool.
- Develop a simple model to explain the phenomenon of pollination and dispersal of seeds.

Disciplinary Core Ideas

- Plants depend on animals for pollination or to move their seeds around.
- Understand the importance of animals in their specialized role of pollination or seed dispersal.
- Identify that animals have different structures that perform specific functions for dispersing seeds or pollinating plants (e.g., chipmunk's cheeks for carrying seeds; a hummingbird's long beak for drinking nectar; animal fur for seeds to cling to).

Cross Cutting Concept

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

<table>
<tr><td colspan="2">

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 2.LS2.A.1

</td></tr>
<tr><td>

<u>Learning Goal</u>

Students can plan and conduct an investigation to determine if plants need sunlight and water to grow.

</td><td>

<u>Proficiency Scale</u>

4: Student demonstrates advanced application and understanding of interdependent relationships in ecosystems.

3: Student demonstrates mastery with the learning goal as evidenced by:

- developing an investigation plan that includes:
  - the plants to be used.
  - the source of light.
  - how plants will be kept with/without light in both the light/dark test and the water/no water test.
  - the amount of water plants will be given in both the light/dark test and the water/no water test.
  - how plant growth will be determined.
- describing how the plan will allow them to answer the question about whether plants need sunlight and water to grow.
- collecting and recording accurate data on the effects of plant growth.

2: Student demonstrates he/she is nearing proficiency by:

- describing the evidence to be collected during the investigation, including:
  - plant growth with both light and water.
  - plant growth without light but with water.
  - plant growth without water but with light.
  - plant growth without water and without light.
- collecting and recording data with guidance and support on the effects of plant growth.

1: Student demonstrates limited understanding of interdependent relationships in ecosystems.

</td></tr>
</table>

Learning Targets - Ecosystems Unit

Science and Engineering Practices

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.
- Determine the types of materials needed for the investigation.
- Guide students to determine the parameters for growing conditions.
    - How much water?
    - Where do we put the plants?
    - What is the source of light?
    - What type of seed/plant?
- Collaboratively develop an investigation plan.

Disciplinary Core Ideas

- Identify basic plant needs.
- Plants depend on water and light to grow.

Cross Cutting Concept

Events have causes that generate observable patterns.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 2.ESS2.B.1

Learning Goal	Proficiency Scale
Students can develop a model to represent the shapes and kinds of land and bodies of water in an area.	4: Student demonstrates advanced application and understanding of Earth's systems and processes that shape the Earth. 3: Student demonstrates mastery with the learning goal as evidenced by: ● developing a model that represents both land and bodies of water in an area. ● identifying and describing the relationships between the specific shapes and kinds of land and specific bodies of water. ● describing patterns of water and land in a given area. 2: Student demonstrates he/she is nearing proficiency by: ● developing a model with guidance and support that represents both land and bodies of water in an area. ● describing the land and water in an area. 1: Student demonstrates limited understanding of Earth's systems and processes that shape the Earth.

Learning Targets - Shaping the Earth Unit

Science and Engineering Practices

- Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.
- Distinguish between a model and the actual object, process, and/or events the model represents.
- Develop a model to represent patterns in the natural world.

Disciplinary Core Ideas

Maps show where things are located. One can map the shapes and kinds of land and water in any area.

Cross Cutting Concept

Patterns in the natural world can be observed.

<table>
<tr><td colspan="2">

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 2.ESS1.C.1

</td></tr>
<tr><td>

Learning Goal

Students can use information from several sources to provide evidence that Earth events can occur quickly or slowly.

</td><td>

Proficiency Scale

4: Student demonstrates advanced application and understanding of Earth's systems and processes that shape the Earth.

3: Student demonstrates mastery with the learning goal as evidenced by:

- making observations using at least 3 or more sources.
- connecting the evidence and describing their reasoning that in some cases, Earth events and the resulting changes can be directly observed; therefore, those events must occur rapidly.
- connecting the evidence and describing their reasoning that in other cases, the resulting changes of Earth events can be observed only after a long period of time; therefore, these Earth events occur slowly, and changes happen over a time period that is much longer than one can observe.

2: Student demonstrates he/she is nearing proficiency by:

- making observations using 1-2 sources.
- describing evidence from observations that:
  - some Earth events occur quickly.
  - some Earth events occur slowly.
  - some results of Earth events that occur quickly and some slowly.

1: Student demonstrates limited understanding of Earth's systems and processes that shape the Earth.

</td></tr>
</table>

Learning Targets - Shaping the Earth Unit

Science and Engineering Practices

- Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.
- Make observations from several sources to construct an evidence-based account for natural phenomena.

Disciplinary Core Ideas

Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe.

Cross Cutting Concept

Things may change slowly or rapidly.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 2.ESS2.A.1	
Learning Goal Students can compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of Earth's systems and processes that shape the Earth. 3: Student demonstrates mastery with the learning goal as evidenced by: ● describing two or more solutions in terms of how they slow or prevent wind or water from changing the shape of the land. ● evaluating features in the solution that would slow or prevent wind or water from washing away sand or soil. ● using their evaluation and comparing the given solution to each other. 2: Student demonstrates he/she is nearing proficiency by: ● describing one solution in terms of how it slows or prevents wind or water from changing the shape of the land. ● describing features in the solution that would slow or prevent wind or water from washing away sand or soil. ● describing features in the solution that would address problems created by slow and rapid changes in the environment. 1: Student demonstrates limited understanding of Earth's systems and processes that shape the Earth.

Learning Targets - Shaping the Earth Unit

Science and Engineering Practices

- Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.
- Compare multiple solutions to a problem.

Disciplinary Core Ideas

Wind and water can change the shape of the land.

Cross Cutting Concept

- Things may change slowly or rapidly.
- Developing and using technology have impacts on the natural world.
- Connections to Nature of Science.
- Scientists study the natural and material world.

<table>
<tr><td colspan="2">High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 2.ESS2.C.1</td></tr>
<tr><td><u>Learning Goal</u>

Students can obtain information to identify where water is found on Earth and that it can be solid or liquid.</td><td><u>Proficiency Scale</u>

4: Student demonstrates advanced application and understanding of Earth’s systems and processes that shape the Earth.

3: Student demonstrates mastery with the learning goal as evidenced by:
using books and other reliable media to identify patterns of where water is found, and what form it is in.
2: Student demonstrates he/she is nearing proficiency by:
using books and other reliable media to identify where water is found on Earth, including oceans, rivers, lakes, ponds, and glaciers.
using books and other reliable media to describe that water can be found on Earth as liquid water or solid ice.
1: Student demonstrates limited understanding of Earth’s systems and processes that shape the Earth.</td></tr>
<tr><td colspan="2"><u>Learning Targets - Shaping the Earth Unit</u>

Science and Engineering Practices
Obtaining, evaluating, and communicating information in K–2 builds on prior experiences and uses observations and texts to communicate new information.
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.
Disciplinary Core Ideas
Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.
Cross Cutting Concept
Patterns in the natural world can be observed.</td></tr>
</table>

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 2.PS1.A.1	
Learning Goal Students can plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of structure and properties of matter. 3: Student demonstrates mastery with the learning goal as evidenced by: ● developing an investigation plan and describing the properties of matter of the materials that would allow for classification and the temperature at which those properties are observed. ● describing how the properties will be classified by their observable similarities (pattern of the properties) and the method for classifying them. ● collecting and recording data on the properties of the materials. 2: Student demonstrates he/she is nearing proficiency by: ● describing which materials will be classified. ● describing which materials will be observed at different temperatures, and how those temperatures will be determined. ● collecting and recording data with guidance and support on the properties of the materials. 1: Student demonstrates limited understanding of structure and properties of matter.
Learning Targets - Matter Unit **Science and Engineering Practices** Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. **Disciplinary Core Ideas** ● Classify different kinds of materials by their observable properties ● Different properties are suited to different purposes. ● Which materials will be observed at different temperatures, and how those temperatures will be determined (e.g., using ice to cool and a lamp	

to warm) and measured (e.g., qualitatively or quantitatively).

Cross Cutting Concept

- To describe and classify
- Patterns in the natural and human designed world can be observed

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 2.PS1.A.2	
Learning Goal Students can analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of structure and properties of matter. 3: Student demonstrates mastery with the learning goal as evidenced by: ● describing relationships between properties of materials and some potential uses. ● using organized data to support or refute their ideas about which properties of materials allow the object or tool to be best suited for the given intended purpose relative to the other given objects/tools. 2: Student demonstrates he/she is nearing proficiency by: ● using the given data from tests of different materials to organize those materials by their properties. ● describing relationships between materials and their properties. 1: Student demonstrates limited understanding of structure and properties of matter.

Learning Targets - Matter Unit

Science and Engineering Practices
Analyze data from tests of an object or tool to determine if it works as intended.

Disciplinary Core Ideas
Different properties are suited to different purposes.

Cross Cutting Concept
Simple tests can be designed to gather evidence to support or refute student ideas about causes.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 3.PS1.B.1

<table>
<tr>
<td>

Learning Goal

Students can construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.

</td>
<td>

Proficiency Scale

4: Student demonstrates advanced application and understanding of structure and properties of matter.

3: Student demonstrates mastery with the learning goal as evidenced by:

- evaluating whether changes in a material after heating or cooling are reversible or non-reversible.
- providing evidence to support their claim about reversible and non-reversible changes.

2: Student demonstrates he/she is nearing proficiency by:

- describing the characteristics of the material before and after heating or cooling.
- describing the difference between a reversible and non-reversible change.

1: Student demonstrates limited understanding of structure and properties of matter.

</td>
</tr>
</table>

Learning Targets - Matter Unit

Science and Engineering Practices

- Engaging in argument from evidence in grades 3–5 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed worlds.
- Construct an argument with evidence to support a claim.

Disciplinary Core Ideas

Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.

Cross Cutting Concept

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

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 3.LS3.C.1	
Learning Goal Students can 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.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of environmental impacts on ecosystems. 3: Student demonstrates mastery with the learning goal as evidenced by: ● evaluating evidence to determine the similarities and differences in needs among at least 3 types of organisms. ● evaluating evidence to determine how and what features of the habitat meet and do not meet the needs of each of the organisms. ● constructing an argument with evidence that suggests a cause-and-effect relationship within the system between the characteristics of a habitat and the survival of organisms within it. 2: Student demonstrates he/she is nearing proficiency by: ● describing the characteristics of a given particular environment. ● describing the characteristics and needs of a particular organism. 1: Student demonstrates limited understanding of environmental impacts on ecosystems.
Learning Targets - Life and Environment Unit **Science and Engineering Practices** Engaging in argument from evidence in grades 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed worlds. **Disciplinary Core Ideas** For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. **Cross Cutting Concept** Cause and effect relationships are routinely identified and used to explain change.	

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 3.LS3.D.1	
Learning Goal Students can make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of environmental impacts on ecosystems. 3: Student demonstrates mastery with the learning goal as evidenced by: ● evaluating the solution to the problem and describing how well the proposed solution reduces the impact of the problem created by the environmental change in the system. ● describing how the solution makes changes to one part of the system, affecting the other parts of the system and how the solution affects plants and animals. 2: Student demonstrates he/she is nearing proficiency by: ● describing a system of plants, animals, and a given environment within which they live before the given environmental change occurs. ● describing a given change in the environment. ● describing how the change in the given environment causes a problem for existing plants and animals living within that area. 1: Student demonstrates limited understanding of environmental impacts on ecosystems.
Learning Targets - Life and Environment Unit **Science and Engineering Practices** ● Engaging in argument from evidence in grades 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed worlds. ● 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. **Disciplinary Core Ideas** ● When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms	

survive and reproduce, some move to new locations, some move into the transformed environment, and some die.

- Populations live in a variety of habitats, and change in those habitats affects the organisms living there.

Cross Cutting Concept

- A system can be described in terms of its components and their interactions.
- Knowledge of relevant scientific concepts and research findings is important in engineering.

<table>
<tr><td colspan="2">High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 3.LS1.B.1</td></tr>
<tr><td><u>Learning Goal</u>

Students can develop models to compare and contrast observations on the life cycles of different plants and animals.</td>
<td><u>Proficiency Scale</u>

4: Student demonstrates advanced application and understanding of life cycles and traits.

3: Student demonstrates mastery with the learning goal as evidenced by:
● developing models and identifying the following:
○ organisms (both plant and animal)
○ birth
○ growth
○ reproduction
○ death
● describing the causal direction of the cycle.
● describing that although organisms can display life cycles that look different, they all follow the same pattern.

2: Student demonstrates he/she is nearing proficiency by:
● developing models and identifying some but not all of the following:
○ organisms (both plant and animal)
○ birth
○ growth
○ reproduction
○ death
● describing that organisms are born, grow and die in a pattern known as a life cycle.

1: Student demonstrates limited understanding of life cycles and traits.</td></tr>
</table>

Learning Targets - Life and Environment Unit

Science and Engineering Practices
Develop models to describe phenomena.
Disciplinary Core Ideas
Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles.
Cross Cutting Concept
Patterns of change can be used to make predictions.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 3.LS3.A.1	
Learning Goal	**Proficiency Scale**
Students can analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and some are influenced by the environment.	4: Student demonstrates advanced application and understanding of life cycles and traits. 3: Student demonstrates mastery with the learning goal as evidenced by: ● identifying and describing patterns in the data to show similarities and differences in the traits of a parent and the traits of an offspring or among siblings. ● using reasoning to connect the evidence to describe a cause-and-effect relationship between a specific causal environmental factor and its effect of a given variation in a trait. 2: Student demonstrates he/she is nearing proficiency by: ● identifying the traits of plant and animal parents and offspring or siblings ● identifying observable inherited traits or organisms in varied environmental conditions. ● describing environmental factors that may influence organisms' traits. 1: Student demonstrates limited understanding of life cycles and traits.

Learning Targets - Life and Environment Unit

Science and Engineering Practices

- Analyze and interpret data to make sense of phenomena using logical reasoning.
- Constructing explanations and designing solutions in grades 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.
- Use evidence (e.g., observations, patterns) to support an explanation.

Disciplinary Core Ideas

- Many characteristics of organisms are inherited from their parents.
- Different organisms vary in how they look and function because they have different inherited information.
- Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment.
- The environment also affects the traits that an organism develops.

Cross Cutting Concept

- Similarities and differences in patterns can be used to sort and classify natural phenomena.
- Cause and effect relationships are routinely identified and used to explain change.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 3.LS3.B.1

Learning Goal	**Proficiency Scale**
Students can 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.	4: Student demonstrates advanced application and understanding of life cycles and traits. 3: Student demonstrates mastery with the learning goal as evidenced by: ● using reasoning to logically connect the evidence to describe that certain variations in characteristics make it harder or easier for an animal to survive, find mates, and reproduce. ● using reasoning to logically connect the evidence to describe characteristics that make it easier for some organisms to survive, find mates, and reproduce give those organisms an advantage over other organisms of the same species that don't have those traits. ● using reasoning to logically connect the evidence to describe that there can be a cause-and –effect relationship between a specific variation in a characteristic and its effect on the ability of the individual organism to survive and reproduce. 2: Student demonstrates he/she is nearing proficiency by: ● describing a given characteristic of a species. ● describing the patterns of variation of a given characteristic among individuals in a species. ● describing the potential benefits of a given variation of the characteristic. 1: Student demonstrates limited understanding of life cycles and traits.

Learning Targets - Life and Environment Unit

Science and Engineering Practices
- Constructing explanations and designing solutions in grades 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.
- Use evidence (e.g., observations, patterns) to support an explanation.

Disciplinary Core Ideas

Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.

Cross Cutting Concept
Cause and effect relationships are routinely identified and used to explain change.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.) Missouri Learning Goal 4.PS2.A.2	
Learning Goal Students can plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of forces and interactions. 3: Student demonstrates mastery with the learning goal as evidenced by: ● developing an investigation which produces sufficient data to serve as the basis for evidence for how balanced and unbalanced forces determine an object's motion. ● describing the change in motion of an object at rest after different strengths and directions of balanced and unbalanced forces are applied to the object. 2: Student demonstrates he/she is nearing proficiency by: ● describing an object at rest and identifying the forces acting on it. ● describing an object in motion and identifying the forces acting on it. 1: Student demonstrates limited understanding of forces and interactions.

Learning Targets - Force and Motion Unit

Science and Engineering Practices
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.

Disciplinary Core Ideas
Each force acts on one particular object and has both strength and 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.

Cross Cutting Concept
Cause and effect relationships are routinely identified.

<table>
<tr><td colspan="2">High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)
Missouri Learning Goal 4.PS2.A.1</td></tr>
<tr><td><u>Learning Goal</u>
Students can make observations and/or measurements of an object’s motion to provide evidence that a pattern can be used to predict future motion.</td><td><u>Proficiency Scale</u>
4: Student demonstrates advanced application and understanding of forces and interactions.
3: Student demonstrates mastery with the learning goal as evidenced by:
● identifying and describing the data to be collected through observations and/or measurement, including data on the motion of the object as it repeats a pattern over time.
● identifying a pattern that can be used to predict future motion.
2: Student demonstrates he/she is nearing proficiency by:
● observing and identifying the motion of an object.
● predicting the future motion of an object.
1: Student demonstrates limited understanding of forces and interactions.</td></tr>
<tr><td colspan="2"><u>Learning Targets - Force and Motion Unit</u>
Science and Engineering Practices
Make observations and/or measurements to provide evidence for the explanation of a pattern within a phenomenon.
Disciplinary Core Ideas
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.
Cross Cutting Concept
Patterns of change can be used to make predictions.</td></tr>
</table>

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 3.PS2.B.1	
Learning Goal Students can ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of forces and interactions. 3: Student demonstrates mastery with the learning goal as evidenced by: ● asking questions from observations of two objects not in contact with each other interacting thought electric or magnetic forces. ● identifying the cause-and-effect relationships between: ○ the sizes of the forces on two interacting objects due to the distance between the two objects. ○ the presence of a magnet and the force the magnet exerts on other objects. ○ static electrically charged objects and a static electric force. 2: Student demonstrates he/she is nearing proficiency by: ● asking questions with guidance and support from observations of two objects not in contact with each other interacting through static electric or magnetic forces. ● determining the relationship between the relative orientation of two magnets and whether the force between the magnets is attractive or repulsive. 1: Student demonstrates limited understanding of forces and interactions.
Learning Targets - Force and Motion Unit **Science and Engineering Practices** Ask questions that can be investigated based on patterns such as cause and effect relationships. **Disciplinary Core Ideas** 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, their distances apart, and, for forces between two magnets, on their orientation relative to each other. **Cross Cutting Concept**	

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

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 4.PS2.B.1	
Learning Goal Students can plan and conduct a fair test to compare and contrast the forces (measured by a spring scale in Newtons) required to overcome friction when an object moves over different surfaces (i.e., rough/smooth)	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of forces and interactions. 3: Student demonstrates mastery with the learning goal as evidenced by: ● developing a testing plan that includes: ○ the surfaces to be tested. ○ the object that will move across each surface. ○ using a spring scale to measure Newtons. ● conducting a fair test that includes an accurate way to collect and record data. ● using the data collected, comparing and contrasting the forces needed to overcome friction when the object moved over different surfaces. 2: Student demonstrates he/she is nearing proficiency by: ● measuring the force required to overcome friction when an object moves over different surfaces using a spring scale in Newtons. ● conducting a fair test and recording data, with guidance and support, to show the forces needed to overcome friction. 1: Student demonstrates limited understanding of forces and interactions.
Learning Targets - Force and Motion Unit **Science and Engineering Practices** 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. **Disciplinary Core Ideas** The effect of unbalanced forces on an object results in a change of motion. Patterns of motion can be used to predict future motion. Some forces act through contact; some forces act even when the objects are not in contact. The gravitational force of Earth acting on an object near Earth's surface	

pulls that object toward Earth’s center.
Cross Cutting Concept
Cause and effect relationships are routinely identified.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 4.LS1.A.1	
Learning Goal Students can construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of structure, function, and information processing. 3: Student demonstrates mastery with the learning goal as evidenced by: ● using reasoning to connect the relevant and appropriate evidence and construct an argument that: ○ internal and external structures serve specific functions within plants and animals. ○ the functions of internal and external structures can support survival, growth, behavior, and/or reproduction in plants and animals. ○ different structures work together as part of a system to support survival, growth, behavior and/or reproduction. 2: Student demonstrates he/she is nearing proficiency by: ● identifying the internal and external structures of selected plants and animals. ● describing the primary functions of those structures. 1: Student demonstrates limited understanding of structure, function, and information processing.
Learning Targets - Survival, Senses, and Adaptations Unit **Science and Engineering Practices** Construct an argument with evidence, data, and/or a model. **Disciplinary Core Ideas** Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction **Cross Cutting Concept** A system can be described in terms of its components and their interactions.	

<table>
<tr><th colspan="2">High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 4.LS1.D.1</th></tr>
<tr><td><u>Learning Goal</u>

Students can use a model 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.</td><td><u>Proficiency Scale</u>

4: Student demonstrates advanced application and understanding of structure, function, and information processing.

3: Student demonstrates mastery with the learning goal as evidenced by:
● using a model to describe that different types of sensory information are relayed to the brain via different sensory receptors allowing experiences to be perceived, stored as memories, and influence behavior.
● using a model to describe interactions between the following:
○ information in the environment.
○ different types of sense receptors.
○ perception and memory of sensory information.
○ animal behavior.

2: Student demonstrates he/she is nearing proficiency by:
● identifying and describing from a given model:
○ different types of information about the surroundings.
○ sense receptors able to detect different types of information from the environment.
○ animals’ actions.

1: Student demonstrates limited understanding of structure, function, and information processing.</td></tr>
</table>

Learning Targets - Survival, Senses, and Adaptations Unit

Science and Engineering Practices
Use a model to test interactions concerning the functioning of a natural system.
Disciplinary Core Ideas
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 interaction.
Cross Cutting Concept
A system can be described in terms of its components and their interactions.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 5.LS1.A.1	
Learning Goal Students can compare and contrast the major organs/organ systems (e.g. support, reproductive, digestive, transport/circulatory, excretory, response) that perform similar functions for animals belonging to different vertebrate classes.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of structure, function, and information processing. 3: Student demonstrates mastery with the learning goal as evidenced by: ● comparing and contrasting major organs/organ systems that perform similar function in at least two different vertebrate classes (ex. fish, amphibians, reptiles, birds, mammals). 2: Student demonstrates he/she is nearing proficiency by: ● identifying major organs/organ systems in animals. ● identifying the functions of major organs/organ systems in animals. 1: Student demonstrates limited understanding of structure, function, and information processing.
Learning Targets - Survival, Senses, and Adaptations Unit **Science and Engineering Practices** ● Identify the evidence that supports particular points and in explanation. ● Construct and/or support an argument with evidence, data, and/or a model **Disciplinary Core Ideas** Organisms have both internal and external macroscopic structures that allow for growth, survival, behavior, and reproduction with organs that are specialized for particular body functions. **Cross Cutting Concept** ● Students understand that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. Students can also describe a system in terms of its components and their interactions. ● Energy can be transferred in various ways and between objects.	

<table>
<tr><th colspan="2">High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 4.PS4.A.1</th></tr>
<tr><td><u>Learning Goal</u>

Students can develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.</td>
<td><u>Proficiency Scale</u>

4: Student demonstrates advanced application and understanding of waves.

3: Student demonstrates mastery with the learning goal as evidenced by:
● developing a model of waves and identifying the following:
○ waves
○ wave amplitude
○ wavelength
○ motion of objects
● identifying and describing that waves can be described in terms of patterns of repeating amplitude and wavelength.
● using the model to describe the similarities and differences in patterns underlying waves and uses these patterns to describe simple relationships involving wave amplitude, wavelength, and the motion of an object.

2: Student demonstrates he/she is nearing proficiency by:
● developing a model of waves and identifying some but not all of the following:
○ waves
○ wave amplitude
○ wavelength
○ motion of objects
● identifying and describing that waves can cause an object to move.
● using the model to describe how waves may be initiated.

1: Student demonstrates limited understanding of waves.</td></tr>
</table>

Learning Targets - Waves and Energy Unit

Science and Engineering Practices
Develop a model using an analogy, example, or abstract representation to describe a scientific principle.

Disciplinary Core Ideas
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).

Cross Cutting Concept
Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 4.PS3.A.1

Learning Goal	Proficiency Scale
Students can use evidence to construct an explanation relating the speed of an object to the energy of that object.	4: Student demonstrates advanced application and understanding of energy. 3: Student demonstrates mastery with the learning goal as evidenced by: ● using evidence to describe that motion can indicate the energy of an object. ● creating models that demonstrate how energy is transferred from a moving object interacting with its surroundings and transferring between objects. 2: Student demonstrates he/she is nearing proficiency by: ● identifying and describing the relative speed of the object. ● identifying and describing the qualitative indicators of the amount of energy of the object, as determined by a transfer of energy from that object. 1: Student demonstrates limited understanding of energy.

Learning Targets - Waves and Energy Unit

Science and Engineering Practices
Use evidence (e.g., measurements, observations, patterns) to construct an explanation.
Disciplinary Core Ideas
Moving objects contain energy. The faster a given object is moving, the more energy it possesses. Energy can be moved from place to place by moving objects.
Cross Cutting Concept
Energy can be transferred in various ways and between objects.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 4.PS3.B.1	
Learning Goal Students can make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of energy. 3: Student demonstrates mastery with the learning goal as evidenced by: ● making and recording observations to provide evidence that energy is present whenever there are moving objects, sound, light, or heat. ● making and recording observation to provide evidence that energy has been transferred from place to place. 2: Student demonstrates he/she is nearing proficiency by: ● describing the motion and collision of objects before and after an interaction. ● describing the relative present of sound, light, or heat before and after an interaction. ● describing the presence of electric currents flowing through wires causally linking one for of energy output to another form of energy output. ● describing that energy can be transferred from place to place by: ○ moving objects ○ sound ○ light ○ heat ○ electric currents 1: Student demonstrates limited understanding of energy.

Learning Targets - Waves and Energy Unit

Science and Engineering Practices
Use evidence (e.g. measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
Disciplinary Core Ideas
Energy can be moved from place to place by moving objects or through sound, light, heat and temperature change, and magnetic effects.
Cross Cutting Concept
Energy can be transferred in various ways and between objects.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 4.PS3.B.2	
Learning Goal Students can apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of energy. 3: Student demonstrates mastery with the learning goal as evidenced by: ● designing a solution to a given problem that converts energy from one form to another. ● testing the device and using the results of the test to address problems in the design or improve its functioning. 2: Student demonstrates he/she is nearing proficiency by: ● designing a solution to a given problem with guidance and support that converts energy from one form to another. ● describing the initial and final forms of energy. ● identifying the device by which the energy will be transformed. 1: Student demonstrates limited understanding of energy.
Learning Targets - Waves and Energy Unit **Science and Engineering Practices** Apply scientific ideas to solve design problems. **Disciplinary Core Ideas** Energy can be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat or light. The currents may have been produced to begin with transforming the energy of motion into electrical energy. **Cross Cutting Concept** Energy can be transferred in various ways and between objects.	

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 4.PS3.C.1	
Learning Goal Students can use models to explain that simple machines change the amount of effort and/or direction of force.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of simple machines. 3: Student demonstrates mastery with the learning goal as evidenced by: ● using 3 or more models to explain how the amount of effort and/or direction of forces is changed with a simple machine. ● describing the relationship between the amount of effort and the direction of force when using a simple machine. 2: Student demonstrates he/she is nearing proficiency by: ● using 1-2 models to explain how the amount of effort and/or direction of forces is changed with a simple machine. ● describing the effort, force, and movement of simple machines. 1: Student demonstrates limited understanding of simple machines.
Learning Targets - Waves and Energy Unit **Science and Engineering Practices** Develop a model using an analogy, example, or abstract representation to describe a scientific principle. **Disciplinary Core Ideas** A simple machine can change the amount of force or distance necessary to do work. **Cross Cutting Concept** A system can be described in terms of its components and their interactions.	

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 1.ESS2.D.1

Learning Goal	Proficiency Scale
Students can identify patterns indicating relationships between observed weather data and weather phenomena (e.g., temperature and types of precipitation, clouds and amounts of precipitation)	4: Student demonstrates advanced application and understanding of weather and climate. 3: Student demonstrates mastery with the learning goal as evidenced by: ● identifying patterns showing the relationship between observed weather data and weather phenomena. 2: Student demonstrates he/she is nearing proficiency by: ● identifying the signs that different weather is going to happen. ● describing typical attributes of weather. 1: Student demonstrates limited understanding of weather and climate.

Learning Targets - Weather Unit

Science and Engineering Practices

- Make observations and collect data about local weather conditions (e.g., temperature, types of precipitation, amount of precipitation, clouds, sun, wind).
- Record weather information using pictures, drawings, and/or writings of observations.
- Use observations to identify patterns and/or relationships of weather phenomena.
- Use information from observations to construct an evidence-based account for weather phenomena.
- Read grade-appropriate texts and/or use media to obtain scientific and/or technical information
- Determine patterns in and/or evidence about the natural and designed world(s).

Disciplinary Core Ideas

- Weather is the combination of sunlight, wind, snow or rain, and temperature at a particular time.
- Temperature varies during the day (e.g., cooler, warmer, hotter, colder).
- Types of precipitation (e.g., rain, snow, sleet, hail) Relationships between weather conditions (e.g., precipitation and clouds, temperature, type of precipitation)

- People measure weather conditions to describe and record the weather and to notice patterns and relationships over time.

Cross Cutting Concept

Weather events have causes that generate observable patterns (e.g., cold temperature cause snow).

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 3.ESS3.B.1

Learning Goal	Proficiency Scale
Students can make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.	4: Student demonstrates advanced application and understanding of weather and climate. 3: Student demonstrates mastery with the learning goal as evidenced by: ● evaluating the evidence to determine how the proposed solution addresses the problem, including the impact of the weather-related hazard after the design solution have been implemented. ● evaluating the merits of a given solution in reducing the impact of a weather-related hazard. ● evaluating the benefits and risks a given solution poses when responding to the societal demand to reduce the impact of the hazard. 2: Student demonstrates he/she is nearing proficiency by: ● identifying weather related hazards. ● identifying problems caused by weather related hazards. ● describing with guidance and support how a proposed solution addresses the problem. 1: Student demonstrates limited understanding of weather and climate.

Learning Targets - Weather Unit

Science and Engineering Practices
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.
Disciplinary Core Ideas
A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.
Cross Cutting Concept
Cause and effect relationships are routinely identified, tested, and used to explain change.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 3.ESS2.D.2	
Learning Goal Students can obtain and combine information to describe climates in different regions of the world.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of weather and climate. 3: Student demonstrates mastery with the learning goal as evidenced by: ● combining obtained information to provide evidence about the climate patterns in a region that can be used to make predictions about typical weather conditions in that region. 2: Student demonstrates he/she is nearing proficiency by: ● describing the difference between weather and climate. ● collecting information about the climate of a region of the world. 1: Student demonstrates limited understanding of weather and climate.
Learning Targets - Weather Unit ● **Science and Engineering Practices** ● Obtain and combine information from books and other reliable media to explain phenomena (observable events). ● **Disciplinary Core Ideas** ● Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. ● **Cross Cutting Concept** ● Patterns of change can be used to make predictions.	

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 3.ESS2.D.1	
Learning Goal Students can represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of weather and climate. 3: Student demonstrates mastery with the learning goal as evidenced by: ● organizing and representing given data by season using tables, pictographs, and/or bar graphs including weather condition data from the same area across multiple seasons and weather conditions data from different areas. ● using patterns of weather conditions in different seasons and different areas to predict the typical weather conditions expected during a particular season in different areas. 2: Student demonstrates he/she is nearing proficiency by: ● organizing and representing given data with guidance and support by season using tables, pictographs, and/or bar graphs. ● identifying and describing weather conditions across different seasons and in different areas. 1: Student demonstrates limited understanding of weather and climate.
Learning Targets - Weather Unit **Science and Engineering Practices** Represent data in tables and various graphical displays (e.g., bar graphs, line graphs, pictographs) to reveal patterns that indicate relationships. **Disciplinary Core Ideas** Scientists record patterns of the weather across different times and areas so they can make predictions about what kind of weather might happen next. **Cross Cutting Concept** Patterns of change can be used to make predictions.	

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 4.ESS1.C.1

Learning Goal	**Proficiency Scale**
Students can identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.	4: Student demonstrates advanced application and understanding of Earth's systems and processes that shape the Earth. 3: Student demonstrates mastery with the learning goal as evidenced by: ● using reasoning to connect the evidence to support the explanation that specific rock layers in the same location show specific fossil patterns. ● using reasoning to connect the evidence to support the explanation that since lower layers were formed first then covered up by upper layers, this pattern indicates that the landscape of the area was transformed onto the landscape indicated by the upper layer. ● using reasoning to connect the evidence to support the explanation that irregularities in the patterns of rock layers indicate disruptions due to Earth forces. 2: Student demonstrates he/she is nearing proficiency by: ● identifying different rock layers found in an area. ● identifying the order of rock layers. ● identifying the presence of particular fossils. ● identifying the occurrence of events due to Earth forces. ● describing how rock layers are formed. 1: Student demonstrates limited understanding of Earth's systems and processes that shape the Earth.

Learning Targets - Our Dynamic Earth Unit

Science and Engineering Practices
Identify the evidence that supports particular points in an explanation.
Disciplinary Core Ideas
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.
Cross Cutting Concept

- Patterns can be used as evidence to support an explanation.
- For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

<table>
<tr><td colspan="2">

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 4.ESS2.A.1
</td></tr>
<tr><td>

<u>Learning Goal</u>

Students can make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, wind, or vegetation.
</td><td>

<u>Proficiency Scale</u>

4: Student demonstrates advanced application and understanding of Earth's systems and processes that shape the Earth.

3: Student demonstrates mastery with the learning goal as evidenced by:

- making and recording observations to provide evidence on how weathering breaks rocks, soil, and sediments into smaller pieces and moves them around.
- identifying the cause and effect relationships between weathering or erosion, and Earth materials.

2: Student demonstrates he/she is nearing proficiency by:

- describing the kind of weathering or erosion to which the Earth material is exposed.
- identifying a variety of forces that break down rocks, soil and sediments.
- defining weathering and erosion and describing the similarities and differences between them.

1: Student demonstrates limited understanding of Earth's systems and processes that shape the Earth.
</td></tr>
<tr><td colspan="2">

<u>Learning Targets - Our Dynamic Earth Unit</u>

Science and Engineering Practices
Make observations and/or measurements to provide evidence for the explanation of a pattern within a phenomenon.
Disciplinary Core Ideas
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>
</table>

Cross Cutting Concept

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

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 4.ESS2.B.1	
Learning Goal Students can analyze and interpret data from maps to describe patterns of Earth's features.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of Earth's systems and processes that shape the Earth. 3: Student demonstrates mastery with the learning goal as evidenced by: ● using maps to identify areas of the Earth where it can be predicted that features such as mountain chains, deep ocean trenches, volcanoes, and earthquake regions can occur. ● describing that Earth features occur in patterns that reflect information about how they are formed or occur. 2: Student demonstrates he/she is nearing proficiency by: ● recognizing that there are areas of the earth that have common patterns such as mountain chains, deep ocean trenches, volcanoes, and earthquake regions. ● identify the location of Earth features, including the locations of mountain ranges, deep ocean trenches, earthquakes, and volcanoes. 1: Student demonstrates limited understanding of Earth's systems and processes that shape the Earth.
Learning Targets - Our Dynamic Earth Unit **Science and Engineering Practices** Analyze and interpret data to make sense of phenomena using logical reasoning. **Disciplinary Core Ideas** 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 of Earth.	

Cross Cutting Concept

Patterns can be used as evidence to support an explanation.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 4.ESS3.A.1	
Learning Goal Students who demonstrate understanding can generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of Earth's systems and processes that shape the Earth. 3: Student demonstrates mastery with the learning goal as evidenced by: ● designing at least two solutions that reduce the impacts of natural Earth processes on humans. ● describing and using cause and effect relationships between the Earth's processes and its observed effect. 2: Student demonstrates mastery with the learning goal as evidenced by: ● designing at least two solutions that reduce the impacts of natural Earth processes on humans. ● describing and using cause and effect relationships between the Earth's processes and its observed effect. 1: Student demonstrates limited understanding of Earth's systems and processes that shape the Earth.
Learning Targets - Our Dynamic Earth Unit **Science and Engineering Practices** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. **Disciplinary Core Ideas** A variety of hazards result from natural processes (e.g., earthquakes, floods, tsunamis, volcanic eruptions, landslides, hurricanes). Humans cannot eliminate the hazards but can take steps to reduce their impacts. **Cross Cutting Concept**	

Cause and effect relationships are routinely identified, tested, and used to explain changes.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 5.PS1.B.1	
Learning Goal Students can plan and conduct investigations to separate the components of a mixture/solution by their physical properties (ie. sorting, filtration, magnets, screening).	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of properties of matter. 3: Student demonstrates mastery with the learning goal as evidenced by: ● developing a plan to separate the components of a mixture/solution by its physical properties. ● collecting and recording observations about different components and their physical properties. ● describing the relationship between the physical properties of different components and the best method used to separate it from the mixture/solution. 2: Student demonstrates he/she is nearing proficiency by: ● identifying and describing the materials to be used to separate the components of a mixture/solution. ● identifying physical properties of different components. 1: Student demonstrates limited understanding of properties of matter.
Learning Targets - Matter Unit **Science and Engineering Practices** ● Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using a fair test in which variables are controlled and the number of trials are considered. ● Describe ways to separate the components of a mixture/solution by their properties (i.e., sorting, filtration, magnets, screening). **Disciplinary Core Ideas** Matter exists as different substances that have observable different properties. Components of mixtures and solutions can be separated using a variety of methods, depending on the properties of the individual components. **Cross Cutting Concept**	

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

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 5.PS1.A.1	
Learning Goal Students can develop a model to describe that matter is made of particles too small to be seen.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of matter. 3: Student demonstrates mastery with the learning goal as evidenced by: ● developing a model that includes the idea that matter is made of particles too small to be seen. ● identifying the relevant components in the model of bulk matter and particles of matter that are too small to be seen. ● describing the relevant relationships between bulk matter and tiny particles that cannot be seen. 2: Student demonstrates he/she is nearing proficiency by: ● using a model to identify the relevant components of bulk matter and particles of matter that are too small to be seen. 1: Student demonstrates limited understanding of matter.
Learning Targets - Matter Unit **Science and Engineering Practices** Using models to describe phenomena **Disciplinary Core Ideas** Matter of any type can be subdivided into particles that are too small to see, but even then 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. **Cross Cutting Concept** Natural objects exist from the very small to the immensely large.	

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 5.PS1.A.2

Learning Goal

Students can measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.

Proficiency Scale

4: Student demonstrates advanced application and understanding of the conservation of matter.

3: Student demonstrates mastery with the learning goal as evidenced by:

- measuring and/or calculating the difference between the total weight of the substances before and after they are heated, cooled, and/or mixed.
- describing the changes in properties they observe during and/or after heating, cooling, or mixing substances.
- using their measurements and calculations to describe that the total weight of the substances did not change, regardless of the reaction or changes in properties that were observed.

2: Student demonstrates he/she is nearing proficiency by:

- measuring and graphing the weight of substances before they are heated, cooled, or mixed.
- measuring and graphing the weight of substances, including any new substances produced by a reaction, after they are heated, cooled, or mixed.

1: Student demonstrates limited understanding of the conservation of matter.

Learning Targets - Matter Unit

Science and Engineering Practices

Measure and graph quantities such as weight to address scientific and engineering questions and problems.

Disciplinary Core Ideas

- The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish.
- No matter what reaction or change in properties occurs, the total weight of the substances does not change. (Boundary: Mass and weight are not distinguished at this grade level.)

Cross Cutting Concept
Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 5.PS1.B.2	
Learning Goal Students can conduct an investigation to determine whether the mixing of two or more substances results in new substances.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of matter. 3: Student demonstrates mastery with the learning goal as evidenced by: ● describing the evidence from data that will be collected including: ○ quantitative (e.g. weight) and qualitative (e.g. state of matter, color, texture, odor) properties of the substances to be mixed). ○ quantitative and qualitative properties of the resulting substances. ● describing how the collected data can serve as evidence for whether the mixing of the two or more rested substances results in one or more new substances. 2: Student demonstrates he/she is nearing proficiency by: ● collaboratively collecting and recording data, including data about the substances before and after mixing. 1: Student demonstrates limited understanding of matter.
Learning Targets - Matter Unit **Science and Engineering Practices** 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 is considered. **Disciplinary Core Ideas** When two or more different substances are mixed, a new substance with different properties may be formed. **Cross Cutting Concept** Cause and effect relationships are routinely identified and used to explain change.	

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goals K.PS1.A.1 and 2.PS1.A.1

Learning Goal	Proficiency Scale
Students can make observations and measurements to identify materials based on their properties.	4: Student demonstrates advanced application and understanding of structure and properties of matter. 3: Student demonstrates mastery with the learning goal as evidenced by: ● describing how data will be collected through: ○ quantitative measures of properties in standard units (e.g. grams, liters). ○ observations of properties such as color, conductivity, and reflectivity. ○ determination of conductors vs. nonconductors and magnetic vs. nonmagnetic materials. ● describing how the observations and measurements they make will allow them to identify materials based on their properties. 2: Student demonstrates he/she is nearing proficiency by: ● collecting and recording data on the properties of materials that can be used to identify those materials (e.g. color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility). 1: Student demonstrates limited understanding of structure and properties of matter.

Learning Targets - Matter Unit

Science and Engineering Practices
Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.
Disciplinary Core Ideas
Measurements of a variety of properties can be used to identify materials.
Cross Cutting Concept

Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 5.LS1.C.1

<table>
<tr><th>Learning Goal</th><th>Proficiency Scale</th></tr>
<tr><td>Students can support an argument that plants get the materials (i.e. carbon dioxide, water, sunlight) they need for growth chiefly from air and water.</td><td>4: Student demonstrates advanced application and understanding of energy flow in organisms.

3: Student demonstrates mastery with the learning goal as evidenced by:
● using reasoning to connect the evidence to support the claim with argumentation that:
○ plants do not acquire most of the material for growth from soil, because some plants don’t need soil to grow.
○ a plant cannot grow without water or air.
○ plant growth must come chiefly from water and air

2: Student demonstrates he/she is nearing proficiency by:
● describing the given evidence, data, and/or models that support the claim.
● showing evidence of plant growth over time and a plant’s inability to grow without water or air.

1: Student demonstrates limited understanding of energy flow in organisms.</td></tr>
</table>

Learning Targets - Ecosystems

Science and Engineering Practices
Support an argument with evidence, data, or a model.
Disciplinary Core Ideas
Plants acquire their material for growth chiefly from air and water.
Cross Cutting Concept
Matter is transported into, out of, and within systems.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 5.LS2.B.1	
Learning Goal Students can develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of the movement of matter in an ecosystem. 3: Student demonstrates mastery with the learning goal as evidenced by: ● developing a model describing the movement of matter within an ecosystem and identifying all of the relevant components, including: ○ matter ○ plants ○ animals ○ decomposers, such as fungi and bacteria ○ environment ● using the model to describe: ○ the cycling of matter in the system between plants, animals, decomposers, and the environment. ○ how interactions in the system of plants, animals, decomposers, and the environment allow multiple species to meet their needs. 2: Student demonstrates he/she is nearing proficiency by: ● developing a model describing the movement of matter within an ecosystem and identifying some, but not all of the relevant components, including: ○ matter ○ plants ○ animals ○ decomposers, such as fungi and bacteria

	○ environment ● Using the model to show: ○ animals that consume other animals. ○ animals that consume other plants. ○ organisms that consume dead plants and animals. 1: Student demonstrates limited understanding of the movement of matter in an ecosystem.

Learning Targets - Ecosystems

Science and Engineering Practices
Develop a model to describe phenomena.

Disciplinary Core Ideas

- 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 plants parts and animals) and therefore operate as decomposers. Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.
- Matter cycles between the air and soil and between plants, animals, and microbes as these organisms live and die. Organisms obtain gases and water from the environment and release waste matter (gas, liquid, or solid) back into the environment.

Cross Cutting Concept
A system can be described in terms of its components and their interactions. 2

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 5.PS3.D.1	
Learning Goal	**Proficiency Scale**
Students can use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.	4: Student demonstrates advanced application and understanding of food chains and food webs. 3: Student demonstrates mastery with the learning goal as evidenced by: ● using models to identify and describe the relationships between all of the following: ○ plants and the energy they get from the sunlight to produce food. ○ food and the energy and materials that animals require for bodily functions (body repair, growth, motion, body warmth maintenance). ○ animals and the food they eat, which is either other animals or plants (or both), to obtain energy for bodily functions and materials for growth and repair. 2: Student demonstrates he/she is nearing proficiency by: ● using models to identify and describe the relationships between some, but not all of the following: ○ plants and the energy they get from the sunlight to produce food. ○ food and the energy and materials that animals require for bodily functions (body repair, growth, motion, body warmth maintenance). ○ animals and the food they eat, which is either other animals or plants (or both), to obtain energy for bodily functions and materials for growth and repair. 1: Student demonstrates limited understanding of food chains and food webs.

Learning Targets - Ecosystems

Science and Engineering Practices
Use models to describe phenomena.

Disciplinary Core Ideas

- 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).
- Food provides animals with the materials they need for body repair and growth, the energy they need to maintain body warmth, and for motion.

Cross Cutting Concept
Energy can be transferred in various ways and between objects.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 5.ESS2.A.1	
Learning Goal Students can develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of Earth’s systems and interactions between them. 3: Student demonstrates mastery with the learning goal as evidenced by: ● developing a model to show the interactions between 2 of Earth’s systems. ● describing the interactions of how parts of an individual Earth system work together to affect the functioning of the Earth system and contribute to the functioning of the other relevant Earth system. 2: Student demonstrates he/she is nearing proficiency by: ● developing a model of 2 of Earth’s systems. ● identifying the relationships between the 2 Earth systems. 1: Student demonstrates limited understanding of Earth’s systems and the interactions between them.
Learning Targets - Earth Unit **Science and Engineering Practices** Develop a model using an example to describe a scientific principle. **Disciplinary Core Ideas** 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. **Cross Cutting Concept** A system can be described in terms of its components and their interactions	

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.) Missouri Learning Goal 5.ESS2.C.1	
Learning Goal Students can describe and graph the amounts and percentages of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.	**Proficiency Scale** 4: Student demonstrates advanced application, understanding, and in-depth inferences with water distribution on Earth. 3: Student demonstrates mastery with the learning goal as evidenced by: ● graphing the given data about the amount and percentage of saltwater and freshwater in each of the following reservoirs, as well as in all the reservoirs combined: ○ oceans ○ lakes ○ rivers ○ glaciers ○ ground water ○ polar ice caps ● using the graphs to describe all of the following: ○ the majority of water on Earth if found in the oceans. ○ most of the Earth's freshwater is stored in glaciers or underground. ○ a small percentage of freshwater is found in lakes, rivers, wetlands, and the atmosphere. 2: Student demonstrates he/she is nearing proficiency by: ● graphing the given data about the amount and percentage of saltwater and freshwater in some, but not all, of the following reservoirs, as well as in all the reservoirs combined: ○ oceans ○ lakes ○ rivers

	○ glaciers ○ ground water ○ polar ice caps ● using the graphs to describe some, but not all of the following: ○ the majority of water on Earth if found in the oceans. ○ most of the Earth’s freshwater is stored in glaciers or underground. ○ s small percentage of freshwater is found in lakes, rivers, wetlands, and the atmosphere. 1: Student demonstrates limited understanding of the water distribution on Earth.

Learning Targets - Earth Unit

Science and Engineering Practices
Describe and graph quantities such as area and volume to address scientific questions.
Disciplinary Core Ideas
Nearly all of Earth’s available water is in the oceans. Most freshwater is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.
Cross Cutting Concept
Standard units are used to measure and describe physical quantities such as weight and volume.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 5.ESS3.C.1	
Learning Goal Students can obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of Earth and human activity. 3: Student demonstrates mastery with the learning goal as evidenced by: ● obtaining and combining information from two or more sources to provide and describe evidence about the positive and negative effects on the environment as a result of human activities. ● describing evidence about how individual communities can use scientific ideas and a scientific understanding of interactions between components of environmental systems to protect a natural resource and the environment in which the resource is found. 2: Student demonstrates he/she is nearing proficiency by: ● obtaining information from books and other reliable media about how a given human activity affects the Earth's resources and environments. ● describing evidence about how a given community uses scientific ideas to protect a given natural resource and the environment in which the resource is found. 1: Student demonstrates limited understanding of Earth and human activity.
Learning Targets - Earth Unit **Science and Engineering Practices** Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. **Disciplinary Core Ideas** Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. **Cross Cutting Concept**	

A system can be described in terms of its components and their interactions.

<table>
<tr><td colspan="2">

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)

Missouri Learning Goal 5.PS2.B.1
</td></tr>
<tr><td>

<u>Learning Goal</u>

Students can support an argument that the gravitational force exerted by Earth on objects is directed towards the planet’s center.
</td><td>

<u>Proficiency Scale</u>

4: Student demonstrates advanced application and understanding of gravitational forces.

3: Student demonstrates mastery with the learning goal as evidenced by:

- defending the conclusion that gravitational force draws towards the Earth’s center based on the location of its surface using evidence, data, or a model.

2: Student demonstrates he/she is nearing proficiency by:

- describing how gravitational forces are present on Earth and that this force is equal on different objects.
- identifying that the gravitational force exerted by Earth on objects is directed down in any location.

1: Student demonstrates limited understanding of gravitational forces.
</td></tr>
<tr><td colspan="2">

<u>Learning Targets - Space Unit</u>

Science and Engineering Practices
Support an argument with evidence, data, or a model.
Disciplinary Core Ideas
The gravitational force of Earth acting on an object near Earth’s surface pulls that object toward the planet’s center.
Cross Cutting Concept
Cause and effect relationships are routinely identified and used to explain change.
</td></tr>
</table>

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 5.ESS1.A.1	
Learning Goal Students can support an argument that relative distances from Earth affects the apparent brightness of the sun compared to other stars.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of Earth's place in the universe. 3: Student demonstrates mastery with the learning goal as evidenced by: ● supporting an argument that the apparent brightness of the sun compared to other stars are due to their relative distances from the Earth. 2: Student demonstrates he/she is nearing proficiency by: ● understanding that differences in the sun's brightness and star brightness is caused by their relative distances from Earth. ● understanding the brightness of a light source is affected by its distance from the location being measured from. 1: Student demonstrates limited understanding of Earth's place in the universe.
Learning Targets - Space Unit **Science and Engineering Practices** Support an argument with evidence, data, or a model. **Disciplinary Core Ideas** 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. **Cross Cutting Concept** Natural objects exist, from the very small to the immensely large.	

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 5.ESS1.B.2	
Learning Goal Students can represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearances of some stars in the night sky.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of Earth's place in the universe. 3: Student demonstrates mastery with the learning goal as evidenced by: ● using data in graphical displays to connect observable patterns and their causes. These include all of the following: ○ daily patterns in length and direction of shadows. ○ daily patterns of day and night. ○ patterns of seasonal appearances of some stars in the night sky. 2: Student demonstrates he/she is nearing proficiency by: ● using data in graphical displays to connect observable patterns and their causes. These include 1-2 of the following: ○ daily patterns in length and direction of shadows. ○ daily patterns of day and night. ○ patterns of seasonal appearances of some stars in the night sky. 1: Student demonstrates limited understanding of Earth's place in the universe.
Learning Targets - Space Unit **Science and Engineering Practices** Represent data in graphical displays (e.g. bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. **Disciplinary Core Ideas** The orbits of Earth around the sun and 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.	

Cross Cutting Concept
Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena.

High Priority Standards (Missouri Learning Standards, National, CREDE, etc.)	
Missouri Learning Goal 5.ESS1.B.1	
Learning Goal Students can make observations during different seasons to relate the amount of daylight to the time of year.	**Proficiency Scale** 4: Student demonstrates advanced application and understanding of Earth's place in the universe. 3: Student demonstrates mastery with the learning goal as evidenced by: ● identifying and describing the relationship between the amount of daylight and the time of year. 2: Student demonstrates he/she is nearing proficiency by: ● making and recording observations about the relative length of the day in different seasons. 1: Student demonstrates limited understanding of Earth's place in the universe.

Learning Targets - Space Unit

Science and Engineering Practices

- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.
- Represent data in tables and/or various graphical displays, bar graphs, pictographs, and/or pie charts to reveal patterns that indicate relationships.
- Organize simple data sets to reveal patterns that suggest relationships.

Disciplinary Core Ideas

Patterns of seasons can be observed, described, and predicted.

Cross Cutting Concept

- Patterns of change can be used to make predictions.
- Events that occur together with regularity might or might not be a cause and effect relationship.
- Natural objects and/or observable phenomena exist, from the very small to the immensely large or from very short to very long time periods.

6th Grade Science

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)
NGSS CCC Patterns. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

Learning Goal	Proficiency Scale

Students will understand how patterns of forms and events guide organization and classification.	4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal.
	
	3: Student demonstrates mastery with the learning goal as evidenced by:
	• using patterns of time, rates of change and cycles to form opinions or ideas about the natural or designed world.
	• classifying information based on observed patterns.
	• organizing data to reveal patterns and uncovers a solution to a natural or designed problem.
	• using patterns to identify cause and effect relationships.
	
	2: Student demonstrates he/she is nearing proficiency by:
	• recognizing and recalling specific vocabulary, such as: evidence, qualitative, quantitative, bias, cause and effect.
	• performing processes such as:
	    o identifying patterns related to time, including simple rates of change and cycles.
	    o developing graphic representations to communicate patterns.
	
	1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets - Rock Cycle • identifying relevant and meaningful data to influence a conclusion.? • identifying bias in interpretations of data.?
Learning Targets - History of the Earth • MS-ESS2-3. Identifying patterns in data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. • Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: rock strata, relative, geologic, time scale, fossils, evolution, extinction, volcano, internal, external, sedimentary, igneous, weathering, erosion, volcano, earthquake, fault, expansion, contraction, decomposition, flood, mudslide, plate, tectonics.
Learning Targets - Matter and Energy in Organisms and Ecosystems • MS-LS2-1. Analyzing and interpreting data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. • Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: photosynthesis, reactants, products, chemical reaction, chloroplast, chlorophyll, molecule, respiration, ecosystem, resource, population, influence, physical, biological, food web, law of conservation of matter, producer, consumer, decomposer, ecosystem, predator, prey, scavenger, recycle, food chain.
Learning Targets - Natural Selection and Adaptation • MS-LS4-1. Identifying 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. • MS-LS4-2. Identifying patterns found in anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. • MS-LS4-3. Identifying patterns found in similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. • Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: fossil, diversity, extinction, anatomy, chronological, layer, era, fossil data, natural selection, adaptation, genetic, trait, survival, reproduction, chromosome, DNA, probability, sexual, asexual, proportional reasoning.

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)

NGSS

CCC Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

Learning Goal	Proficiency Scale
Students will be able to investigate and explain causal relationships.	4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: • demonstrating that events that occur together with regularity might or might not signify a cause and effect relationship. • designing mechanisms in order to test the outcomes. • explaining effects that are seen as a result of causes that are unseen. • proving how effects, resulting from factors, are beneficial or detrimental to a system or organism. 2: Student demonstrates he/she is nearing proficiency by: • recognizing and recalling specific vocabulary, such as: factor, organism, outcome. • performing processes such as: o identifying and testing causal relationships. o using relationships to explain change. 1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets - Earth's Resources

- MS-ESS3-1. Determining how past and current geoscience processes (cause) have influenced the uneven distributions of

Earth's mineral, energy, and groundwater resources (effect).
Learning Targets - Engineering Design • MS-ETS1-1. Defining 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. • Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: deforestation, overpopulation, water and air pollution, global warming, restoration of natural environments, river bank/coastal stabilization, recycling, channelization, reintroduction of species, depletion of resources, technology, mitigate, catastrophic, solution, monitoring, design, impact, aquifer, levee, development, wetland, pollution, population, per capita, consumption, resources, society
Learning Targets - Growth, Development, and Reproduction of Organisms • MS-LS1-4. Identifying patterns in animal behaviors and specialized plant structures that affect the probability of successful reproduction of animals and plants respectively. • Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: characteristics, behaviors, asexual, sexual, hereditary, Punnett square, genetic modification, chromosome, gene, gene therapy, predators, prey, trait, genetic modification, chromosome, gene, gene therapy, trait, sexual, asexual, agar, code, biotic, abiotic, composition, organism, competition, genotype, phenotype
Learning Targets - Human Impact • MS-ESS3-4. Determining how increases in human population and per-capita consumption of natural resources impact Earth's systems. • Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: volcano, earthquake, interior, exterior, mass wasting, tsunami, hurricane, typhoon, tornado, flood, magnitude, hazard, technology, mitigate, catastrophic, solution, monitoring, design, impact, aquifer, levee, development, wetland, pollution, population, per capita, consumption, resources, society, deforestation, overpopulation, water and air pollution, global warming, restoration of natural environments, river bank/coastal stabilization, recycling, channelization, reintroduction of species, depletion of resources, technology, mitigate, catastrophic, solution, monitoring, design, impact, aquifer, levee, development, wetland, pollution, population, per capita, consumption, resources, society
Learning Targets - Interdependent Relationships in Ecosystems

- MS-LS2-2. Using patterns to predict interactions among organisms across multiple ecosystems.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: ecosystem, biotic, abiotic, producer, consumer, decomposer, community, population, species, niche, habitat, photosynthesis, organism, competitive, predator, prey, symbiotic, mutually beneficial, purification, recycling, nutrient, erosion, deforestation, overpopulation, pollution, global warming, climate change, channelization, depletion, endangered, invasive species, habitat, biodiversity.

Learning Targets - Matter and Energy in Organisms and Ecosystems

- MS-LS2-1. Providing evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: photosynthesis, reactants, products, chemical reaction, chloroplast, chlorophyll, molecule, respiration, ecosystem, resource, population, influence, physical, biological, food web, law of conservation of matter, producer, consumer, decomposer, ecosystem, predator, prey, scavenger, recycle, food chain.

Learning Targets - Natural Selection and Adaptation

- MS-LS4-4. Describing how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
- MS-LS4-6. Explaining how natural selection may lead to increases and decreases of specific traits in populations over time.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: fossil, diversity, extinction, anatomy, chronological, layer, era, fossil data, natural selection, adaptation, genetic, trait, survival, reproduction, chromosome, DNA, probability, sexual, asexual, proportional reasoning.

Learning Targets - Earth's Systems

- MS-ESS3-1. Determining how past and current geoscience processes (cause) have influenced the uneven distributions of Earth's mineral, energy, and groundwater resources (effect).
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: melting, crystallization, weathering, deformation, sedimentation, minerals, metamorphic, igneous, hydrosphere, geosphere, atmosphere, evaporation, condensation, precipitation, surface run-off, groundwater flow, convection, conduction, radiation, water cycle, rock cycle, gravity, renewable, nonrenewable, geothermal, hydroelectric, fossil fuel, petroleum, sediment, ore, subduction zone, hydrothermal, resources.

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)

NGSS

CCC Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

<table>
<tr><th><u>Learning Goal</u></th><th><u>Proficiency Scale</u></th><th></th></tr>
<tr><td>Students will understand how changes in scale, proportion, or quantity affect a system’s structure and/or performance</td><td>4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal.

3: Student demonstrates mastery with the learning goal as evidenced by:
• recognizing what is relevant to a phenomena at different measures of size, time, and energy
• understanding the scale of systems too large or too small to be seen.
• comparing models to a natural or designed system in terms of scale, proportion, or quantity.
• creating a visual representation of data to communicate scale, proportion and/or quantity.

2: Student demonstrates he/she is nearing proficiency by:
• recognizing and recalling specific vocabulary, such as: proportion.
• performing processes such as:
  o recognizing natural objects and observable phenomena exist from the very small to the immensely large.
  o using standard units to measure and describe physical quantities such as, but not limited to, weight, time, temperature, and volume.
  o creating a visual representation of data to communicate scale, proportion and/or quantity.
  o recognizing numerical values of powers of 10.

1: Student demonstrates limited understanding or skill with the learning goal.</td><td></td></tr>
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Learning Targets - History of the Earth

- MS-ESS1-4. Explain, using evidence from rock strata, how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.
- MS-ESS2-2. Describing how geoscience processes have changed Earth's surface at varying time and spatial scales.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: rock strata, relative, geologic, time scale, fossils, evolution, extinction, volcano, internal, external, sedimentary, igneous, weathering, erosion, volcano, earthquake, fault, expansion, contraction, decomposition, flood, mudslide, plate, tectonics

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)

NGSS

CCC Systems and system models. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

Learning Goal	Proficiency Scale

Students will be able to define systems they are studying.	4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal.
	
	3: Student demonstrates mastery with the learning goal as evidenced by:
	• proving a system's boundaries, conditions, inputs and outputs.
	• identifying patterns of the inputs and outputs of a system.
	• using models to simulate systems.
	• evaluating the strengths and weaknesses of the models.
	
	2: Student demonstrates he/she is nearing proficiency by:
	• recognizing and recalling specific vocabulary, such as: boundaries, conditions, model.
	• performing processes such as:
	    ○ identifying the various functions the parts do within the whole.
	    ○ categorizing parts of a system and how they relate to the whole.
	
	1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets - Matter and Energy in Organisms and Ecosystems
• MS-LS1-7. Developing a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. • MS-LS2-3. Developing a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. • Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: photosynthesis, reactants, products, chemical reaction, chloroplast, chlorophyll, molecule, respiration, ecosystem, resource, population, influence, physical, biological, food web, law of conservation of matter, producer, consumer, decomposer, ecosystem, predator, prey, scavenger, recycle, food chain.
Learning Targets - Earth's Systems
• MS-ESS2-1. Developing a model to describe the cycling of Earth's materials and the flow of energy that drives this process. • MS-ESS2-4. Developing a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. • Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: melting, crystallization, weathering, deformation, sedimentation, minerals, metamorphic, igneous, hydrosphere, geosphere, atmosphere, evaporation, condensation, precipitation, surface run-off, groundwater flow, convection, conduction, radiation, water cycle, rock cycle, gravity, renewable, nonrenewable, geothermal, hydroelectric, fossil fuel, petroleum, sediment, ore, subduction zone, hydrothermal, resources.

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)
NGSS CCC *Energy and matter: Flows, cycles, and conservation.* Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

Learning Goal	Proficiency Scale
Students will understand how changes in energy and matter help them define a system's limitations and possibilities.	4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: • applying the law of conservation of matter as it is displayed in a natural or designed system. • illustrating the transfer and cycling of matter and energy in a system. 2: Student demonstrates he/she is nearing proficiency by: • recognizing and recalling specific vocabulary, such as: illustrate. • performing processes such as: o recognizing energy can be transferred in various ways and between objects. o observing and illustrating energy and matter flows and cycles in systems. 1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets - Matter and Energy in Organisms and Ecosystems

- MS-LS1-6. Interpreting the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- MS-LS1-7. Showing how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
- MS-LS2-3. Describing the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: photosynthesis, reactants, products, chemical reaction, chloroplast, chlorophyll, molecule, respiration, ecosystem, resource, population, influence, physical, biological, food web, law of conservation of matter, producer, consumer, decomposer, ecosystem, predator, prey, scavenger, recycle, food chain

Learning Targets - Earth’s Systems

- MS-ESS2-1. Describing the cycling of Earth's materials and the flow of energy that drives this process.
- MS-ESS2-4. Describing the cycling of water through Earth's systems highlighting the energy from the sun and the force of gravity.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: melting, crystallization, weathering, deformation, sedimentation, minerals, metamorphic, igneous, hydrosphere, geosphere, atmosphere, evaporation, condensation, precipitation, surface run-off, groundwater flow, convection, conduction, radiation, water cycle, rock cycle, gravity, renewable, nonrenewable, geothermal, hydroelectric, fossil fuel, petroleum, sediment, ore, subduction zone, hydrothermal, resources.

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)
NGSS CCC *Stability and change*. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Learning Goal	Proficiency Scale

Students will understand conditions of stability and rates of change.	4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal.
	
	3: Student demonstrates mastery with the learning goal as evidenced by:
	• understanding factors that influence stability and rates of change in a larger system.
	• identifying examples of systems in dynamic equilibrium.
	• measuring change (in systems, objects or organisms) in terms of differences over time.
	• identifying examples of systems that appear stable, but over long periods of time they will eventually, or already have, changed.
	
	2: Student demonstrates he/she is nearing proficiency by:
	• recognizing and recalling specific vocabulary, such as: rate, system, equilibrium, dynamic equilibrium.
	• performing processes such as:
	  o recognizing that change happens over time.
	  o identifying rates of change.
	  o identifying examples of stability and change within a system.
	
	1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets - Interdependent Relationships in Ecosystems ● MS-LS2-5. Evaluating ways of maintaining biodiversity and ecosystem services. ● Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: ecosystem, biotic, abiotic, producer, consumer, decomposer, community, population, species, niche, habitat, photosynthesis, organism, competitive, predator, prey, symbiotic, mutually beneficial, purification, recycling, nutrient, erosion, deforestation, overpopulation, pollution, global warming, climate change, channelization, depletion, endangered, invasive species, habitat, biodiversity.
Learning Targets - Matter and Energy in Organisms and Ecosystems ● MS-LS2-4. Predict how changes to physical or biological components of an ecosystem affect populations. ● Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: photosynthesis, reactants, products, chemical reaction, chloroplast, chlorophyll, molecule, respiration, ecosystem, resource, population, influence, physical, biological, food web, law of conservation of matter, producer, consumer, decomposer, ecosystem, predator, prey, scavenger, recycle, food chain.

7th Grade Science Curriculum

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)
NGSS CCC Patterns. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

Learning Goal	Proficiency Scale

Students will understand how patterns guide organization and classification.	4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal.
	
	3: Student demonstrates mastery with the learning goal as evidenced by:
	• making observations using both qualitative and quantitative data.
	• assessing the validity of the data from the process by which it was collected.
	• forming conclusions based on evidence and patterns from data.
	• organizing data in multiple ways to uncover patterns.
	
	2: Student demonstrates he/she is nearing proficiency by:
	• recognizing and recalling specific vocabulary, such as: audience, influence, conclusion, relevant, validity.
	• performing processes such as:
	  o organizing data to best meet the needs of the audience.
	  o Identifying relevant and meaningful data to influence a conclusion.
	  o identifying bias in interpretations of data.
	
	1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets - Universe

Universe - Goal 1: Student will analyze and interpret data to compare and contrast objects in the universe.
Universe - Goal 3: Student will develop and use models to describe cyclic patterns of lunar phases.
Universe - Goal 4: Student will develop and use models to describe cyclic patterns of Earth's seasons.
Universe - Goal 5: Student will develop and use models to describe cyclic patterns of eclipses.
Scientific Method - Goal 2: Student will be able to make qualitative and quantitative observations and distinguish between the two.
Scientific Method - Goal 3: Student clearly communicates data using tables and graphs.

Learning Targets - Human Impact

- MS-ESS3-2. Identifying patterns in data on natural hazards to forecast future catastrophic events.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: volcano, earthquake, interior, exterior, mass wasting, tsunami, hurricane, typhoon, tornado, flood, magnitude, hazard, technology, mitigate, catastrophic, solution, monitoring, design, impact, aquifer, levee, development, wetland, pollution, population, per capita, consumption, resources, society, deforestation, overpopulation, water and air pollution, global warming, restoration of natural environments, river bank/coastal stabilization, recycling, channelization, reintroduction of species, depletion of resources, technology, mitigate, catastrophic, solution, monitoring, design, impact, aquifer, levee, development.

Learning Targets - Space Systems

- MS-ESS1-1. Describing the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: eclipse, ellipse, season, axial tilt, rotation, revolution, latitude, equator, lunar, phase, scale, proportionality, crust, atmosphere, orbital radius, telescopes, satellites, solar system, galaxy, universe, gravity, satellites, orbit, ellipse

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)

NGSS

CCC Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

Learning Goal	Proficiency Scale
Students will be able to investigate and explain causal relationships.	4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: • identifying how various factors contribute to a cause and/or different results. • explaining why events have simple and multifaceted causes. • using relationships to predict phenomena in natural or designed systems. • proving that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. • classifying relationships as causal or correlational, and recognizing that correlation does not necessarily imply causation. 2: Student demonstrates he/she is nearing proficiency by: • recognizing and recalling specific vocabulary, such as: probability, correlation, causation, multifaceted. • performing processes such as: o explaining causes and the results of events in familiar contexts. o demonstrating that events that occur together with regularity might or might not signify a cause and effect relationship. o explaining effects that are seen as a result of causes that are unseen. 1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets - Universe

- **Universe - Goal 2:** Student will develop and use models to describe the role of gravity.
- **Universe - Goal 3:** Student will develop and use models to describe cyclic patterns of lunar phases.
- **Universe - Goal 4:** Student will develop and use models to describe cyclic patterns of Earth's seasons.
- **Universe - Goal 5:** Student will develop and use models to describe cyclic patterns of eclipses.

Learning Targets - Engineering Design

- MS-ETS1-1. Defining 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.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: science, engineering, technology, research, climate, natural resource, economics, renewable, non-renewable.

Learning Targets - Growth Development and Reproduction of Organisms

- MS-LS3-2. Describing why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.
- MS-LS1-5. Explaining how environmental and genetic factors influence the growth of organisms.
- MS-LS4-5. Interpreting the way humans influence (or have influenced) the inheritance of desired traits in organisms.
- **Growth, Development, & Reproduction - Goal 2:** Student describes how environmental and genetic factors affect growth and development of organisms.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: characteristics, behaviors, asexual, sexual, hereditary, Punnett square, chromosome, gene, predators, prey, trait, genetic modification, chromosome, gene, gene therapy, trait, sexual, asexual.

Learning Targets - Human Impact

- MS-ESS3-3. Determining how human activities impact the environment.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: volcano, earthquake, interior, exterior, mass wasting, tsunami, hurricane, typhoon, tornado, flood, magnitude, hazard, technology, mitigate, catastrophic, solution, monitoring, design, impact, aquifer, levee, development, wetland, pollution, population, per capita, consumption, resources, society, deforestation, overpopulation, water and air pollution, global warming,

restoration of natural environments, river bank/coastal stabilization, recycling, channelization, reintroduction of species, depletion of resources, technology, mitigate, catastrophic, solution, monitoring, design, impact, aquifer, levee, development.

Learning Targets - Structure, Function, and Information Processing

- MS-LS1-8. Explaining how sensory receptors cause a response to stimuli and how they are stored.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: brain, sensory, input, stimuli, response, nerve, receptor, memory, cell, organelle, multicellular, unicellular, nucleus, chloroplasts, mitochondria, cell membrane, cell wall, tissue, organs, cytoplasm, system, organism, biology, biomedical, nanotechnology, centrifuge, botany, veterinarian, circulatory, excretory, digestive, respiratory, muscular.
- **Structure, Function, & Information Processing - Goal 3:** Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. [Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.]

Learning Targets -Weather and Climate

- MS-ESS2-5. Demonstrating that the motions and complex interactions of air masses results in changes in weather conditions.
- MS-ESS2-5. Collecting data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
- **Weather - MS-ESS2-5. Goal 1:** Student can analyze data, including maps, and construct and use models to develop understanding of the factors that control weather.
- **Weather - MS-ESS2-6. Goal 2:** Student can analyze data, including maps, and construct and use models to develop understanding of the factors that control climate.
- **Weather - Goal 3:** Student can analyze evidence, including tables, graphs, maps to develop understanding of the natural factors and human activities that influence change in global temperature.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: weather, temperature, pressure, humidity, precipitation, wind, latitude, altitude, geographic land distribution, atmospheric circulation, oceanic circulation, climate, global temperature, natural factors, human activities

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)

NGSS

CCC Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

<table>
<tr><th>Learning Goal</th><th>Proficiency Scale</th></tr>
<tr><td>Students will understand how changes in scale, proportion, or quantity affect a system's structure and/or performance</td><td>4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal.

3: Student demonstrates mastery with the learning goal as evidenced by:
Relate objects or organisms using ratios and/or scales.
determining ratio or scale from data.
comparing quantities of objects or organisms using data.
2: Student demonstrates he/she is nearing proficiency by:
recognizing and recalling specific vocabulary, such as: ratio, magnitude, equation, model.
performing processes such as:
using estimation to make determinations of scale, proportion and quantity.
comparing a scale model to a natural or designed system.
creating a visual representation of data to communicate scale, proportion and/or quantity.
1: Student demonstrates limited understanding or skill with the learning goal.</td></tr>
</table>

Learning Targets - Energy

- MS-PS3-4. Describing the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: kinetic energy, speed, velocity, mass, force, conservation of energy, potential energy, thermal energy, heat, temperature, conductor, insulator, calorie, joule.

Learning Targets - Structure, Function, and Information Processing

- MS-LS1-1. Providing evidence that living things are made of cells, either one cell or many different numbers and types of cells.
- **Structure, Function and Information Processing - Goal 1:** Student will understand that living organisms are systems of interacting subsystems composed, on the most basic level, of cells.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: brain, sensory, input, stimuli, response, nerve, receptor, memory, cell, organelle, multicellular, unicellular, nucleus, chloroplasts, mitochondria, cell membrane, cell wall, tissue, organs, cytoplasm, system, organism, biology, biomedical, nanotechnology, centrifuge, botany, veterinarian, circulatory, excretory, digestive, respiratory, muscular.

Learning Targets - Space Systems

- MS-ESS1-3. Determining scale properties of objects in the solar system.
- MS-ESS1-3. Analyzing and interpreting data to determine scale properties of objects in the solar system.
- **Universe - MS-LS1-1. Goal 1:** Student will analyze and interpret data to compare and contrast objects in the universe.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: eclipse, ellipse, season, axial tilt, rotation, revolution, latitude, equator, lunar, phase, scale, proportionality, crust, atmosphere, orbital radius, telescopes, satellites, solar system, galaxy, universe, gravity, satellites, orbit, ellipse

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)
NGSS CCC Systems and system models. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

Learning Goal	Proficiency Scale

Students will be able to relate parts of a system to the whole.	4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal.
	
	3: Student demonstrates mastery with the learning goal as evidenced by:
	• use models and simulations to illustrate a system.
	• critiquing how systems interact with other systems
	• provinging how systems may have sub-systems and may be a part of larger complex systems.
	
	2: Student demonstrates he/she is nearing proficiency by:
	• recognizing and recalling specific vocabulary, such as: component, interaction, simulation, complex.
	• performing processes such as:
	  ○ making observations of a system created to do a task.
	  ○ identifying patterns of the inputs and outputs of a system.
	  ○ analyzing models used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.
	
	1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets - Engineering Design

- MS-ETS1-1. Defining 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.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: science, engineering, technology, research, climate, natural resource, economics, renewable, non-renewable.

Learning Targets - Forces and Interactions

- MS-PS2-4. Developing or using a system to demonstrate gravitational interactions on interacting objects.

Learning Targets - Structure, Function, and Information Processing

- MS-LS1-3. Proving the body is a system of interacting subsystems composed of groups of cells.
- MS-LS1-2. Developing and using a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
- **Growth, Development, & Reproduction - Goal 1:** Student describes factors that impact reproduction.
- **Growth, Development, & Reproduction - Goal 2:** Student describes how environmental and genetic factors affect growth and development of organisms.
- **Structure, Function and Information Processing - MS-LS1-1. Goal 1:** Student will understand that living organisms are systems of interacting subsystems composed, on the most basic level, of cells.
- **Structure, Function, & Information Processing - Goal 3:** Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. [Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.]
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: brain, sensory, input, stimuli, response, nerve, receptor, memory, cell, organelle, multicellular, unicellular, nucleus, chloroplasts, mitochondria, cell membrane, cell wall, tissue, organs, cytoplasm, system, organism, biology, biomedical, nanotechnology, centrifuge, botany, veterinarian, circulatory, excretory, digestive, respiratory, muscular.

Learning Targets - Space Systems

- MS-ESS1-1. Developing and using a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

- MS-ESS1-2. Developing and using a model to describe the role of gravity in the motions within galaxies and the solar system.
- **Universe - Goal 2:** Student will develop and use models to describe the role of gravity.
- **Universe - Goal 3:** Student will develop and use models to describe cyclic patterns of lunar phases.
- **Universe - Goal 4:** Student will develop and use models to describe cyclic patterns of Earth's seasons.
- **Universe - Goal 5:** Student will develop and use models to describe cyclic patterns of eclipses.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: eclipse, ellipse, season, axial tilt, rotation, revolution, latitude, equator, lunar, phase, scale, proportionality, crust, atmosphere, orbital radius, telescopes, satellites, solar system, galaxy, universe, gravity, satellites, orbit, ellipse

Learning Targets -Weather and Climate

- MS-ESS2-6. Using models to describe atmospheric and oceanic circulation and their impacts.
- **Weather - Goal 1:** Student can analyze data, including maps, and construct and use models to develop understanding of the factors that control weather.
- **Weather - Goal 2:** Student can analyze data, including maps, and construct and use models to develop understanding of the factors that control climate.
- **Weather - Goal 4: MS-ESS2-4.** Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: weather, temperature, pressure, humidity, precipitation, wind, latitude, altitude, geographic land distribution, atmospheric circulation, oceanic circulation, climate, global temperature, natural factors, human activities

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)

NGSS

CCC *Energy and matter: Flows, cycles, and conservation*. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

Learning Goal	Proficiency Scale
Students will understand how changes in energy and matter help them define a system's limitations and possibilities.	4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: • demonstrating the energy or matter as it flows in a system or process. • comparing different forms of energy or matter in a system. 2: Student demonstrates he/she is nearing proficiency by: • recognizing and recalling specific vocabulary, such as: potential energy, kinetic energy. • performing processes such as: o applying the law of conservation of matter as it is displayed in a natural or designed system. o illustrating the matter and energy in a system. 1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets - Weather and Climate • **Weather - MS-ESS2-5. Goal 1:** Student can analyze data, including maps, and construct and use models to develop understanding of the factors that control weather. • **Weather - MS-ESS2-6 Goal 2:** Student can analyze data, including maps, and construct and use models to develop understanding of the factors that control climate. • **Weather - Goal 4: MS-ESS2-4.** Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
Learning Targets - Energy • MS-PS3-3. Applying scientific principles of thermal energy transfer. • MS-PS3-5. Proving that when the kinetic energy of an object changes, energy is transferred to or from the object. • **Energy - Goal 1: MS-PS2-2.** Student describes, demonstrates, or models thermal energy transfer factors. **Energy - Goal 2: MS-PS3-4.** Students will describe, demonstrate, or model energy transfer among materials and is able to explain the relationship between temperature and average kinetic energy of the particles. • **Energy - Goal 3: MS-PS3-5.** Students are able to provide evidence to support their conclusion regarding energy transfer between objects. • Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: kinetic energy, speed, velocity, mass, force, conservation of energy, potential energy, thermal energy, heat, temperature, conductor, insulator, calorie, joule.

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)
NGSS CCC *Structure and function*. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

Learning Goal	Proficiency Scale
Students will understand the structures of an object or organism determines its properties and functions.	4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: • analyzing structures and system to determine how they function. • analyzing the function of the structure to the whole object or organism. • critiquing a structure's design and construction in relation to how it serves particular function. • critiquing a living thing's adaptations and how it serves particular functions. • categorizing substructures based on their shapes and the parts that serve functions. 2: Student demonstrates he/she is nearing proficiency by: • recognizing and recalling specific vocabulary, such as structure, function, shape, composition, substructure, relationship. • performing processes such as: o making observations about the shape, composition, and relationship among the parts in a system. o investigating the different substructures of different materials. o defining components that make up a system. o identifying the functions of various structures. 1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets - Growth Development and Reproduction of Organisms

- MS-LS3-1. Developing and using 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.
- MS-LS3-2. Developing and using a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.
- **Growth, Development, & Reproduction - Goal 1:** Student describes factors that impact reproduction.
- **Growth, Development, & Reproduction - Goal 2:** Student describes how environmental and genetic factors affect growth and development of organisms.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: characteristics, behaviors, asexual, sexual, hereditary, Punnett square, chromosome, gene, predators, prey, trait, genetic modification, chromosome, gene, gene therapy, trait, sexual, asexual.

Learning Targets - Structure, Function, and Information Processing

- MS-LS1-2. Describing how the function of a cell as a whole and ways parts of cells contribute to the function.
- MS-LS1-1. Conducting an investigation to provide evidence that living things are made of cells, either one cell or many different numbers and types of cells.
- ·MS-LS1-8. Gathering and synthesizing information to prove/demonstrate/refute that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
- **Structure, Function and Information Processing - MS-LS1-1. Goal 1:** Student will understand that living organisms are systems of interacting subsystems composed, on the most basic level, of cells.
- **Structure, Function and Information Processing - MS-LS1-2. MS-LS1-3. Goal 2:** Student will develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
- **Structure, Function, & Information Processing - Goal 3:** Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. [Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.]
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: brain, sensory, input, stimuli, response, nerve, receptor, memory, cell, organelle, multicellular, unicellular, nucleus, chloroplasts, mitochondria, cell membrane, cell wall, tissue, organs, cytoplasm, system, organism, biology, biomedical, nanotechnology, centrifuge, botany, veterinarian, circulatory, excretory, digestive, respiratory, muscular.

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)

NGSS

CCC *Stability and change*. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

<table>
<tr><th>Learning Goal</th><th>Proficiency Scale</th></tr>
<tr><td>Students will understand conditions of stability and rates of change.</td><td>4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal.

3: Student demonstrates mastery with the learning goal as evidenced by:
• evaluating factors that contribute to the stability or rate of change.
• comparing stability and change relative to time.
• proving how cyclic change patterns can be stable.
• assessing the role of equilibrium in maintaining stability.

2: Student demonstrates he/she is nearing proficiency by:
• recognizing and recalling specific vocabulary, such as: relative, maintain.
• performing processes such as:
o identifying factors that influence stability and change.
o measuring change (in systems, objects or organisms) in terms of differences over time.
o observing that change may occur at different rates.
o identifying examples of systems that appear stable, but over long periods of time they will eventually change.

1: Student demonstrates limited understanding or skill with the learning goal.</td></tr>
</table>

Learning Targets - Weather and Climate

- MS-ESS3-5. Assessing and citing evidence factors that have caused the rise in global temperatures over the past century.
- **Weather - MS-ESS3-5. MS-ESS3-2. MS-ESS3-3. Goal 3:** Student can analyze evidence, including tables, graphs, maps to develop understanding of the natural factors and human activities that influence change in global temperature.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: weather, temperature, pressure, humidity, precipitation, wind, latitude, altitude, geographic land distribution, atmospheric circulation, oceanic circulation, climate, global temperature, natural factors, human activities.

8th Grade Science Curriculum

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)
NGSS CCC Patterns. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

Learning Goal	Proficiency Scale
Students will understand how patterns of forms and events guide organization and classification.	4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: • analyzing micro and macroscopic patterns in rates of change and other numerical relationships. • analyzing graphic representations to identify patterns in data. • differentiating patterns through various types of classification systems. • diagnosing the patterns of failure of a designed system. 2: Student demonstrates he/she is nearing proficiency by: • recognizing and recalling specific vocabulary, such as: microscopic, macroscopic. • performing processes such as: o making observations using both qualitative and quantitative data. o assessing the validity of the data from the process by which it was collected. o forming a conclusion based on evidence and patterns from data. o organizing data in multiple ways to uncover patterns. 1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets - Waves and Electromagnetic Radiation

- MS-PS4-1. Using 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.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: wave, amplitude, frequency, wavelength, crest, trough, medium, energy, compression, rarefaction, reflection, absorption, transmission, disturbance, mechanical wave, electromagnetic wave, digital, analog, signal, fiber optic, transmit, pulse, binary.
- **Wave Energy Learning Target 1**- Students will understand the properties of waves.

Learning Targets - Engineering Design

- MS-ETS1-3. Analyzing 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.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: model, test, modification, fair test, bias, tool, design, design solution, engineering, characteristics, solution
- **Foundations Learning Target 3**: Students will use the scientific method to design and evaluate an experiment for any testable question.
- **Foundations Learning Target 1:** Students will use correct tools to measure matter in metric units and label units correctly
- **Chemistry Learning Target 7-** Students will describe heat and how it is transferred
- **Electricity Learning Target 5**- Students will be able to demonstrate advantages and disadvantages of each wired complete circuit.
- **Wave Energy Learning Target 7:** Students will identify and explain types of reflection
- **Wave Energy Learning target 8:** Students will compare refraction of light through different materials

Learning Targets - Energy

- MS-PS3-1. Constructing and interpreting graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: kinetic energy, potential energy, speed, acceleration, gravity, velocity, mass, force, conservation of energy, potential energy, kinetic energy, thermal energy, heat, temperature, conductor, insulator, conservation of energy, calorie, joule

Learning Targets - Chemical Reactions

- Atomic structure
- MS-PS1-2. Analyzing and interpreting data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: chemical reaction, physical change, chemical change, law of conservation of matter, atom, molecule, mass, matter, exothermic, endothermic, temperature, atom, heat, kinetic molecular theory, conductor, insulator, law of conservation of energy, exothermic, endothermic, temperature
- **Chemistry Learning Target 6** - Student is able to classify chemical reactions and provide evidence of the law of conservation of mass.
- **Chemistry Learning target 5** - Student is able to recognize and classify changes in matter as chemical or physical.
- **Chemistry Learning Target 1:** Student is able to use the periodic table to identify and determine properties of Elements, Compounds, and Molecules.

Learning Targets - Forces and Interactions

- MS-PS2-2. Planning an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
- MS-PS2-5. Conducting an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: electric, magnetic, force, field, balanced, unbalanced, gravity, static, interaction, Newton, inertia, speed, acceleration, interaction, independent variable, dependent variable, control, tools.

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)

NGSS

CCC Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

<table>
<tr><th>Learning Goal</th><th>Proficiency Scale</th></tr>
<tr><td>Students will be able to investigate and explain causal relationships.</td><td>4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal.

3: Student demonstrates mastery with the learning goal as evidenced by:
classifying correlational and causal relationships.
explaining that correlation does not necessarily imply causation.
applying cause and effect relationships to predict phenomena in natural or designed systems.
communicating that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
2: Student demonstrates he/she is nearing proficiency by:
recognizing and recalling specific vocabulary, such as: predict.
performing processes such as:
identifying how various factors contribute to a cause and/or different results.
explaining why some events have simple and other events have multifaceted causes.
1: Student demonstrates limited understanding or skill with the learning goal.</td></tr>
</table>

Learning Targets - Structure and Properties of matter ● MS-PS1-4. Predicting and describing how adding or removing thermal energy changes particle motion, temperature, and state of a pure substance. ● Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: temperature, thermal energy, molecule, heat, equilibrium, conduction, convection, radiation, solid, liquid, gas, kinetic molecular theory, phase change, molecule, atoms, natural resource, synthetic resource, solids, liquids, gases, physical properties, chemical properties, mixture, pure substance, matter. ● **Chemistry Learning Target 3:** Students will use the Kinetic Molecular Theory to illustrate particle arrangement and movement in each state of matter. ● **Chemistry Learning Target 4:** Students will use changes in energy to describe volume changes within various states of matter.
Learning Targets - Forces and Interactions ● MS-PS2-3. Determining the factors that affect the strength of electric and magnetic forces. ● MS-PS2-5. Proving that fields exist between objects exerting forces on each other even though the objects are not in contact. ● Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: electric, magnetic, force, field, balanced, unbalanced, gravity, static, interaction, Newton, inertia, speed, acceleration, interaction, independent variable, dependent variable, control, tools.
Learning Targets - Energy ● MS-PS3-5. Constructing, using, and presenting arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. ● Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: kinetic energy, potential energy, speed, acceleration, gravity, velocity, mass, force, conservation of energy, potential energy, conservation of energy, thermal energy, heat, temperature, conductor, insulator, conservation of energy, calorie, joule

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)

NGSS

CCC Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Learning Goal	Proficiency Scale
Students will understand how changes in scale, proportion, or quantity affect a system's structure and/or performance	4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: • comparing models of time, space, or energy. • explaining how examples observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale. • using proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes. • representing scientific relationships through the use of algebraic expressions and equations. 2: Student demonstrates he/she is nearing proficiency by: • recognizing and recalling specific vocabulary, such as: observable, relationship, ratio, magnitude, algebraic, expression. • performing processes such as: o using ratios or scales to relate objects or organisms. o determining ratio or scale from data. o comparing quantities of objects or organisms using data. 1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets - Structure and Properties of Matter

- MS-PS1-1. Developing models to describe the atomic composition of simple molecules and extended structures.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: temperature, thermal energy, molecule, heat, equilibrium, conduction, convection, radiation, solid, liquid, gas, kinetic molecular theory, phase change, molecule, atoms, natural resource, synthetic resource, solids, liquids, gases, physical properties, chemical properties, mixture, pure substance, matter.

Learning Targets - Energy

- MS-PS3-1. Describing the relationships of kinetic energy to the mass of an object and to the speed of an object.
- MS-PS3-4. Describing the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: kinetic energy, potential energy, speed, acceleration, gravity, velocity, mass, force, conservation of energy, potential energy, kinetic energy, thermal energy, heat, temperature, conductor, insulator, conservation of energy, calorie, joule

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)
NGSS CCC Systems and system models. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

<table>
<tr><th>Learning Goal</th><th>Proficiency Scale</th></tr>
<tr><td>Students will be able to define systems they are studying.</td><td>4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal.

3: Student demonstrates mastery with the learning goal as evidenced by:
• investigating or analyzing a system by defining its boundaries and initial conditions, as well as its inputs and outputs.
• using models (e.g., physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales.
• using models or simulations to predict the behavior of a system
• recognizing that predictions have limited precision and reliability due to the assumptions and approximations inherent in the models.
• designing systems to do specific tasks.

2: Student demonstrates he/she is nearing proficiency by:
• recognizing and recalling specific vocabulary, such as: scale, behavior, prediction, precision, reliability, assumption, approximation, inherent, tasks.
• performing processes such as:
    ○ use models and simulations to illustrate a system.

1: Student demonstrates limited understanding or skill with the learning goal.</td></tr>
</table>

<u>Learning Targets - Forces and Interactions</u> • MS-PS2-1. Developing or using a system to apply Newton's Third Law involving the motion of two colliding objects. • Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: electric, magnetic, force, field, balanced, unbalanced, gravity, static, interaction, Newton, inertia, speed, acceleration, interaction, independent variable, dependent variable, control, tools
<u>Learning Targets - Energy</u> • MS-PS3-2. Using a system or system model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. • Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: kinetic energy, potential energy, speed, acceleration, gravity, velocity, mass, force, conservation of energy, potential energy, conservation of energy, thermal energy, heat, temperature, conductor, insulator, conservation of energy, calorie, joule
<u>Learning Targets - Engineering Design</u> • MS-ETS1-4. Developing 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. • Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: model, test, modification, fair test, bias, tool, design, design solution, engineering, characteristics, solution • Foundations Learning Target 3: Students will use the scientific method to design and evaluate an experiment for any testable question. • Foundations Learning Target 1: Students will use correct tools to measure matter in metric units and label units correctly • Chemistry Learning Target 7- Students will describe heat and how it is transferred • Electricity Learning Target 5- Students will be able to demonstrate advantages and disadvantages of each wired complete circuit. • Wave Energy Learning Target 7: Students will identify and explain types of reflection • Wave Energy Learning target 8: Students will compare refraction of light through different materials
<u>Learning Targets - Chemical Reactions</u> • MS-PS1-5. Developing and using a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. • Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: chemical reaction, physical change, chemical change, law of conservation of matter, atom, molecule, mass, matter, exothermic, endothermic, temperature, atom, heat, kinetic molecular theory, conductor, insulator, law of conservation of energy,

exothermic, endothermic, temperature

- **Chemistry Learning Target 6** - Student is able to classify chemical reactions and provide evidence of the law of conservation of mass.
- **Chemistry Learning target 5** - Student is able to recognize and classify changes in matter as chemical or physical.

Learning Targets - Waves and Electromagnetic Radiation

- MS-PS4-2. Developing and using a model to describe that waves are reflected, absorbed, or transmitted through various materials.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: wave, amplitude, frequency, wavelength, crest, trough, medium, energy, compression, rarefaction, reflection, absorption, transmission, disturbance, mechanical wave, electromagnetic wave, digital, analog, signal, fiber optic, transmit, pulse, binary.
- Wave Energy Learning Target 8- Students will compare refraction of light through different materials
- Wave Energy Learning Target 1- Students will understand the properties of waves.

Learning Targets - Structure and Properties of Matter

- MS-PS1-1. Developing models to describe the atomic composition of simple molecules and extended structures.
- MS-PS1-4. Developing a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: temperature, thermal energy, molecule, heat, equilibrium, conduction, convection, radiation, solid, liquid, gas, kinetic molecular theory, phase change, molecule, atoms, natural resource, synthetic resource, solids, liquids, gases, physical properties, chemical properties, mixture, pure substance, matter.
- **Chemistry Learning Target 1:** Student is able to use the periodic table to identify and determine properties of Elements, Compounds, and Molecules.
- **Chemistry Learning Target 2:** Student is able to use properties to describe matter as either pure substance or mixture.
- **Chemistry Learning Target 3:** Students will use the Kinetic Molecular Theory to illustrate particle arrangement and movement in each state of matter.
- **Chemistry Learning Target 4:** Students will use changes in energy to describe volume changes within various states of matter.

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)

NGSS

CCC *Energy and matter: Flows, cycles, and conservation*. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

Learning Goal	Proficiency Scale
Students will understand how changes in energy and matter help them define a system's limitations and possibilities.	4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: • proving atoms are conserved in physical and chemical processes. • analyzing the transfer of energy, within a natural or designed system, that drives the motion and/or cycling of matter. • classifying forms of energy (e.g. energy in fields, thermal energy, energy of motion). • distinguishing between mass and weight. 2: Student demonstrates he/she is nearing proficiency by: • recognizing and recalling specific vocabulary, such as: system, atom, physical, chemical. • performing processes such as: o drawing conclusions from evidence about the law of conservation of matter. o demonstrating the energy as it flows into, out of, and within a system. o describing forms of energy (e.g. energy in fields, thermal energy, energy of motion). o defining the energy stored in a system. 1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets - Chemical Reactions

- MS-PS1-5. Developing and using a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.
- MS-PS1-6. Demonstrating that either thermal energy is released or absorbed by chemical processes.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: chemical reaction, physical change, chemical change, law of conservation of matter, atom, molecule, mass, matter, exothermic, endothermic, temperature, atom, heat, kinetic molecular theory, conductor, insulator, law of conservation of energy, exothermic, endothermic, temperature
- **Chemistry Learning Target 6** - Student is able to classify chemical reactions and provide evidence of the law of conservation of mass.
- **Chemistry Learning target 5** - Student is able to recognize and classify changes in matter as chemical or physical.
- **Chemistry Learning Target 7-** Students will describe heat and how it is transferred

Learning Targets - Energy

- MS-PS3-5. Proving that when the kinetic energy of an object changes, energy is transferred to or from the object.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: kinetic energy, potential energy, speed, acceleration, gravity, velocity, mass, force, conservation of energy, potential energy, conservation of energy, thermal energy, heat, temperature, conductor, insulator, conservation of energy, calorie, joule

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)

NGSS

CCC *Structure and function*. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

Learning Goal	Proficiency Scale
Students will understand that the way in which an object or living thing is shaped determines its properties and functions.	4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: • modeling complex structures and systems to visualize how their function depends on the shape, composition, and relationships among its parts. • understanding complex natural and designed structures and systems to determine how they function. • designing structures to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. • evaluating the composition of material to improve the function. 2: Student demonstrates he/she is nearing proficiency by: • recognizing and recalling specific vocabulary, such as structure, function, shape, composition, substructure, relationship. • performing processes such as: o modeling simple systems. o evaluating how the function depends on the shapes, composition, and relationships among its parts. o analyzing a simple structures and system to determine how they function. o designing structures to serve particular functions. 1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets - Waves and Electromagnetic Radiation ● MS-PS4-2. Describe that waves are reflected, absorbed, or transmitted through various materials. ● Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: wave, amplitude, frequency, wavelength, crest, trough, medium, energy, compression, rarefaction, reflection, absorption, transmission, disturbance, mechanical wave, electromagnetic wave, digital, analog, signal, fiber optic, transmit, pulse, binary.
Learning Targets - Structure and Properties of Matter ● MS-PS1-3. Gathering and making sense of information to describe that synthetic materials come from natural resources. ● MS-PS1-3. Proving how synthetic materials have impacted society. ● Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: temperature, thermal energy, molecule, heat, equilibrium, conduction, convection, radiation, solid, liquid, gas, kinetic molecular theory, phase change, molecule, atoms, natural resource, synthetic resource, solids, liquids, gases, physical properties, chemical properties, mixture, pure substance, matter.
Learning Targets - Engineering Design ● MS-ETS1-2. Evaluating competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. ● Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: model, test, modification, fair test, bias, tool, design, design solution, engineering, characteristics, solution.
Learning Targets - Energy ● MS-PS3-3. Designing, constructing, and testing a device that either minimizes or maximizes thermal energy transfer. ● Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: kinetic energy, potential energy, speed, acceleration, gravity, velocity, mass, force, conservation of energy, potential energy, kinetic energy, thermal energy, heat, temperature, conductor, insulator, conservation of energy, calorie, joule ●
Learning Targets - Chemical Reactions ● MS-PS1-6. Undertaking a design project to construct, test, and modify a device that either releases or absorbs thermal

energy by chemical processes.

- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: chemical reaction, physical change, chemical change, law of conservation of matter, atom, molecule, mass, matter, exothermic, endothermic, temperature, atom, heat, kinetic molecular theory, conductor, insulator, law of conservation of energy, exothermic, endothermic, temperature

Learning Targets - Waves and Electromagnetic Radiation

- MS-PS4-3. Integrating qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: wave, amplitude, frequency, wavelength, crest, trough, medium, energy, compression, rarefaction, reflection, absorption, transmission, disturbance, mechanical wave, electromagnetic wave, digital, analog, signal, fiber optic, transmit, pulse, binary.

High Priority Standards (CCSS, State, National, TILS, CREDE, etc.)

NGSS

CCC *Stability and change*. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

<table>
<tr><th>Learning Goal</th><th>Proficiency Scale</th></tr>
<tr><td>Students will understand conditions of stability and rates of change.</td><td>4: Student demonstrates an in-depth inference, advanced application or innovates with the learning goal.

3: Student demonstrates mastery with the learning goal as evidenced by:
• critiquing stability and change in natural or designed systems by considering forces at different scales.
• determining cause and effect of changes in one part of a system on another part.
• proving how a system in dynamic equilibrium is stable due to a balance of feedback mechanisms.
• connecting how the stability might be disturbed by either sudden events or gradual changes that accumulate over time.

2: Student demonstrates he/she is nearing proficiency by:
• recognizing and recalling specific vocabulary, such as: feedback mechanism, gradual, balance.
• performing processes such as:
o developing an argument about how factors influence the stability or change in various systems.
o summarizing how forces impact the larger system.
o comparing systems in dynamic equilibrium.

1: Student demonstrates limited understanding or skill with the learning goal.</td></tr>
</table>

Learning Targets - Forces and Interactions

- MS-PS2-2. Proving an object's motion depends on the sum of the forces on the object and the mass of the object.
- Students will be able to use/know and understand/recognize and recall domain specific vocabulary such as: electric, magnetic, force, field, balanced, unbalanced, gravity, static, interaction, Newton, inertia, speed, acceleration, interaction, independent variable, dependent variable, control, tools.

High School Science Curriculum
Animal Behavior

Mechanisms of Animal Behavior

Missouri Grade-Level Expectations (or other standards)

HS-LS1-1: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.
HS-LS1-2: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
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.
HS-LS2-8: Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.
HS--LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
HS-LS4-1: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
HS-LS4-2: Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
HS-LS4-4: Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
HS-LS4-5: Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
CCSS-R.11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
CCSS-W-11-12.7: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a question; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
CCSS-R.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
CCSS-W.11-12.1e: Provide a concluding statement or section that follows from or supports the argument presented.

Learning Goal	Proficiency Scales

<table>
<tr>
<td>Students will be able to differentiate the biologically determined mechanisms that control behavior and mediate the effects of evolutionary influences.</td>
<td>
4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal.

3: Student demonstrates mastery with the learning goal as evidenced by:

Hypothesizing and drawing conclusions about how genes translate into behavior by using techniques such as inbreeding, twin studies, cross fostering, selective breeding, mutations/knockout genes.
Creating an experiment to analyze how nervous system complexity of organisms relates to behaviors seen in response to various stimuli.
Generating and testing data about the size of the somatosensory cortex to analyze behavioral adaptations.
Drawing conclusions about how nerve pathways constitute the structural and functional basis for behavior.

2: Student demonstrates he/she is nearing proficiency by:

Recognizing or recalling specific vocabulary, such as: behavior genetics, gene, allele, evolution, epigenesis, polygenic, neuron, synapse, neurotransmitter, hormone.
Performing processes such as:

Recognizing ways that evidence is used to show the evolution of a behavior (phylogeny, domestication and comparative studies).
Recognizing the Nature/Nurture influences on behavior.
Identifying the general functions of the nervous system.
Labeling the parts of a neuron.
Summarizing how neurons communicate.
Identifying the types of neurons and types of sensory receptors.
Labeling the parts and functions of the human brain.

</td>
</tr>
</table>

	● Summarizing the behavioral responses caused by hormone secretions. ● Identifying techniques that are used to determine how genes are translated into behavior. ● Identifying how nervous system complexity relates to complexity of behaviors. ● Comparing how the nervous and endocrine system influences behaviors of animals. 1: Student demonstrates limited understanding skill with the learning goal.

WGSD Curriculum -- Animal Behavior

Mating Systems

Missouri Grade-Level Expectations (or other standards)
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. **HS-LS2-8:** Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. **HS--LS3-1:** Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. **HS-LS4-2:** Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. **HS-LS4-5:** Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. **CCSS-R.11-12.9**: Synthesize information from a range of sources into a coherent understanding of a process, phenomenon, or concept, resolving conflicting

information when possible.

Learning Goal	Proficiency Scales

Students will be able to determine the cost and benefit of different animal mating systems.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal.
	
	3: Student demonstrates mastery with the learning goal as evidenced by:
	● Assessing the costs and benefits of sexual reproduction.
	● Explaining the reasons for sexual dimorphism.
	● Classifying the types of mating systems.
	
	2: Student demonstrates mastery with the learning goal as evidenced by:
	
	● Recognizing or recalling specific vocabulary, such as: *sexual reproduction, asexual reproduction, sexual dimorphism, gametes, sexual selection, estrus, intrasexual selection, intersexual selection, monogamy, polygyny, and polyandry*.
	
	● Performing processes such as:
	  ● Identifying the causes of reproductive behavior.
	  ● Recognizing the difference between k-selected and r-selected species.
	  ● Recognizing problems animals face with parenthood.
	  ● Identifying the costs and benefits of sexual reproduction.
	  ● Identifying the causes the of sexual dimorphism (gametes and sexual selection).
	
	1: Student demonstrates a limited understanding or skill with the learning goal.

WGSD Curriculum -- Animal Behavior
Learning Mechanisms

Missouri Grade-Level Expectations (or other standards)
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. **HS-LS2-8:** Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. **CCSS-W.11-12.7:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics. **CCSS-R.11-12.4:** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a question; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Learning Goal	Proficiency Scales
Students will be able to design experiments to determine the effectiveness of different mechanisms of learning.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Designing and conducting an experiment to determine whether operant conditioning occurs in mice. ● Comparing and contrasting the different types of learning that can occur in the animal kingdom.

	2: Student demonstrates he/she is nearing proficiency by:
	
	● Recognizing or recalling specific vocabulary, such as: *learning, habituation, sensitization, classical conditioning, operant conditioning, reinforcement, observational learning, imitation, imprinting, cognition*.
	
	● Performing processes such as:
	    ● Identifying examples of the different types of learning.
	    ● Recognizing how learning enhances survival and reproductive success.
	    ● Reciting how experiences prompt learning (how memories are formed).
	
	1: Student demonstrates a limited understanding or skill with the learning goal.

WGSD Curriculum -- Animal Behavior

Communication

Missouri Grade-Level Expectations (or other standards)
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. **HS-LS2-8:** Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. **CCSS.R.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or

technical context relevant to grades 11-12 texts and topics.
CCSS.R.11-12.8: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

<table>
<tr><th><u>Learning Goal</u></th><th><u>Proficiency Scales</u></th></tr>
<tr><td>Students will be able to correlate how and why communication occurs within the animal kingdom.</td><td>4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal.

3: Student demonstrates mastery with the learning goal as evidenced by:
● Classifying the different functions (in terms of survival and reproduction) of communication such as group spacing, recognition, reproduction, social status, alarm, hunting, care and soliciting play.
● Comparing and contrasting the six channels of communication.

2: Student demonstrates he/she is nearing proficiency by:

Recognizing or recalling specific vocabulary, such as:
● Communication, signal, discrete signals, continuous signals, complex communication.

● Performing processes such as:
    ● Identifying the characteristics of signals used in communication.
    ● Identifying examples of complex communication in the animal world.
    ● Recognizing the six channels of communication.
    ● Identifying the different functions of animal communication.

1: Student demonstrates a limited understanding or skill with the learning</td></tr>
</table>

	goal.

WGSD Curriculum -- Animal Behavior

Approaches and Methods

Missouri Grade-Level Expectations (or other standards)
HS-LS1-2: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. **HS-LS2-7:** Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. **HS-LS2-8:** Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. **CCSS.R.11-12.3:** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. **CCSS.W.11-12-1e:** Provide a concluding statement or section that follows from or supports the argument presented.

Learning Goal	Proficiency Scales
Students will be able to judge the best use of various approaches and methods when studying animal behavior.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Demonstrating the differences between the 4 approaches to studying animal behavior (ethology, comparative psychology, behavioral ecology and sociobiology).

	- Drawing conclusions about the purposes of studying animal behavior. - Comparing the advantages and disadvantages of field and lab experiments. - Creating, analyzing and drawing conclusions about ethograms created in class. 2: Student demonstrates he/she is nearing proficiency by: - Recognizing or recalling specific vocabulary, such as: *behavior, stimulus, ethology, ethogram, focal sampling, scan sampling, one zero sampling, equal observability, interobserver reliability, proximate factor, ultimate factor.* - Performing processes such as: - Recognizing the difficulties with studying animal behavior. - Identifying the four components to studying animal behavior. - Explaining how ethograms are beneficial to scientists. - Identifying the four approaches to studying animal behavior. - Listing the reasons why we study animal behavior. - Recognizing the advantages and disadvantages of field and lab studies. - Discriminating between an instinctive behavior and a learned behavior 1: Student demonstrates a limited understanding or skill with the learning goal.

WGSD Curriculum -- Animal Behavior
Aggression

Missouri Grade-Level Expectations (or other standards)

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.
HS-LS2-8: Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.
HS-LS4-5: Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
CCSS.R.11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
CCSS.W.11-12.7: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a question; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Learning Goal	Proficiency Scales
Students will be able to analyze patterns of aggression in the animal kingdom.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Categorizing aggressive behaviors of animals. ● Hypothesizing why evolution has not led to an increasingly more aggressive individuals and societies even though aggression is adaptive.

	2: Student demonstrates he/she is nearing proficiency by:
	
	● Recognizing or recalling specific vocabulary, such as: *aggression, territory, home range, core area, individual distance, lek*.
	
	● Performing processes such as:
	    ● Comparing the types of aggression (territorial, dominance, sexual, parental, parent-offspring, anti-predatory, and extreme forms such as cannibalism and infanticide).
	    ● Recognizing the internal and external factors of aggression.
	    ● Understanding why animals use aggressive displays rather than fight for resources.
	
	1: Student demonstrates a limited understanding or skill with the learning goal.

Astronomy

Motion of Stellar Object

Missouri Grade-Level Expectations (or other standards)

HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
CCSS:
CCSS.ELA-LITERACY.RST.11-12.1
Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
CCSS.ELA-LITERACY.RST.11-12.3
Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
CCSS.ELA-LITERACY.RST.11-12.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11-12 texts and topics*.
CCSS.ELA-LITERACY.RST.11-12.7
Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
CCSS.ELA-LITERACY.RST.11-12.8
Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Learning Goal	Proficiency Scales
Students will be able to interpret how the	4: Student demonstrates an in-depth inference or advanced application

organization of the solar system can be used to understand the motion of the stars, sun, moon and planets in the sky.	or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Evaluating the effects of the relative positions of the Earth, moon, and sun on observable phenomena, e.g. phases of the moon, eclipses, seasons, and diurnal cycles. ● Inferring the effects of orbit, mass, and other factors on real and imaginary objects. ● Describing how latitude and time of the year affect visibility of constellations. ● Predicting visibility of planets (major and minor) in the solar system based on relative orbital motion. ● Applying mathematically Newtonian gravity to celestial bodies to determine their masses and explain their motion (e.g. Kepler's Laws). 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as *Azimuth, Altitude, Celestial sphere, Zenith, Polaris, Circumpolar, Celestial equator, Horizon, Meridian, Vernal equinox, Autumnal equinox, Solstice (summer/winter), phases of the moon, eclipses, seasons, diurnal cycles, orbit, mass, waxing, waning, gibbous, crescent, rotation, revolution, tilt, and constellation.* ● Performing specific processes such as: ○ Identifying constellations and planets in the night sky using a sky sphere. ○ Listing the phases of the moon and seasons.

	○ Calculating orbital motions using Kepler and Newtonian laws. 1: Student demonstrates a limited understanding or skill with the learning goal.

Learning Targets
• Create sky sphere • Analyze the causes of the seasons • Observe and predict the moon phases • Diagram elliptical and orbital patterns • Manipulate Kepler's laws of planetary motion and Newton's gravitational laws • Understand the celestial sphere and the system of celestial coordinates on the sky
Learning Design

Historical Perspective

Missouri Grade-Level Expectations (or other standards)
HS-ESS1-6. 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. CCSS: CCSS.ELA-LITERACY.RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. CCSS.ELA-LITERACY.RST.11-12.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. CCSS.ELA-LITERACY.RST.11-12.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11-12 texts and topics*. CCSS.ELA-LITERACY.RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. CCSS.ELA-LITERACY.RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Learning Goal	Proficiency Scales
Students will be able to analyze the dynamic nature of astronomy.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal.

	3: Student demonstrates mastery with the learning goal as evidenced by: • Identifying how astronomy was integrated into ancient civilizations and then through modern astronomy. • Examining similarities and differences in cultures about what physical, cultural, and spiritual purposes were addressed through astronomical observation and prediction. • Investigating how the civilization learned about the universe. • Comparing and contrasting how celestial observation was used by ancient cultures to measure time, plant crops, and influence the fate of kingdom. 2: Student demonstrates he/she is nearing proficiency by: • Recognizing or recalling specific vocabulary, such as *archaeoastronomy, geocentric, heliocentric, Brahe, Copernicus, Galileo, Hubble, Ptolemaic model.* • Performing processes such as: ○ Listing the ancient, renaissance, and modern astronomer and their discoveries. ○ Recognizing that various civilizations used astronomy and the influence on modern astronomy. 1: Student demonstrates a limited understanding or skill with the learning goal.

Learning Targets

- Understand a historical approach when analyzing the formation of the universe

- Recognize names of great astronomers and know their contribution to science (Bruno, Copernicus, Brahe, Galileo , Kepler, and, also, Hubble, Friedman, Hoyle, Tinsley, Burbidge, etc.)
- Investigate other cultures beliefs and explanations of the universe

Learning Design

Exploration of the Universe

Missouri Grade-Level Expectations (or other standards)

No applicable NGSS standards.
CCSS:
CCSS.ELA-LITERACY.RST.11-12.1
Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
CCSS.ELA-LITERACY.RST.11-12.3
Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
CCSS.ELA-LITERACY.RST.11-12.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11-12 texts and topics*.

CCSS.ELA-LITERACY.RST.11-12.7
Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
CCSS.ELA-LITERACY.RST.11-12.8
Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

<table>
<tr><th><u>Learning Goal</u></th><th><u>Proficiency Scales</u></th></tr>
<tr><td>Students will be able to articulate the challenges inherent in human exploration of the universe.</td><td>4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal.

3: Student demonstrates mastery of the learning goal as evidenced by:
● Investigating space exploration through historical evidence.
● Reasoning the purpose and desire of human space exploration.

2: Student demonstrates he/she is nearing proficiency by:
● Recognizing or recalling specific vocabulary, such as sputnik, Apollo, Gemini, Mars Rover, Hubble, Voyager.
● Performing specific processes, such as identifying the major space explorations and generalizing rationale for human space exploration.

1: Student demonstrates limited understanding or skill with the learning goal.</td></tr>
</table>

Learning Targets

- Identify different methods of the space exploration
- Describe the history of piloted space projects
- Analyze advances in astronomical instruments
- Discuss future opportunities of space exploration

Learning Design

Evolution and Evidence of Stellar Objects

Missouri Grade-Level Expectations (or other standards)

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 that eventually reaches Earth in the form of radiation.
HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements.
CCSS:

CCSS.ELA-LITERACY.RST.11-12.1
Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
CCSS.ELA-LITERACY.RST.11-12.3
Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
CCSS.ELA-LITERACY.RST.11-12.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11-12 texts and topics*.
CCSS.ELA-LITERACY.RST.11-12.7
Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
CCSS.ELA-LITERACY.RST.11-12.8
Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Learning Goal	Proficiency Scales
Students will be able to categorize stars and describe their life cycles.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery of the learning goal as evidenced by: ● Describing the life cycle of a star and explaining the role gravity and mass play in the brightness, life span, and end-stages of stars. ● Describing how spectroscopy provides information about the inherent properties and motions of objects. ● Relating nuclear fusion reactions and mass-energy equivalence to the life cycle of stars.

	• Explaining the relationship between the energy produced by fusion in stars to the luminosity.
	• Analyzing the energy relationships between the mass, power output, and lifespan of stars.
	• Describing energy transfers and transformations associated with the motion and interactions of celestial bodies (e.g. orbits, binary pulsars, meteors, black holes, and galaxy mergers).
	
	2: Student demonstrates he/she is nearing proficiency by:
	• Recognizing or recalling specific vocabulary, such as *blue giant, dwarf, HR diagram, parsec, red giant, red dwarf, spectroscopic parallax, protostar,nebulae, spectroscopy, luminosity, orbits, binary pulsars, meteors, black holes, and galaxy mergers.*
	• Performing processes such as:
	  ○ Outlining the life cycle of a star using correct sequence and terminology.
	  ○ Identifying spectrums of light related to various types of stars.
	  ○ Correlating the mass of stars to the stage in life or the type of star.
	
	1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets

- Define the concept of atomic structure
- Identify continuous, emission, and absorption spectra

- Understand Kirchoff's rules of spectral analysis
- Describe the meaning of Wein's and Stefan-Boltzmann's laws
- Define major characteristics of stars
- Discuss steps of stellar evolution
- Identify different categories of luminous astronomical objects and describe their properties

Learning Design

Composition and Observation of the Universe

Missouri Grade-Level Expectations (or other standards)

HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system
HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.
CCSS:
CCSS.ELA-LITERACY.RST.11-12.1
Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
CCSS.ELA-LITERACY.RST.11-12.3
Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
CCSS.ELA-LITERACY.RST.11-12.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific

scientific or technical context relevant to *grades 11-12 texts and topics*.

CCSS.ELA-LITERACY.RST.11-12.7

Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

CCSS.ELA-LITERACY.RST.11-12.8

Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Learning Goal	Proficiency Scales
Students will be able to differentiate among the objects that comprise the universe.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Critiquing and analyzing the main arguments and evidence in support of the standard cosmological model (e.g. elements, solar systems, and universe). ● Comparing and contrasting the major properties of the components of our solar system. ● Applying the science of comparative planetology to identify similarity and differences in planets and how to identify components of types of planets. ● Analyzing the development and composition and position of objects in the universe. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as *Jovian, terrestrial, moon, asteroid, accretion, albedo, cosmology.* ● Performing specific processes, such as ○ Outlining the arguments of the development of the universe. ○ Listing properties of the objects of the universe. ○ Identifying similarities and differences of planets in the solar system.

	1: Student demonstrates a limited understanding or skill with the learning goal.

Learning Targets

- Research various theories for the origin of the universe
- Investigate the composition and origin of various components of the universe (comets, asteroids, planets, etc)
- Compare and contrast the similarities and differences of stellar objects, such as comparing terrestrial and gaseous planets

Learning Design

Biology

Scientific Inquiry

Missouri Grade-Level Expectations (or other standards)
ETS1.A.1 - Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. ETS1.A.2 - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. ETS1.B.1 - 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. ETS1.B.2. - 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.

Learning Goal	Proficiency Scales
Students will be able to solve real world problems by using scientific method and engineering design process	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Formulate a testable hypothesis ● Identify constants and variables in an investigation ● Determine the appropriate tools and techniques to collect, analyze, and interpret data ● Determine scientific conclusion based on observations ● Identify factors required to make investigative results reliable ● Analyze quantitative data ● Design scientific investigations consisting of at least three steps ● Explain why accurate records and replications are essential for experimental credibility (includes peer review) ● Communicate procedures and results of investigations 2: Student demonstrates he/she is nearing proficiency by: ● Select appropriate investigation methods (techniques

	only) ● Use data to formulate an explanation ● Calculate average/mean for sets of data ● Identify possible effects of errors in data collection and calculations ● Identify a valid conclusion in an experiment ● Use simple tools to measure length, mass, and volume ● Communicate basic information from an experiment ● Construct a simple graph of independent variable versus dependent variable from given data 1: Student demonstrates a limited understanding or skill with the learning goal.

Photosynthesis/Cellular Respiration

Missouri Grade-Level Expectations (or other standards)
LS1.C.1 - Use a model to demonstrate how photosynthesis transforms light energy into stored chemical energy. LS1.C.2 - Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. *Overarching standards:* *LS2.B.1 - Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow of energy through ecosystems and that environmental conditions restrict which reactions can occur.*

Learning Goal	Proficiency Scales
Students will be able to explain how energy is transferred via chemical reactions of photosynthesis and respiration within the cell's organelles.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Explain the chemical and physical interactions between organelles as they carry out life processes

	● Explain interrelationships between photosynthesis and respiration (reactant and product only) ● Determine factors that affect the processes of photosynthesis and respiration (excludes light intensity) 2: Student demonstrates he/she is nearing proficiency by: ● Identify and describe cell structures and functions ● Define organelles by their functions 1: Student demonstrates a limited understanding or skill with the learning goal.

Macromolecules

Missouri Grade-Level Expectations (or other standards)
LS1.C.3 - Construct and revise an explanation based on evidence that organic macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules.

Learning Goal	Proficiency Scales
Students will be able to use the atomic to molecular scale to explain how biological structures and chemical reactions take place.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Explain how the carbon, hydrogen, and oxygen atoms found in sugar molecules can be rearranged to create other large carbon-based molecules. 2: Student demonstrates he/she is nearing proficiency by: ● Identify that sugars, amino acids, and other complex

	carbon-based molecules are composed largely of carbon, hydrogen, and oxygen atoms. 1: Student demonstrates a limited understanding or skill with the learning goal.

Evolution

Missouri Grade-Level Expectations (or other standards)
LS4.A.1 - Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. LS4.A.2 - Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. LS4.B.1 - Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. LS4.B.2 - Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. LS4.C.1 - Construct an explanation based on evidence for how natural selection leads to adaptation of populations. LS4.C.2 - Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. *Overarching standards:* *LS4.C.3 - Create or revise a model to test a solution to mitigate adverse impacts of human activity on biodiversity.*

Learning Goal	Proficiency Scales
Students will be able to use biological evidence to understand and support the concept that the process of natural selection leads to adaptations.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Explain the natural and/or human factors that may lead to the extinction of a species ● Given a scenario describing an environmental change,

	hypothesize why a given species was unable to survive 2: Student demonstrates he/she is nearing proficiency by: • Explain how environmental factors can be agents of natural selection • Explain the importance of reproduction to the survival of a species • Identify the impact a natural environmental event may have on the diversity of different species in an ecosystem 1: Student demonstrates a limited understanding or skill with the learning goal.

Ecology

Missouri Grade-Level Expectations (or other standards)

LS2.A.1 - Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations.
LS2.B.1 - Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and
anaerobic respiration are responsible for the cycling of matter and flow of energy through ecosystems and that environmental
conditions restrict which reactions can occur.
LS2.B.2 - Communicate the pattern of the cycling of matter and the flow of energy among trophic levels in an ecosystem.
LS2.B.3 - Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere.
LS2.C.1 - Evaluate the claims, evidence, and reasoning that the interactions in ecosystems maintain relatively consistent populations of species while conditions remain stable, but changing conditions may result in new ecosystem dynamics.
LS2.C.2 - Design, evaluate, and/or refine solutions that positively impact the environment and biodiversity.
LS4.C.3 - Create or revise a model to test a solution to mitigate adverse impacts of human activity on biodiversity.

Overarching standards:
LS1.A.3 - Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
LS1.C.2 - Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.
LS1.C.3 - Construct and revise an explanation based on evidence that organic macromolecules are primarily composed

of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules.

Learning Goal	Proficiency Scales
Students will be able to analyze the interaction of biotic and abiotic factors, including human induced effects.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Identify and explain limiting factor that affect carrying capacity ● Describe how natural environmental events impact diversity ● Explain impact human activity on diversity of different species ● Predict energy flow in food web 2: Student demonstrates he/she is nearing proficiency by: ● Explain how interactions within ecosystems maintain balance ● Explain relationships predator/prey and symbiosis ● Define carrying capacity ● Explain importance of reproduction to survival. 1: Student demonstrates a limited understanding or skill with the learning goal.

DNA Structure and Protein Synthesis

Missouri Grade-Level Expectations (or other standards)
LS1.A.1 - Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

Learning Goal	Proficiency Scales
Students will be able to model how DNA structure determines protein structure and function.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Describe the chemical and structural properties of DNA ● Recognize that DNA codes for proteins, which are expressed as the heritable characteristics of an organism ● Identify the causes of mutations in DNA and explain the possible effects on the organism 2: Student demonstrates he/she is nearing proficiency by: ● Identify and describe cell structures and functions ● Define organelles by their functions ● Identify that all living organisms have DNA ● Identify that DNA carries inherited information 1: Student demonstrates a limited understanding or skill with the learning goal.

Cell Transport and Communication

Missouri Grade-Level Expectations (or other standards)
LS1.A.2 - Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. LS1.A.3 - Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. LS1.B.1 - Develop and use models to communicate the role of mitosis, cellular division, and differentiation in producing and maintaining complex organisms. (*here focus on DIFFERENTIATION)*

Learning Goal	Proficiency Scales
Students will be able to develop and use models to communicate the role of mitosis, cell division, and differentiation in producing and maintaining the organ systems of complex organisms.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Identify cell differentiation ● Identify homeostasis and its effect on cellular activities 2: Student demonstrates he/she is nearing proficiency by: ● Explain how water is important to cells 1: Student demonstrates a limited understanding or skill with the learning goal.

Cell Division and Genetics

Missouri Grade-Level Expectations (or other standards)
LS1.B.1 - Develop and use models to communicate the role of mitosis, cellular division, and differentiation in producing and maintaining complex organisms. (*focus on MITOSIS within this unit).* LS3.A.1 - Develop and use models to clarify relationships about how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction. LS3.B.1 - Compare and contrast asexual and sexual reproduction with regard to genetic information and variation in offspring. LS3.B.2 - 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. LS3.B.3 - Make and defend a claim that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) mutations occurring during replication, and/or (3) mutations caused by environmental factors. LS3.B.4 - Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Learning Goal	Proficiency Scales
Students will be able to identify the	

processes of genetic inheritance and how genetic recombination and mutations create variation within a species.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Compare the processes of mitosis and meiosis (excludes identification of steps) ● Explain the advantages and disadvantages of sexual and asexual reproduction within a population ● Identify diploid and haploid chromosome number ● Explain how daughter cells compare to the original parent cell ● Explain how genotypes contribute to phenotypic variation within a species 2: Student demonstrates he/she is nearing proficiency by: ● Use a Punnett square to show a simple monohybrid cross ● Identify that DNA carries inherited information 1: Student demonstrates a limited understanding or skill with the learning goal.

Biology A

Scientific Method

Missouri Grade-Level Expectations (or other standards)
7.1.A: Scientific inquiry includes the ability of students to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation. 7.1.B: Scientific inquiry relies upon gathering evidence from qualitative and quantitative observation. 7.1.C: Scientific inquiry includes evaluation of explanations in light of evidence and scientific principles. 7.1.D: The nature of science relies upon communication of results and justification of explanations.

Learning Goal	Proficiency Scales
Students will be able to formulate a testable hypothesis, gather data, and draw a conclusion.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Applying the steps of the scientific method. ● Designing an experiment with an independent and dependent variable, and with an experimental and control group. ● Graphing data. ● Analyzing how the hypothesis is supported or rejected by the data. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as *dependent/independent variable, hypothesis, control/experimental group, and conclusion*. ● Performing processes such as: ○ Listing the steps of the scientific method. ○ Identifying from a teacher-provided lab the independent and dependent variables, the experimental and control groups. ○ Constructing a line graph.

	○ Deciding if the hypothesis is supported or rejected by the data. 1: Student demonstrates a limited understanding or skill with the learning goal.

Learning Targets
● Students list the steps of the scientific method. ● Students identify the independent and dependent variables from teacher-provided scenarios. ● Students identify the experimental and control group from teacher-provided scenarios. ● Students graph data. ● Students determine if the hypothesis is supported or rejected by the data. ● Students perform and write up lab report for designated lab.
Learning Design

Populations

Missouri Grade-Level Expectations (or other standards)
CLE 4.1.B: Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite.

Learning Goal	Proficiency Scales
Students will relate population growth patterns to population change.	4. Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3. Student demonstrates mastery with the learning goal as

	evidenced by: ● Contrasting population growth graphs. ● Determining a population's carrying capacity with examples of density-dependent/density-independent limiting factors. ● Determining characteristics of r-strategist/k-strategist 2. Student demonstrates he/she is nearing proficiency by: ● Recognizing and recalling specific vocabulary, such as *population growth, exponential/boom and bust/logistic, carrying capacity, density-dependent/density-independent, and r-strategist/k-strategist.* ● Performing processes such as: ○ Identifying the four types of population growth graphs. ○ Defining r-strategist/k-strategist characteristics. 1: Student demonstrates a limited understanding or skill with the learning goal.

Mendelian Genetics

Missouri Grade-Level Expectations (or other standards)
3.3.E: The pattern of inheritance for many traits can be predicted by using the principles of Mendelian genetics.

Learning Goal	Proficiency Scales
Students will be able to apply the principles of Mendelian genetics to patterns of inheritance.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by:

	- Completing a dihybrid genetic cross using a Punnett square. - Identifying 3 mechanisms that contribute to genetic variation. - Explaining how sex chromosomes determine offspring gender for humans. 2: Student demonstrates he/she is nearing proficiency by: - Recognizing or recalling specific vocabulary, such as *heredity, autosomal & sex chromosomes, dominant, recessive, heterozygous, homozygous, sex-linked, hybrids, alleles, phenotype, genotype, Punnett squares.* - Performing processes such as: - Completing a monohybrid genetic cross using a Punnett square. - Explaining how sex chromosomes determine offspring gender for humans. 1: Student demonstrates a limited understanding or skill with the learning goal.

Ecosystems

Missouri Grade-Level Expectations (or other standards)
3.2.B: Photosynthesis and cellular respiration are complementary processes necessary to the survival of most organisms on Earth. 4.1.A All populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem. 4.2.A As energy flows through the ecosystems, all organisms capture a portion of that energy and transform it to a form they can use.

Learning Goal	Proficiency Scales
Students will be able to analyze the	4: Student demonstrates an in-depth inference or advanced

interactions between organisms and their environment.	application or innovates with the learning goal.
	
	3: Student demonstrates mastery with the learning goal as evidenced by:
	
	● Assessing how changes in abiotic and biotic factors affect a habitat.
	● Identifying and mapping the biotic and abiotic factors with a specific ecosystem and show the influences that humans have on that site.
	● ~~Predicting the order of succession species.~~
	● Creating 3-level food web showing energy lost at each level.
	● Tracing the interactions of the products and reactants of photosynthesis and cellular respiration.
	
	2: Student demonstrates he/she is nearing proficiency by:
	
	● Recognizing or recalling specific vocabulary, such as *ecology, ecosystem, biotic/abiotic, succession, producer, primary/secondary/tertiary consumer, omnivore/herbivore/carnivore, food chain, food web, symbiosis, parasitism, mutualism, commensalism, niche, predation, competition, carbon cycle, photosynthesis, cellular respiration.*
	
	● Performing processes such as:
	
	    ● Identifying biotic and abiotic factors.
	    ● Identifying the correct order of succession of species.
	    ● Creating a 2-level food web showing energy lost at each level.
	    ● Defining the 3 types of symbiotic relationship.
	    ● Labeling the reactants of photosynthesis and cellular respiration using a teacher-provided diagram.
	    ● Identifying the type of symbiotic relationship from an example.
	
	1: Student demonstrates a limited understanding or skill with the learning goal.

DNA Structure and Function

Missouri Grade-Level Expectations (or other standards)
3.2.E: Protein structure and function are coded by the DNA. 3.3.B: All living organisms have genetic material that carries hereditary information.

Learning Goal	Proficiency Scales
The student will be able to demonstrate how the structure and function of DNA determines an organism's traits.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal 3: Student demonstrates mastery with the learning goal as evidenced by: ● Tracing the contributions of Watson, Crick and Franklin to the discovery of DNA's function. ● Identifying major parts on a strand of DNA. ● Generating the end product of DNA replication if given the original strand. ● Describing the steps of gene expression. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as *adenine, guanine, cytosine, thymine, nucleotide, base pair, hydrogen bond, double helix, DNA, RNA, replication, transcription, translation, amino acids, codon, anticodon, protein synthesis, peptide bond, gene, trait.* ● Performing processes such as: ○ Labeling the base pairs in a strand of DNA. ○ Identifying the correct number of strands at the end of DNA replication. ○ Ordering the steps of gene expression. 1: Student demonstrates limited understanding or skill with the learning goal.

WGSD Curriculum -- Biology A
Cells

Missouri Grade-Level Expectations (or other standards)
3.1.C: Cells are the fundamental units of structure and function of all living things. 3.2.A: The cell contains a set of structures called organelles that interact to carry out life processes through physical and chemical means. 3.2.F: Cellular activities and responses can maintain stability internally while external condition are changing (homeostasis).

Learning Goal	Proficiency Scales
The student will be able to explain how cell organelles carry out life processes and homeostasis.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Stating the 3 parts of the cell theory ● Comparing and contrasting prokaryotic, eukaryotic, plant and animal cells. ● Identifying functions for all cell organelles. ● Labeling pictures of plant and animal cell organelles. ● Drawing and labeling the cell membrane. ● Predicting transport of molecules across the cell membrane based on size and polarity. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing and recalling specific vocabulary, such as *cell theory, prokaryote, eukaryote, cell membrane, cell wall, chloroplast, chromosomes, cytoplasm, golgi apparatus, lysosome, mitochondria, nuclear membrane, nucleolus, nucleus, ribosomes, rough endoplasmic reticulum, smooth endoplasmic reticulum, vacuole, selectively permeable, phospholipid bilayer, homeostasis, passive and active transport, concentration gradient,*

	equilibrium, diffusion, osmosis, transport proteins, membrane pump, endocytosis, exocytosis, hypotonic, isotonic, hypertonic. ● Performing processes such as: ○ Recognizing the 3 parts of the cell theory. ○ Identifying prokaryotic, eukaryotic, plant and animal cells. ○ Matching cell organelles to their functions. ○ Labeling pictures of plant and animal cell organelles. ○ Stating the scientific name of the cell membrane and its basic characteristics. ○ Providing two examples of active and passive transport. 1: Student demonstrates a limited understanding or skill with the learning goal.

WGSD Curriculum -- Biology A
Cell Growth and Reproduction

Missouri Grade-Level Expectations (or other standards)
3.1.B: Organisms progress through life cycles unique to different types of organisms. 3.3.C: Chromosomes are components of cells that occur in pairs and carry hereditary information from one cell to daughter cells and from parents to offspring during reproduction.

Essential Learning Goal	Proficiency Scales
The student will be able to contrast the processes involved in and the end results of mitosis and meiosis.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Differentiating among the 6 phases of mitosis.

	● Describing the G1,S,G2 phases of interphase and the 3 checkpoints. ● Contrasting cytokinesis in plant and animal cells of mitosis. ● Contrasting chromatids and homologous chromosomes of meiosis. ● Contrasting the end products of mitosis and meiosis (number of cells and number of chromosomes) in mitosis and meiosis. ● Creating a human life cycle diagram (that depicts diploid, haploid, mitosis, meiosis, fertilization, and zygote). 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as *mitosis, meiosis, interphase, prophase, metaphase, anaphase, telophase, cytokinesis, chromosome, chromatid, homologous chromosomes, centomere, spindle fibers, diploid, haploid, gamete, zygote, sexual* and *asexual reproduction.* ● Performing processes such as: ○ Labeling cells in 6 phases of mitosis. ○ Defining chromatids and homologous chromosomes. ○ Contrasting cytokinesis in plant and animal cells. ○ Contrasting the end products of mitosis and meiosis (# of cells and # of chromosomes). ○ Labeling a teacher-provided human life cycle diagram. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-BIOCHEMISTRY

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 1.D.1: There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence.
Essential knowledge 1.D.2: Scientific evidence from many different disciplines supports models of the origin of life.
Essential knowledge 2.C.2: Organisms respond to changes in their external environments.
Essential knowledge 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.
Essential knowledge 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule
Essential knowledge 4.A.2:The structure and function of subcellular components, and their interactions, provide essential cellular processes.
Essential knowledge 4.B.1: Interactions between molecules affect their structure and function.
Essential knowledge 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.
Essential knowledge 4.C.1: Variation in molecular units provides cells with a wider range of functions.

Learning Goal	Proficiency Scales
The student will be able to identify essential molecules for life and explain how they interact as well as their impact on living organisms. The student will be able to use scientific evidence to explain the origin of life.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● The student is able to justify the selection of geological, physical, and chemical data that reveal early Earth conditions. ● The student is able to describe the reasons for revisions of scientific hypotheses of the origin of life on Earth. 2: Student demonstrates he/she is nearing proficiency by: ● The student is able to evaluate the accuracy and legitimacy of data to answer scientific questions about the origin of life on Earth. ● The student is able to describe a scientific hypothesis about the origin of life on Earth. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-CELLS AND CELL COMMUNICATION

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 1.B.1: Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.
Essential knowledge 1.B.2: Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.
Essential knowledge 2.A.2: Organisms capture and store free energy for use in biological processes.
Essential knowledge 2.A.3: Organisms must exchange matter with the environment to grow, reproduce and maintain organization.
Essential knowledge 2.B.1: Cell membranes are selectively permeable due to their structure.
Essential knowledge 2.B.2: Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.
Essential knowledge 2.B.3: Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.
Essential knowledge 2.C.1: Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.
Essential knowledge 2.D.1: All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.
Essential knowledge 2.D.2: Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.
Essential knowledge 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis.
Essential knowledge 3.D.1: Cell communication processes share common features that reflect a shared evolutionary history.
Essential knowledge 3.D.2: Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.

Learning Goal	Proficiency Scales
The student will be able to tell the similarities and differences between prokaryotic and eukaryotic cells. The student will be able to explain how cells control their internal environment via different mechanisms and molecular properties.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● The student can justify a claim made about the effect(s) on a biological system at the molecular, physiological or organismal level when given a scenario in which one or more components within a negative regulatory system is altered. ● The student is able to justify the scientific claim that organisms share many conserved core processes and features that evolved and are widely distributed among organisms today. 2: Student demonstrates he/she is nearing proficiency by: ● The student is able to evaluate data that show the effect(s) of changes in concentrations of key molecules on negative feedback mechanisms. ● The student is able to describe specific examples of conserved core biological processes

	and features shared by all domains or within one domain of life. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-PHOTOSYNTHESIS AND RESPIRATION

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 2.A.1: All living systems require constant input of free energy.
Essential knowledge 2.A.2: Organisms capture and store free energy for use in biological processes.
Essential knowledge 2.A.3: Organisms must exchange matter with the environment to grow, reproduce and maintain organization.
Essential knowledge 2.B.2: Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.
Essential knowledge 2.C.1: Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.
Essential knowledge 4.A.2: The structure and function of subcellular components, and their interactions, provide essential cellular processes.
Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.
Essential knowledge 4.C.1: Variation in molecular units provides cells with a wider range of functions.

Learning Goal	Proficiency Scales
The student will be able to illustrate and describe the chemical reaction sequence of major cycles in photosynthesis and respiration. The student will be able to use data and graphs to support claims of human impact on global warming via respiration.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● The student is able to construct explanations of the mechanisms and structural features of cells that allow organisms to capture, store or use free energy. ● The student is able to apply mathematical routines to quantities that describe interactions among living systems and their environment, which result in the movement of matter and energy. 2: Student demonstrates he/she is nearing proficiency by:

	● The student is able to explain how biological systems use free energy based on empirical data that all organisms require constant energy input to maintain organization, to grow and to reproduce. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-DNA AND CELL REPLICATION

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 1.A.4: Biological evolution is supported by scientific evidence from many disciplines, including mathematics.
Essential knowledge 1.B.1: Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.
Essential knowledge 2.C.1: Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.
Essential knowledge 2.C.2: Organisms respond to changes in their external environments.
Essential knowledge 2.E.1:Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.
Essential knowledge 2.E.2: Timing and coordination of physiological events are regulated by multiple mechanisms.
Essential knowledge 2.E.3: Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.
Essential knowledge 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.
Essential knowledge 3.A.2: In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis or meiosis plus fertilization.
Essential knowledge 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.
Essential knowledge 4.A.2:The structure and function of subcellular components, and their interactions, provide essential cellular processes.

Learning Goal	Proficiency Scales
The student will be able to discuss the benefits and consequences of sexual and asexual reproduction. The student will be able to label DNA structures and explain in detail the steps of	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● The student is able to evaluate evidence provided by data sets to support the

cell and DNA replication.	claim that heritable information is passed from one generation to another generation through mitosis, or meiosis followed by fertilization. ● The student is able to design a plan for collecting data to support the scientific claim that the timing and coordination of physiological events involve regulation. 2: Student demonstrates he/she is nearing proficiency by: ● The student can describe the events that occur in the cell cycle. ● The student is able to represent the connection between meiosis and increased genetic diversity necessary for evolution. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-PROTEIN SYNTHESIS

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 2.B.3: Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.
Essential knowledge 2.E.1:Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.
Essential knowledge 3.B.1: Gene regulation results in differential gene expression, leading to cell specialization.
Essential knowledge 3.B.2: A variety of intercellular and intracellular signal transmissions mediate gene expression.
Essential knowledge 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.
Essential knowledge 4.A.2:The structure and function of subcellular components, and their interactions, provide essential cellular processes.
Essential knowledge 4.B.1: Interactions between molecules affect their structure and function.

Learning Goal	Proficiency Scales
The student will be able to discuss the processes and transcription and translation and their role in protein synthesis. The student will be able to understand how external and internal stimuli can cause	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● The student is able to explain how the regulation of gene

protein synthesis to occur to keep normal cell function.	expression is essential for the processes and structures that support efficient cell function. 2: Student demonstrates he/she is nearing proficiency by: ● The student is able to explain the connection between the sequence and the subcomponents of a biological polymer and its properties. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-Gene Regulation

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 2.B.3: Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.
Essential knowledge 2.D.1: All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.
Essential knowledge 2.E.1:Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.
Essential knowledge 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.
Essential knowledge 3.B.1: Gene regulation results in differential gene expression, leading to cell specialization.
Essential knowledge 3.B.2: A variety of intercellular and intracellular signal transmissions mediate gene expression.
Essential knowledge 3.C.1: Changes in genotype can result in changes in phenotype.
Essential knowledge 3.C.2: Biological systems have multiple processes that increase genetic variation.
Essential knowledge 4.A.3: Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.
Essential knowledge 4.B.1: Interactions between molecules affect their structure and function.

Learning Goal	Proficiency Scales
The student will be able to explain how external stimuli like temperature and nutrients can cause genes to turn on or off.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal.

The student will be able to analyze data and predict the physiological outcome of organism development.	3: Student demonstrates mastery with the learning goal as evidenced by: ● The student is able to explain how the regulation of gene expression is essential for the processes and structures that support efficient cell function. ● The student is able to explain how signal pathways mediate gene expression, including how this process can affect protein production. 2: Student demonstrates he/she is nearing proficiency by: ● The student is able to describe the connection between the regulation of gene expression and observed differences between different kinds of organisms. ● The student can use representations to describe mechanisms of the regulation of gene expression. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-GENETICS

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.
Essential knowledge 3.A.2: In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis or meiosis plus fertilization.
Essential knowledge 3.A.3:The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.
Essential knowledge 3.A.4:The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.
Essential knowledge 3.C.1: Changes in genotype can result in changes in phenotype.
Essential knowledge 3.C.2: Biological systems have multiple processes that increase genetic variation.
Essential knowledge 4.A.3: Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.
Essential knowledge 4.C.2: Environmental factors influence the expression of the genotype in an organism.
Essential knowledge 4.C.3:The level of variation in a population affects population dynamics.

Learning Goal	Proficiency Scales
The student will be able to analyze	4: Student demonstrates an in-depth inference or advanced application or

advanced inheritance patterns. The student will be able to use ratios, mathematical equations, and data to calculate phenotype and genotype ratios of future generations.	innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● The student is able to pose questions about ethical, social or medical issues surrounding human genetic disorders. ● The student is able to describe representations of an appropriate example of inheritance patterns that cannot be explained by Mendel's model of the inheritance of traits. 2: Student demonstrates he/she is nearing proficiency by: ● The student is able to apply mathematical routines to determine Mendelian patterns of inheritance provided by data sets. ● The student is able to explain deviations from Mendel's model of the inheritance of traits. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-BIOTECHNOLOGY

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 1.A.2: Natural selection acts on phenotypic variations in populations.
Essential knowledge 1.A.3: Evolutionary change is also driven by random processes.
Essential knowledge 1.A.4: Biological evolution is supported by scientific evidence from many disciplines, including mathematics.
Essential knowledge 1.B.1: Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.
Essential knowledge 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.
Essential knowledge 3.A.3:The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.
Essential knowledge 3.A.4:The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.
Essential knowledge 3.C.3: Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.
Essential knowledge 4.B.1: Interactions between molecules affect their structure and function.
Essential knowledge 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.

Learning Goal	Proficiency Scales
The student will be able to illustrate the life cycles of viruses and explain how this allows genetic transfer between cells to occur. The student will be able to describe different technologies available and match them with what real life application would use these tools.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● The student is able to construct an explanation of how viruses introduce genetic variation in host organisms. ● The student can justify the claim that humans can manipulate heritable information by identifying at least two commonly used technologies. 2: Student demonstrates he/she is nearing proficiency by: ● The student is able to use representations and appropriate models to describe how viral replication introduces genetic variation in the viral population. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-MICROEVOLUTION

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 1.A.1: Natural selection is a major mechanism of evolution.
Essential knowledge 1.A.2: Natural selection acts on phenotypic variations in populations.
Essential knowledge 1.A.3: Evolutionary change is also driven by random processes.
Essential knowledge 1.A.4: Biological evolution is supported by scientific evidence from many disciplines, including mathematics.
Essential knowledge 1.B.2: Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.
Essential knowledge 1.C.3: Populations of organisms continue to evolve.
Essential knowledge 1.D.1:There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence.
Essential knowledge 1.D.2: Scientific evidence from many different disciplines supports models of the origin of life.
Essential knowledge 3.C.1: Changes in genotype can result in changes in phenotype.

Essential knowledge 3.D.1: Cell communication processes share common features that reflect a shared evolutionary history.

Learning Goal	Proficiency Scales
The student will be able to use data and mathematical equations to predict population growth, evolution, and extinction/speciation of organisms. The student will be able to explain how chromosomal and base mutations can lead to advantageous phenotypes and cause speciation.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● The student is able to convert a data set from a table of numbers that reflect a change in the genetic makeup of a population over time and to apply mathematical methods and conceptual understandings to investigate the cause(s) and effect(s) of this change. ● The student is able to use data from mathematical models based on the Hardy-Weinberg equilibrium to analyze genetic drift and effects of selection in the evolution of specific populations. 2: Student demonstrates he/she is nearing proficiency by: ● The student is able to evaluate evidence provided by data to qualitatively and quantitatively investigate the role of natural selection in evolution. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-MACROEVOLUTION

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 1.A.1: Natural selection is a major mechanism of evolution.
Essential knowledge 1.A.2: Natural selection acts on phenotypic variations in populations.
Essential knowledge 1.A.3: Evolutionary change is also driven by random processes.
Essential knowledge 1.A.4: Biological evolution is supported by scientific evidence from many disciplines, including mathematics.
Essential knowledge 1.B.2: Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.
Essential knowledge 1.C.1: Speciation and extinction have occurred throughout the Earth's history.

Essential knowledge 1.C.2: Speciation may occur when two populations become reproductively isolated from each other.
Essential knowledge 1.C.3: Populations of organisms continue to evolve.
Essential knowledge 1.D.1:There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence.
Essential knowledge 1.D.2: Scientific evidence from many different disciplines supports models of the origin of life.
Essential knowledge 2.E.3:Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.
Essential knowledge 3.D.1: Cell communication processes share common features that reflect a shared evolutionary history.

Learning Goal	Proficiency Scales
The student will be able to use data and evidence to support the claim that speciation and evolution has occurred. The student will be able to categorize organisms based on similar structures, functions, and abilities and use this categorization to sort unknown organisms.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● The student is able to evaluate data-based evidence that describes evolutionary changes in the genetic makeup of a population over time. ● The student is able to design a plan for collecting data to investigate the scientific claim that speciation and extinction have occurred throughout the Earth's history. ● The student is able to describe a model that represents evolution within a population. 2: Student demonstrates he/she is nearing proficiency by: ● The student is able to connect evolutionary changes in a population over time to a change in the environment. ● The student is able to analyze data related to questions of speciation and extinction throughout the Earth's history. ● The student is able to justify the selection of data that address questions related to reproductive isolation and speciation. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-NERVOUS SYSTEM

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 3.D.1: Cell communication processes share common features that reflect a shared evolutionary history.
Essential knowledge 3.D.2: Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.
Essential knowledge 3.D.3: Signal transduction pathways link signal reception with cellular response.
Essential knowledge 3.D.4: Changes in signal transduction pathways can alter cellular response.
Essential knowledge 3.E.1: Individuals can act on information and communicate it to others.
Essential knowledge 3.E.2: Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.

Learning Goal	Proficiency Scales
The student will be able to illustrate the complex process of receiving stimuli and eliciting a response via nerve impulses and chemicals. The student will be able to explain the difference between cell to cell communication and communication between organisms.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● The student is able to construct explanations of cell communication through cell-to-cell direct contact or through chemical signaling. ● The student is able to construct an explanation, based on scientific theories and models, about how nervous systems detect external and internal signals, transmit and integrate information, and produce responses. 2: Student demonstrates he/she is nearing proficiency by: ● The student is able to create representation(s) that depict how cell-to-cell communication occurs by direct contact or from a distance through chemical signaling. ● The student is able to describe how nervous systems transmit information. ● The student is able to describe how nervous systems detect external and internal signals. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-ENDOCRINE SYSTEM

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 2.B.1: Cell membranes are selectively permeable due to their structure.
Essential knowledge 3.D.1: Cell communication processes share common features that reflect a shared evolutionary history.
Essential knowledge 3.D.2: Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.
Essential knowledge 4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.
Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.
Essential knowledge 4.B.1: Interactions between molecules affect their structure and function.

Learning Goal	Proficiency Scales
The student will be able to explain the role the endocrine system has in cell communication.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● The student is able to construct explanations of cell communication through cell-to-cell direct contact or through chemical signaling. ● The student is able to use representation(s) and appropriate models to describe features of a cell signaling pathway. 2: Student demonstrates he/she is nearing proficiency by: ● The student is able to create representation(s) that depict how cell-to-cell communication occurs by direct contact or from a distance through chemical signaling. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-IMMUNE SYSTEM

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 2.D.1: All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.
Essential knowledge 2.D.2: Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.
Essential knowledge 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis.
Essential knowledge 2.D.4: Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.
Essential knowledge 3.D.2: Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.
Essential knowledge 4.B.1: Interactions between molecules affect their structure and function.

Learning Goal	Proficiency Scales
The student will be able to identify and describe key leukocytes and their role in fighting pathogens. The student will be able to explain the chemical communication done between the immune system cells and other system cells.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● The student can create representations and models to describe immune responses. ● The student can connect concepts in and across domains to show that timing and coordination of specific events are necessary for normal development in an organism and that these events are regulated by multiple mechanisms. 2: Student demonstrates he/she is nearing proficiency by: ● The student can create representations or models to describe nonspecific immune defenses in plants and animals. ● The student is able to connect concepts that describe mechanisms that regulate the timing and coordination of physiological events. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-BOTANY

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 2.E.1:Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.
Essential knowledge 2.E.2:Timing and coordination of physiological events are regulated by multiple mechanisms.
Essential knowledge 2.E.3:Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.
Essential knowledge 3.C.2: Biological systems have multiple processes that increase genetic variation.
Essential knowledge 3.D.1: Cell communication processes share common features that reflect a shared evolutionary history.
Essential knowledge 4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.
Essential knowledge 4.C.1: Variation in molecular units provides cells with a wider range of functions.
Essential knowledge 4.C.2: Environmental factors influence the expression of the genotype in an organism.
Essential knowledge 4.C.3:The level of variation in a population affects population dynamics.

Learning Goal	Proficiency Scales
The student will be able to identify plant anatomy that illustrates differentiation and organ system functions. The student will be able to explain reproductive organ parts and the variety of reproductive life cycles.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● The student is able to analyze data to identify how molecular interactions affect structure and function. ● The student is able to evaluate scientific questions concerning organisms that exhibit complex properties due to the interaction of their constituent parts. ● The student is able to construct explanations based on evidence of how variation in molecular units provides cells with a wider range of functions. 2: Student demonstrates he/she is nearing proficiency by: ● The student is able to refine representations and models to illustrate biocomplexity due to interactions of the constituent parts. 1: Student demonstrates a limited understanding or skill with the learning goal.

AP BIOLOGY-ECOLOGY

Missouri Grade-Level Expectations (or other standards)

Essential knowledge 1.A.1: Natural selection is a major mechanism of evolution.
Essential knowledge 1.A.2: Natural selection acts on phenotypic variations in populations.
Essential knowledge 1.A.3: Evolutionary change is also driven by random processes.
Essential knowledge 1.A.4: Biological evolution is supported by scientific evidence from many disciplines, including mathematics.
Essential knowledge 1.B.1: Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today
Essential knowledge 2.A.1: All living systems require constant input of free energy.
Essential knowledge 2.A.2: Organisms capture and store free energy for use in biological processes.
Essential knowledge 2.A.3: Organisms must exchange matter with the environment to grow, reproduce and maintain organization.
Essential knowledge 2.C.2: Organisms respond to changes in their external environments.
Essential knowledge 2.D.2: Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.
Essential knowledge 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis.
Essential knowledge 3.E.1: Individuals can act on information and communicate it to others.
Essential knowledge 3.E.2: Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.
Essential knowledge 4.A.5: Communities are composed of populations of organisms that interact in complex ways.
Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.
Essential knowledge 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.
Essential knowledge 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.
Essential knowledge 4.B.4: Distribution of local and global ecosystems changes over time.
Essential knowledge 4.C.3:The level of variation in a population affects population dynamics.
Essential knowledge 4.C.4:The diversity of species within an ecosystem may influence the stability of the ecosystem.

Learning Goal	Proficiency Scales
The student will be able to draw abiotic cycles of materials and explain their role in an ecosystem. The student will be able to use behavior and lifestyle to identify what type of role an organism plays in an ecosystem. The student will be able to analyze data to	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● The student is able to apply mathematical routines to quantities that describe communities composed of populations of organisms that interact in complex ways. ● The student is able to use visual representations to analyze situations or solve problems qualitatively to illustrate how interactions among living systems and with their environment result in the movement of matter and energy.

conclude what interactions and relationships organisms have with each other.	2: Student demonstrates he/she is nearing proficiency by: • The student is able to predict the effects of a change in the community's populations on the community. • The student is able to predict the effects of a change of matter or energy availability on communities. 1: Student demonstrates a limited understanding or skill with the learning goal.

WGSD Curriculum -- Conceptual Chemistry - Role of Energy

Missouri Grade-Level Expectations (or other standards)
9-12.PS1.A.2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. 9-12.PS1.A.5 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. 9-12.PS1.B.1: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. 9-12.PS1.B.2: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

Learning Goal	Proficiency Scales
Students will be able to show the role of energy in chemical reactions (ie. rates of reactions).	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery of the learning goal as evidenced by: ● Explaining how changing the conditions of a reaction will affect the rate of that reaction. ● Modifying an explanation of rate change based on experimental data. ● Interpreting a phase change graph using heat energy and temperature. 2: Student demonstrates he/she is nearing proficiency by ● Recognizing or recalling specific vocabulary, such as: *endothermic, melting, boiling, condensing, freezing, temperature.*

	● Performing processes such as:
	  ● Identifying actions that will affect the rate of a reaction: stirring, particle size, temperature.
	  ● Describing why temperature doesn't change during a phase change.
	  ● Identifying melting, boiling, condensing, and freezing on a phase change graph.
	
	1: Student demonstrates a limited understanding or skill with the learning goal.

WGSD Curriculum -- Conceptual Chemistry
Interaction of Geospheres

Missouri Grade-Level Expectations (or other standards)
9-12.ESS2.C.1 : Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. 9-12.ESS3.C.2 : Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. 9-12.ESS3.D.2 : Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Learning Goal	Proficiency Scales

The student will be able to develop a logical argument about about how the interaction of geospheres affects, and is affected by, earth populations.	4: The student demonstrates an in-depth inference or advanced application, or innovates with the learning goal.
	
	3: The student demonstrates mastery of the learning goal by
	
	● analyzing the interaction of the chemical properties of pollution with air and water to assess their effects.
	● showing and discussing evidence illustrating the effects of humans on a particular resource scarcity and purity.
	● assessing the impact of chemistry on the environment.
	
	2: The student demonstrates he/she is nearing proficiency by
	
	● recognizing or recalling specific vocabulary, such as: *geosphere, population, pollution, acid rain, deposition.*
	
	● performing specific processes, such as:
	
	  ● summarizing the properties of air and water.
	  ● summarizing the major sources of pollution of air and water.
	  ● giving examples of the interactions of properties and human behavior.
	
	1: The student demonstrates limited understanding or skill with the learning goal.

WGSD Curriculum -- Conceptual Chemistry

Energy Transferred

Missouri Grade-Level Expectations (or other standards)

9-12.PS3.A.1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other components(s) and energy flows in and out of the system are known.
9-12.PS3.A.2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.
9-12.PS3.B.1: 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).

Learning Goal	Proficiency Scales
Students will be able to apply the Law of Conservation of Energy.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery of the learning goal as evidenced by: ● Demonstrating experimentally the conservation of energy in a system. ● Creating a computational model relating a system to its surroundings. ● Evaluating the transfer of thermal energy. ● Discussing the behavior of particles that creates the observed temperature, pressure and volume changes. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as: *pressure, temperature, volume, kinetic, heat, specific heat capacity, endothermic, exothermic, and insulator.*

	- Performing processes such as: - Describing the movement of heat energy. - Discussing the Law of Conservation of Energy and its affect on systems. - Evaluating an experiment to determine the system studied and the surroundings present. 1: Student demonstrates a limited understanding or skill with the learning goal.

WGSD Curriculum -- Conceptual Chemistry
Composition and Interaction of Atoms

Missouri Grade-Level Expectations (or other standards)
9-12.PS1.A.1: 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. 9-12.PS1.A.3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. 9-12.PS1.B.3: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Learning Goal	Proficiency Scales

Students will be able to create models and predict interactions of atoms.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery of the learning goal as evidenced by: ● Drawing a sketch showing the relative position of subatomic particles in an atom. ● Interpreting the development of the modern model of the atom. ● Constructing chemical formulas using outermost electron energy levels. ● Developing a model of interaction of subatomic particles. ● Constructing simple chemical reaction equations showing conservation of atoms and mass. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as: *period, group, nucleus, electron cloud, isotope, ion, formula, molecule, valence electrons.* ● Performing processes such as: ○ Matching the development of the modern model of the atom with the correct scientist. ○ Describing the structure of the periodic table. ○ Balancing simple chemical equations. 1: Student demonstrates a limited understanding or skill with the learning goal.

Classify Matter

Missouri Grade-Level Expectations (or other standards)
9-12.PS1.A.1 : 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. NGSS-HS-PS 1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. NGSS-HS-PS 2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

<table>
<tr><th><u>Learning Goal</u></th><th><u>Proficiency Scales</u></th></tr>
<tr><td>Students will be able to describe and classify matter.</td><td>4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal.

3: Student demonstrates mastery of the learning goal as evidenced by:
Differentiating matter as pure substances or mixtures.
Describing physical and chemical properties and changes of matter.
Classifying chemical change based on experimental evidence.
2: Student demonstrates he/she is nearing proficiency by:
Recognizing or recalling specific vocabulary, such as: matter, density, solubility, mixture, pure substance, phases of matter, homogeneous, heterogeneous, precipitate.
Performing processes such as:
Classifying an object based on its physical and chemical properties.
Classifying matter as a pure substance, mixture, element, compound and type of mixture.
Identifying types of mixtures.
Recognizing evidence of a chemical change.
1: Student demonstrates a limited understanding or skill with the learning goal.</td></tr>
<tr><td></td><td></td></tr>
</table>

WGSD Curriculum -- Conceptual Chemistry
Nuclear

Missouri Grade-Level Expectations (or other standards)
9-12.PS1.C.1 : 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. 9-12.PS4.B.2: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. 9-12.ESS1.A.1: Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in sun's core to release energy that eventually reaches Earth in the form of radiation. 9-12.ESS1.A.3: Communicate scientific ideas about the way stars, over their life cycle, produce elements. (fusion)

Learning Goal	Proficiency Scales
Students will be able to evaluate the composition and interactions of the atomic nucleus.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery of the learning goal as evidenced by: ● Modeling the process by which energy and particles are released from an atomic nucleus. ● Comparing energy released through nuclear processes. ● Evaluating the validity and reliability of claims of effects of EMR on living organisms. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as: *radiation, decay, half-life, exposure, alpha particle, beta particle, gamma*

	radiation, fission, fusion, isotope, ionizing, and EMR. ● Performing processes such as: ○ Completing a nuclear decay series. ○ Describing the process by which stars produce/release energy. ○ Comparing and contrasting the processes of fission and fusion. ○ Describing three ways we may limit radiation exposure. 1: Student demonstrates a limited understanding or skill with the learning goal.

WGSD Curriculum -- Chemistry A
Role of Energy

Missouri Grade-Level Expectations (or other standards)
NGSS-HS-PS 1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. NGSS-HS-PS 1-4: 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. NGSS-HS-PS 1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. NGSS-HS-PS 1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

Learning Goal	Proficiency Scales
Students will be able to show the role of energy in chemical reactions (ie. rates of reactions).	4: The student demonstrates an in-depth inference or advanced application, or innovates with the learning goal. 3: The student demonstrates mastery of the learning goal by ● explaining how changing the conditions of a reaction will affect the rate of that reaction. ● give evidentiary support how changing conditions affect the amount of product. ● calculating the total energy change required to change the temperature of a substance a given amount. ● modifying an explanation of rate change based on experimental data.

	2: The student demonstrates he/she is nearing proficiency by
	
	● recognizing or recalling specific vocabulary, such as: *endothermic, exothermic, entropy, heat of vaporization, heat of fusion, enthalpy.*
	
	● performing specific processes, such as:
	
	  ● identifying actions that will affect the rate of a reaction: stirring, particle size, temperature.
	  ● explaining what changing conditions might affect the amount of product.
	  ● describing why temperature doesn't change during a phase change.
	
	1: The student demonstrates limited understanding or skill with the learning goal.

WGSD Curriculum -- Chemistry A
Interaction of Geospheres

Missouri Grade-Level Expectations (or other standards)
NGSS-HS-ESS 2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. NGSS-HS-ESS 3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. NGSS-HS-ESS 3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Learning Goal	Proficiency Scales

The student will be able to develop a logical argument about about how the interaction of geospheres affects, and is affected by, earth populations.	4: The student demonstrates an in-depth inference or advanced application, or innovates with the learning goal.
	
	3: The student demonstrates mastery of the learning goal by
	
	● analyzing the interaction of the chemical properties of pollution with air and water to assess their effects.
	● showing and discussing evidence illustrating the effects of humans on a particular resource scarcity and purity.
	● discussing how colligative properties are affected by the hydrogen bonding in water.
	● assessing the impact of chemistry on the environment.
	
	2: The student demonstrates he/she is nearing proficiency by
	
	● recognizing or recalling specific vocabulary, such as: *geosphere, population, pollution, acid rain, deposition.*
	
	● performing specific processes, such as:
	
	    ● summarizing the properties of air and water.
	    ● summarizing the major sources of pollution of air and water.
	    ● analyzing the interaction of the properties and human behavior with teacher help.
	
	1: The student demonstrates limited understanding or skill with the learning goal.

Energy Transferred

Missouri Grade-Level Expectations (or other standards)

NGSS-HS-PS 3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other components(s) and energy flows in and out of the system are known.
NGSS-HS-PS 3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.
NGSS-HS-PS 3-4: 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).

Learning Goal	Proficiency Scales
Students will be able to model energy transfer within chemical systems as the total energy remains constant (i.e., Law of Conservation of Energy).	4: The student demonstrates an in-depth inference or advanced application, or innovates with the learning goal. 3: The student demonstrates mastery of the learning goal by ● demonstrating mathematically and experimentally the conservation of energy in a system. ● creating a computational model relating a system to its surroundings. ● evaluating the transfer of thermal energy. ● discussing the behavior of particles that creates the observed temperature, pressure and volume changes. 2: The student demonstrates he/she is nearing proficiency by

	- recognizing or recalling specific vocabulary, such as: *pressure, temperature, volume, kinetic, heat, specific heat capacity.* - performing specific processes, such as: - describing the movement of heat energy. - discussing the Law of Conservation of Energy and its affect on systems. - evaluating an experiment to determine the system studied and the surroundings present. 1: The student demonstrates limited understanding or skill with the learning goal.

WGSD Curriculum -- Chemistry A
Composition and Interaction of Atoms

Missouri Grade-Level Expectations (or other standards)
NGSS-HS-PS 1-1: 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. NGSS-HS-PS 1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. NGSS-HS-PS 1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. NGSS-HS-PS 2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Learning Goal	Proficiency Scales
Students will be able to identify the composition and model the interactions of atoms.	4: The student demonstrates an in-depth inference or advanced application, or innovates with the learning goal. 3: The student demonstrates mastery of the learning goal by ● drawing a sketch showing the relative position of subatomic particles in an atom and their relative numbers for a given isotope. ● drawing conclusions on how the characteristics used to identify atoms relate to the periodicity of the periodic table. ● interpreting the development of the modern model of the atom. ● constructing chemical formulas using outermost electron energy levels. ● developing a model of interaction of subatomic particles. ● constructing simple chemical reaction equations showing conservation of atoms and mass. 2: The student demonstrates he/she is nearing proficiency by ● recognizing or recalling specific vocabulary, such as: *period, group, nucleus, electron cloud, isotope, ion, formula, molecule.* ● performing specific processes, such as ○ creating a timeline depicting the development of the modern model of the atom. ○ describing the structure of the periodic table and how that structure was developed. ○ balancing simple chemical equations. 1: The student demonstrates limited understanding or skill with the learning goal.

WGSD Curriculum -- Chemistry A
Classify Matter

Missouri Grade-Level Expectations (or other standards)
NGSS-HS-PS 1-1: 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. NGSS-HS-PS 1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. NGSS-HS-PS 2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

<table>
<tr><th><u>Learning Goal</u></th><th><u>Proficiency Scales</u></th></tr>
<tr><td>Students will be able to describe and classify matter.</td><td>4: The student demonstrates an in-depth inference or advanced application, or innovates with the learning goal.

3: The student demonstrates mastery of the learning goal by
predicting physical and chemical properties of matter based on their position on the periodic table.
differentiating matter as pure substances or mixtures.
describing physical and chemical properties and changes of matter.
classifying chemical change based on experimental evidence.
2: The student demonstrates he/she is nearing proficiency by
recognizing or recalling specific vocabulary, such as: matter, density, solubility, mixture, pure substance, phases of matter, homogeneous, heterogeneous, precipitate.
performing basic processes, such as:
classifying an object based on its physical and chemical properties.
describing the relationships among matter, pure substances, mixtures, elements, compounds and types of mixtures.
identifying types of mixtures.
recognizing evidence of a chemical change.
1: The student demonstrates limited understanding or skill with the learning goal.</td></tr>
<tr><td></td><td></td></tr>
</table>

AP Chemistry Unit 1 - Atomic Structure and Property

Next Generation Science Standards (NGSS)

NGSS-HS-PS 1-1: 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.

NGSS-HS-PS 1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

NGSS-HS-PS 1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

NGSS-HS-PS 1-4: 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.

NGSS-HS-PS 1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

NGSS-HS-PS 1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

NGSS-HS-PS 1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

NGSS-HS-PS 2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

NGSS-HS-PS 3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other components(s) and energy flows in and out of the system are known.

NGSS-HS-PS 3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.

NGSS-HS-PS 3-4: 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).

NGSS-HS-ESS 2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

<table>
<tr><td colspan="2">NGSS-HS-ESS 3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

NGSS-HS-ESS 3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.</td></tr>
<tr><td><u>Learning Goal</u>

The student will understand:

1.1.A Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept.

1.2.A Explain the quantitative relationship between the mass spectrum of an element and the masses of the element’s isotopes.

1.3.A Explain the quantitative relationship between the elemental composition by mass and the empirical formula of a pure substance.

1.4.A Explain the quantitative relationship between the elemental composition by mass and the composition of substances in a mixture.

1.5.A Represent the ground-state electron configuration of an atom of an element or its ions using the Aufbau principle.

1.6.A Explain the relationship between the photoelectron spectrum of an atom or ion and:
i. The ground-state electron configuration of the species.
ii. The interactions between the electrons and the nucleus.

1.7.A Explain the relationship between trends in atomic properties of elements and electronic structure and periodicity.

1.8.A Explain the relationship between trends in the reactivity of elements and periodicity.</td>
<td><u>Proficiency Scale</u>

4: Student demonstrates innovation, in depth inference(s), or advanced application(s) with the learning goal (can have multiple bullets underneath)

3: Student demonstrates evidence of the learning goal (define, give an example, assessment, etc.)

2: Student demonstrates overall proficiency with the objectives and essential vocabulary (included here or in objectives below)
(can have multiple bullets underneath)

1: Student demonstrates limited proficiency with the objectives and essential vocabulary</td></tr>
<tr><td colspan="2"><u>Learning Targets</u>

1.1.A.1 One cannot count particles directly while performing laboratory work. Thus, there must be a connection between the masses of substances reacting and the actual number of particles undergoing chemical changes.

1.1.A.2 A Avogadro’s number (N = 6.022 × 1023 mol−1) provides the connection between the number of moles in a pure sample of a substance and the number of constituent particles (or formula units) of that substance.</td></tr>
</table>

1.1.A.3 Expressing the mass of an individual atom or molecule in atomic mass units (amu) is useful because the average mass in amu of one particle (atom or molecule) or formula unit of a substance will always be numerically equal to the molar mass of that substance in grams. Thus, there is a quantitative connection between the mass of a substance and the number of particles that the substance contains. EQN: $n = m/M$

1.2.A.1 The mass spectrum of a sample containing a single element can be used to determine the identity of the isotopes of that element and the relative abundance of each isotope in nature.

1.2.A.2 The average atomic mass of an element can be estimated from the weighted average of the isotopic masses using the mass of each isotope and its relative abundance.

> *Exclusion Statement: Interpreting mass spectra of samples containing multiple elements or peaks arising from species other than singly charged monatomic ions will not be assessed on the AP Exam.*

1.3.A.1 Some pure substances are composed of individual molecules, while others consist of atoms or ions held together in fixed proportions as described by a formula unit.

1.3.A.2 According to the law of definite proportions, the ratio of the masses of the constituent elements in any pure sample of that compound is always the same.

1.3.A.3 The chemical formula that lists the lowest whole number ratio of atoms of the elements in a compound is the empirical formula.

1.4.A.1 Pure substances contain atoms, molecules, or formula units of a single type. Mixtures contain atoms, molecules, or formula units of two or more types, whose relative proportions can vary.

1.4.A.2 Elemental analysis can be used to determine the relative numbers of atoms in a substance and to determine its purity.

1.5.A.1 The atom is composed of negatively charged electrons and a positively charged nucleus that is made of protons and neutrons.

1.5.A.2 Coulomb's law is used to calculate the force between two charged particles. EQN: $F_{coulombic} \propto q_1 q_2$

1.5.A.3 In atoms and ions, the electrons can be thought of as being in "shells (energy levels)" and "subshells (sublevels)," as described by the ground-state electron configuration. Inner electrons are called core electrons, and outer electrons are called valence electrons. The electron configuration is explained by quantum mechanics, as delineated in the Aufbau principle and exemplified in the periodic table of the

> *Exclusion Statement: The assignment of quantum numbers to electrons in subshells of an atom will not be assessed on the AP Exam.*

1.5.A.4 The relative energy required to remove an electron from different subshells of an atom or ion or from the same subshell in different atoms or ions (ionization energy) can be estimated through a qualitative application of Coulomb's law. This energy is related to the distance from the nucleus and the effective(shield) charge of the nucleus.

1.6.A.1 The energies of the electrons in a given shell can be measured experimentally with photoelectron spectroscopy (PES). The position of each peak in the PES spectrum is related to the energy required to remove an electron from the corresponding subshell, and the relative height of each peak is (ideally) proportional to the number of electrons in that subshell.

1.7.A.1 The organization of the periodic table is based on patterns of recurring properties of the elements, which are explained by patterns of ground-state electron configurations and the presence of completely or partially filled shells (and sub-shells) of electrons in atoms. *Exclusion Statement: Writing the electron configuration of elements that are exceptions to the Aufbau principle will not be assessed on the AP Exam.*

1.7.A.2 Trends in atomic properties within the periodic table (periodicity) can be predicted by the position of the element on the periodic table and qualitatively understood using Coulomb's law, the shell model, and the concepts of shielding and effective nuclear charge. These properties include:

i.Ionization energy
ii. Atomic and ionic radii
iii. Electron affinity
iv. Electronegativity

1.7.A.3 The periodicity (in 1.7.A.2) is useful to predict/ estimate values of properties in the absence of data.

1.8.A.1 The likelihood that two elements will form a chemical bond is determined by the interactions between the valence electrons and nuclei of elements.

1.8.A.2 Elements in the same column of the periodic table tend to form analogous compounds.

1.8.A.3 Typical charges of atoms in ionic compounds are governed by the number of valence electrons and predicted by their location on the periodic table.

AP Chemistry Unit 2 - Molecular and Ionic Compounds Structure and Properties

Next Generation Science Standards (NGSS)

NGSS-HS-PS 1-1: 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.

NGSS-HS-PS 1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

NGSS-HS-PS 1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

NGSS-HS-PS 1-4: 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.

NGSS-HS-PS 1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

NGSS-HS-PS 1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

NGSS-HS-PS 1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

NGSS-HS-PS 2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

NGSS-HS-PS 3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other components(s) and energy flows in and out of the system are known.

NGSS-HS-PS 3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.

NGSS-HS-PS 3-4: 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).

NGSS-HS-ESS 2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
NGSS-HS-ESS 3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

NGSS-HS-ESS 3-6: Use a computational representation to illustrate the relationships among Earth

systems and how those relationships are being modified due to human activity.

Learning Goal	**Proficiency Scale**
The student will understand: 2.1.A Explain the relationship between the type of bonding and the properties of the elements participating in the bond. 2.2.A Represent the relationship between potential energy and distance between atoms, based on factors that influence the interaction strength. 2.3.A Represent an ionic solid with a particulate model that is consistent with Coulomb's law and the properties of the constituent ions. 2.4.A Represent a metallic solid and/or alloy using a model to show essential characteristics of the structure and interactions present in the substance. 2.5.A Represent a molecule with a Lewis diagram. 2.6.A Represent a molecule with a Lewis diagram that accounts for resonance between equivalent structures or that uses formal charge to select between nonequivalent structures. 2.7.A Based on the relationship between Lewis diagrams, VSEPR theory, bond orders, and bond polarities: i. Explain structural properties of molecules. ii. Explain electron properties of molecules.	4: Student demonstrates innovation, in depth inference(s), or advanced application(s) with the learning goal (can have multiple bullets underneath) 3: Student demonstrates evidence of the learning goal (define, give an example, assessment, etc.) (can have multiple bullets underneath) 2: Student demonstrates overall proficiency with the objectives and essential vocabulary (included here or in objectives below) (can have multiple bullets underneath) 1: Student demonstrates limited proficiency with the objectives and essential vocabulary

Learning Target:
Specific content or skills taught in order to achieve mastery of the learning goal 2.1.A.1 Electronegativity values for the representative elements increase going from left to right across a period and decrease going down a group. These trends can be understood qualitatively through the electronic structure of the atoms, the shell model, and Coulomb's law. 2.1.A.2 Valence electrons shared between atoms of similar electronegativity constitute a nonpolar covalent bond. For example, bonds between carbon and hydrogen are effectively nonpolar even though carbon is slightly more electronegative than hydrogen.

2.1.A.3 Valence electrons shared between atoms of unequal electronegativity constitute a polar covalent bond.

- i. The atom with a higher electronegativity will develop a partial negative charge relative to the other atom in the bond.
- ii. In single bonds, greater differences in electronegativity lead to greater bond dipoles.
- iii. All polar bonds have some ionic character, and the difference between ionic and covalent bonding is not distinct but rather a continuum.

2.1.A.4 The difference in electronegativity is not the only factor in determining if a bond should be designated as ionic or covalent. Generally, bonds between a metal and nonmetal are ionic, and bonds between two nonmetals are covalent. Examination of the properties of a compound is the best way to characterize the type of bonding.

2.1.A.5 In a metallic solid, the valence electrons from the metal atoms are considered to be delocalized and not associated with any individual atom.

2.2.A.1 A graph of potential energy versus the distance between atoms (internuclear distance) is a useful representation for describing the interactions between atoms. Such graphs illustrate both the equilibrium bond length (the separation between atoms at which the potential energy is lowest) and the bond energy (the energy required to separate the atoms).

2.2.A.2 In a covalent bond, the bond length is influenced by both the size of the atom's core and the bond order (i.e., single, double, triple). Bonds with a higher order are shorter and have larger bond energies.

2.2.A.3 Coulomb's law can be used to understand the strength of interactions between cations and anions.

- i. Because the interaction strength is proportional to the charge on each ion, larger charges lead to stronger interactions.
- ii. Because the interaction strength increases as the distance between the centers of the ions (nuclei) decreases, smaller ions lead to stronger interactions.

2.3.A.1 The cations and anions in an ionic crystal are arranged in systematic, periodic 3-D array that maximizes the attractive forces among cations and anions while minimizing the repulsive forces.

Exclusion Statement: Knowledge of specific crystal structures is not essential to an understanding of the learning objective and will not be assessed on the AP Exam.

2.4.A.1 Metallic bonding can be represented as an array of positive metal ions surrounded by delocalized valence electrons (i.e., a“sea of electrons”).

2.4.A.2 Interstitial alloys form between atoms of significantly different radii, where the smaller atoms fill the interstitial spaces between the larger atoms (e.g., with steel in which carbon occupies the interstices in iron).

2.4.A.3 Substitutional alloys form between atoms of comparable radius, where one atom substitutes for the other in the lattice. (e.g., in certain brass alloys, other elements, usually zinc, substitute for copper.)

2.5.A.1 Lewis diagrams can be constructed according to an established set of principles.

2.6.A.1 In cases where more than one equivalent Lewis structure can be constructed, resonance must be included as are refinement to the Lewis structure. In many such cases, this refinement is needed to provide qualitatively accurate predictions of molecular structure and properties.

2.6.A.2 The octet rule and formal charge can be used as criteria for determining which of several possible valid Lewis diagrams provides the best model for predicting molecular structure and properties.

2.6.A.3 As with any model, there are limitations to the use of the Lewis structure model, particularly in cases with an odd number of valence electrons.

2.7.A.1 VSEPR theory uses the Coulombic repulsion between electrons as a basis for predicting the arrangement of electron pairs around a central atom.

2.7.A.2 Both Lewis diagrams and VSEPR theory must be used for predicting electronic and structural properties of many covalently bonded molecules and polyatomic ions, including the following:

i. Molecular geometry (linear, trigonal planar, tetrahedral, trigonal pyramidal, bent, trigonal bipyramidal, seesaw, T-shaped, octahedral, square pyramidal, square planar)
ii. Bond angles
iii. Relative bond energies based on bond order
iv. Relative bond lengths (multiple bonds, effects of atomic radius)
v. Presence of a dipole moment
vi. Hybridization of valence orbitals for atoms within a molecule or polyatomic ion

2.7.A.3 The terms "hybridization" and "hybrid atomic orbital" are used to describe the arrangement of electrons around a central atom. When the central atom is sp hybridized, its ideal bond angles are 180°; for sp^2 hybridized atoms, the bond angles are 120°; and for sp^3 hybridized atoms, the bond angles are 109.5°.

Exclusion Statement: An understanding of the derivation and depiction of hybrid orbitals will not be assessed on the AP Exam. The course includes the distinction between sigma and pi bonding, the use of VSEPR to explain the shapes of molecules, and the sp, sp^2, and sp^3 nomenclature.

Exclusion Statement: Hybridization involving ***d*** *orbitals will not be assessed on the AP Exam. When an atom has more than four pairs of electrons surrounding the central atom, students are only responsible for the shape of the resulting molecule.*

2.7.A.4 Bond formation is associated with overlap between atomic orbitals. In multiple bonds, such overlap leads to the formation of both sigma and pi bonds. The overlap is stronger in sigma than pi bonds, which is reflected in sigma bonds having greater bond energy than pi bonds. The presence of a pi bond also prevents the rotation of the bond and leads to geometric isomers.

Exclusion Statement: Molecular orbital theory is recommended as a way to provide deeper insight into bonding. However, the AP Exam will neither explicitly assess molecular orbital diagrams, filling of molecular orbitals, nor the distinction between bonding, nonbonding, and antibonding orbitals.

AP Chemistry Unit 3 - Intermolecular Forces and Properties

Missouri Learning Standards

NGSS Next Generation Science Standards (NGSS)

NGSS-HS-PS 1-1: 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.

NGSS-HS-PS 1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

NGSS-HS-PS 1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

NGSS-HS-PS 1-4: 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.

NGSS-HS-PS 1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

NGSS-HS-PS 1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

NGSS-HS-PS 1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

NGSS-HS-PS 2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

NGSS-HS-PS 3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other components(s) and energy flows in and out of the system are known.

NGSS-HS-PS 3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.

NGSS-HS-PS 3-4: 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).

NGSS-HS-ESS 2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
NGSS-HS-ESS 3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

NGSS-HS-ESS 3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Learning Goal	Proficiency Scale
The student will be able to: 3.1.A Explain the relationship between the chemical structures of molecules and the relative strength of their intermolecular forces when: i. The molecules are of the same chemical species. ii. The molecules are of two different chemical species. 3.2.A Explain the relationship among the macroscopic properties of a substance, the particulate-level structure of the substance, and the interactions between these particles. 3.3.A Represent the differences between solid, liquid, and gas phases using a particulate level model. 3.4.A Explain the relationship between the macroscopic properties of a sample of gas or mixture of gases using the ideal gas law. 3.5.A Explain the relationship between the motion of particles and the macroscopic properties of gases with: i. The kinetic molecular theory (KMT). ii. A particulate model. iii. A graphical representation. 3.6.A Explain the relationship among non-ideal behaviors of gases, interparticle forces, and/or volumes. 3.7.A Calculate the number of solute particles, volume, or molarity of solutions. 3.8.A Using particulate models for mixtures: i. Represent interactions between components. ii. Represent concentrations of components. 3.9.A Explain the results of a separation experiment based on intermolecular interactions. 3.10.A Explain the relationship between the solubility of ionic and molecular compounds in aqueous and nonaqueous solvents, and the intermolecular interactions between particles.	4: Student demonstrates innovation, in depth inference(s), or advanced application(s) with the learning goal (can have multiple bullets underneath) 3: Student demonstrates evidence of the learning goal (define, give an example, assessment, etc.) (can have multiple bullets underneath) 2: Student demonstrates overall proficiency with the objectives and essential vocabulary (included here or in objectives below) (can have multiple bullets underneath) 1: Student demonstrates limited proficiency with the objectives and essential vocabulary

3.11.A Explain the relationship between a region of the electromagnetic spectrum and the types of molecular or electronic transitions associated with that region. 3.12.A Explain the properties of an absorbed or emitted photon in relationship to an electronic transition in an atom or molecule. 3.13.A Explain the amount of light absorbed by a solution of molecules or ions in relationship to the concentration, path length, and molar absorptivity.	

Learning Targets

Specific content or skills taught in order to achieve mastery of the learning goal

3.1.A.1 London dispersion forces are a result of the Coulombic interactions between temporary, fluctuating dipoles. London dispersion forces are often the strongest net intermolecular force between large molecules.

i. Dispersion forces increase with increasing contact area between molecules and with increasing polarizability of the molecules.

ii. The polarizability of a molecule increases with an increasing number of electrons in the molecule and the size of the electron cloud. It is enhanced by the presence of pi bonding.

iii. The term “London dispersion forces” should not be used synonymously with the term “van der Waals forces.”

3.1.A.2 The dipole moment of a polar molecule leads to additional interactions with other chemical species.

i. Dipole-induced dipole interactions are t between a polar and nonpolar molecule. These forces are always attractive. The strength of these forces increases with the magnitude of the dipole of the polar molecule and with the polarizability of the nonpolar molecule.

Ii. Dipole-dipole interactions are present between polar molecules. The interaction strength depends on the magnitudes of the dipoles and their relative orientation. Interactions between polar molecules are typically greater than those between nonpolar molecules of comparable size because these interactions act in addition to London dispersion forces.

iii. Ion-dipole forces of attraction are present between ions and polar molecules. These tend to be stronger than dipole-dipole forces.

3.1.A.3 The relative strength and orientation dependence of dipole-dipole and ion-dipole forces can be understood qualitatively by considering the sign of the partial charges responsible for the molecular dipole moment, and how these partial charges interact with an ion or with an adjacent dipole.

3.1.A.4 Hydrogen bonding is a strong type of intermolecular interaction that exists when hydrogen atoms covalently bonded to the highly electronegative atoms (N, O, and F) are attracted to the negative end of a dipole formed by the electronegative atom (N, O, and F)in a different molecule, or a different part of the same molecule.

3.1.A.5 In large biomolecules, noncovalent interactions may occur between different molecules or between different regions of the same large biomolecule.

3.2.A.1 Many properties of liquids and solids are determined by the strengths and types of intermolecular forces present. Because intermolecular interactions are overcome completely when substances vaporize, the vapor pressure and boiling point are directly related to the strength of those interactions. Melting points also tend to correlate with interaction strength, but because the interactions are only rearranged, in melting, the relations can be more subtle.

3.2.A.2 Particulate-level representations, showing multiple interacting chemical species, are a useful means to communicate or understand how intermolecular interactions help to establish macroscopic properties.

3.2.A.3 Due to strong interactions between ions, ionic solids tend to have low vapor pressures, high melting points, and high boiling points. They tend to be brittle due to the repulsion of like charges caused when one layer slides across another layer. They conduct electricity only when the ions are mobile, as when the ionic solid is melted (i.e., in a molten state) or dissolved in water or another solvent.

3.2.A.4 In covalent network solids, the atoms are covalently bonded together into a three-dimensional network (e.g., diamond) or layers of two-dimensional networks (e.g., graphite). These are only formed from nonmetals and metalloids: elemental (e.g., diamond, graphite) or binary compounds (e.g., silicon dioxide and silicon carbide). Due to the strong covalent interactions, covalent solids have high melting points. Three-dimensional network solids are also rigid and hard, because the covalent bond angles are fixed. However, graphite is soft because adjacent layers can slide past each other relatively easily.

3.2.A.5 Molecular solids are composed of distinct, individual units of covalently-bonded molecules attracted to each other through relatively weak intermolecular forces. Molecular solids generally have a low melting point because of the relatively weak intermolecular forces present between the molecules. They do not conduct electricity because their valence electrons are tightly held within the covalent bonds and the lone pairs of each constituent molecule. Molecular solids are sometimes composed of very large molecules or polymers.

3.2.A.6 Metallic solids are good conductors of electricity and heat, due to the presence of free valence electrons. They also tend to be malleable and ductile, due to the ease with which the metal cores can rearrange their structure. In an interstitial alloy, interstitial atoms tend to make the lattice more rigid, decreasing malleability and ductility. Alloys typically retain a sea of mobile electrons and so remain conducting.

3.2.A.7 In large biomolecules or polymers, noncovalent interactions may occur between different molecules or between different regions of the same large biomolecule. The functionality and properties of such molecules depend strongly on the shape of the molecule, which is largely dictated by noncovalent interactions.

3.3.A.1 Solids can be crystalline, where the particles are arranged in a regular three-dimensional structure, or they can be amorphous, where the particles do not have a regular, orderly arrangement. In both cases, the motion of the individual particles is limited, and the particles do not undergo overall translation with respect to each other. The structure of the solid is influenced by interparticle interactions and the ability of the particles to pack together.

3.3.A.2 The constituent particles in liquids are in close contact with each other, and they are continually moving and colliding. The arrangement and movement of particles are influenced by the nature and strength of the forces (e.g., polarity, hydrogen bonding, and temperature) between the particles.

3.3.A.3 The solid and liquid phases for a particular substance typically have similar molar volume because, in both phases, the constituent particles are in close contact at all times.

3.3.A.4 In the gas phase, the particles are in constant motion. Their frequencies of collision and the average spacing between them are dependent on temperature, pressure, and volume. Because of this constant motion, and minimal effects of forces between particles, a gas has neither a definite volume nor a definite shape.

> *Exclusion Statement: Understanding/ interpreting phase diagrams will not be assessed on the AP Exam.*

3.4.A.1 The macroscopic properties of ideal gases are related through the ideal gas law: EQN: $PV = nRT$.

3.4.A.2 In a sample containing a mixture of ideal gases, the pressure exerted by each component (the partial pressure) is independent of the other components. Therefore, the partial pressure of a gas within the mixture is proportional to its mole fraction (X), and the total pressure of the sample is the sum of the partial pressures. EQN: $PA = Ptotal \times XA$, where XA = moles A/total moles; EQN: $Ptotal = PA + PB + PC + \ldots$

3.4.A.3 Graphical representations of the relationships between P, V, T, and n are useful to describe gas behavior.

3.5.A.1 The kinetic molecular theory (KMT) relates the macroscopic properties of gases to motions of the particles in the gas. The Maxwell-Boltzmann distribution describes the distribution of the kinetic energies of particles at a given temperature.

3.5.A.2 All the particles in a sample of matter are in continuous, random motion. The average kinetic energy of a particle is related to its average velocity by the equation: EQN: KE = ½ mv2.

3.5.A.3 The Kelvin temperature of a sample of matter is proportional to the average kinetic energy of the particles in the sample.

3.5.A.4 The Maxwell-Boltzmann distribution provides a graphical representation of the energies/ velocities of particles at a given temperature.

3.6.A.1 The ideal gas law does not explain the actual behavior of real gases. Deviations from the ideal gas law may result from interparticle attractions among gas molecules, particularly at conditions that are close to those resulting in condensation. Deviations may also arise from particle volumes, particularly at extremely high pressures.

3.7.A.1 Solutions, also sometimes called homogeneous mixtures, can be solids, liquids, or gases. In a solution, the macroscopic properties do not vary throughout the sample. In a heterogeneous mixture, the macroscopic properties depend on location in the mixture.

3.7.A.2 Solution composition can be expressed in a variety of ways; molarity is the most common method used in the laboratory. EQN: M = n solute /L solution

3.8.A.1 Particulate representations of solutions communicate the structure and properties of solutions, by illustration of the relative concentrations of the components in the solution and/or drawings that show interactions among the components.

> *Exclusion Statement: Colligative properties will not be assessed on the AP Exam. Exclusion Statement: Calculations of molality, percent by mass, and percent by volume for solutions will not be assessed on the AP Exam.*

3.9.A.1 The components of a liquid solution cannot be separated by filtration. They can, however, be separated using processes that take advantage of differences in the intermolecular interactions of the components.

- i. Chromatography(paper,thin-layer, and column) separates chemical species by taking advantage of the differential strength of intermolecular interactions between and among the components of the solution (the mobile phase) and with the surface components of the stationary phase. The resulting chromatogram can be used to infer the relative polarities of components in a mixture.
- ii. Distillation separates chemical species by taking advantage of the differential strength of intermolecular interactions between and among the components and the effects these interactions have on the vapor pressures of the components in the mixture.

3.10.A.1 Substances with similar intermolecular interactions tend to be miscible or soluble in one another.

3.11.A.1 Differences in absorption or emission of photons in different spectral regions are related to the different types of molecular motion or electronic transition:

- i. Microwave radiation is associated with transitions in molecular rotational levels.
- ii. Infrared radiation is associated with transitions in molecular vibrational levels.

iii. Ultraviolet/visible radiation is associated with transitions in electronic energy levels.

3.12.A.1 When a photon is absorbed (or emitted) by an atom or molecule, the energy of the species is increased (or decreased) by an amount equal to the energy of the photon.

3.12.A.2 The wavelength of the electromagnetic wave is related to its frequency and the speed of light by the equation: EQN: $c = \lambda v$. The energy of a photon is related to the frequency of the electromagnetic wave through Planck's equation: EQN: E = □v.

3.13.A.1 The Beer-Lambert law relates the absorption of light by a solution to three variables according to the equation: EQN: $A = \varepsilon bc$. The molar absorptivity, ε, describes how intensely a chemical species absorbs light of specific wavelength. The path length, b, and concentration, c, are proportional to the number of light-absorbing particles in the light path.

3.13.A.2 In most experiments the path length and wavelength of light are held constant. In such cases,theabsorbanceisproportional only to the concentration of absorbing molecules or ions. The spectrophotometer is typically set to the wavelength of maximum absorbance (optimum wavelength) for the species being analyzed to ensure the maximum sensitivity of measurement.

AP Chemistry Unit 4 - Chemical Reactions

Next Generation Science Standards (NGSS)

NGSS-HS-PS 1-1: 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.

NGSS-HS-PS 1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

NGSS-HS-PS 1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

NGSS-HS-PS 1-4: 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.

NGSS-HS-PS 1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

NGSS-HS-PS 1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

NGSS-HS-PS 1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

NGSS-HS-PS 2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. NGSS-HS-PS 3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other components(s) and energy flows in and out of the system are known. NGSS-HS-PS 3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields. NGSS-HS-PS 3-4: 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). NGSS-HS-ESS 2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. NGSS-HS-ESS 3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. NGSS-HS-ESS 3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Learning Goal	**Proficiency Scale**
The student will be able to: 4.1.A Identify evidence of chemical and physical changes in matter. 4.2.A Represent changes in matter with a balanced chemical or net ionic equation: i. For physical changes. ii. For given information about the identity of the reactants and/or product. iii. For ions in a given chemical reaction 4.3.A Represent a given chemical reaction or physical process with a consistent particulate model. 4.4.A Explain the relationship between macroscopic characteristics and bond interactions for: i. Chemical processes. ii. Physical processes 4.5.A Explain changes in the amounts of reactants and products based on the balanced	4: Student demonstrates innovation, in depth inference(s), or advanced application(s) with the learning goal (can have multiple bullets underneath) 3: Student demonstrates evidence of the learning goal (define, give an example, assessment, etc.) (can have multiple bullets underneath) 2: Student demonstrates overall proficiency with the objectives and essential vocabulary (included here or in objectives below) (can have multiple bullets underneath) 1: Student demonstrates limited proficiency with the objectives and essential vocabulary

reaction equation for a chemical process. 4.6.A Identify the equivalence point in a titration based on the amounts of the titrant and analyte, assuming the titration reaction goes to completion. 4.7.A Identify a reaction as acid base, oxidation-reduction, or precipitation. 4.8.A Identify species as Brønsted Lowry acids, bases, and/or conjugate acid-base pairs, based on proton-transfer involving those species. 4.9.A Represent a balanced redox reaction equation using half-reactions.	

Learning Targets

Specific content or skills taught in order to achieve mastery of the learning goal

4.1.A.1 A physical change occurs when a substance undergoes a change in properties but not a change in composition. Changes in the phase of a substance (solid, liquid, gas) or formation/ separation of mixtures of substances are common physical changes.

4.1.A.2 A chemical change occurs when substances are transformed into new substances, typically with different compositions. Production of heat or light, formation of a gas, formation of a precipitate, and/or color change provide possible evidence that a chemical change has occurred.

4.2.A.1 All physical and chemical processes can be represented symbolically by balanced equations.

4.2.A.2 Chemical equations represent chemical changes. These changes are the result of a rearrangement of atoms into new combinations; thus, any representation of a chemical change must contain equal numbers of atoms of every element before and after the change occurred. Equations thus demonstrate that mass and charge are conserved in chemical reactions.

4.2.A.3 Balanced molecular, complete ionic, and net ionic equations are differing symbolic forms used to represent a chemical reaction. The form used to represent the reaction depends on the context in which it is to be used.

4.3.A.1 Balanced chemical equations in their various forms can be translated into symbolic particulate representations.

4.4.A.1 Processes that involve the breaking and/or formation of chemical bonds are typically classified as chemical processes. Processes that involve only changes in intermolecular interactions, such as phase changes, are typically classified as physical processes.

4.4.A.2 Sometimes physical processes involve the breaking of chemical bonds. For example, plausible arguments could be made for the dissolution of a salt in water, as either a physical or chemical process, involves breaking of ionic bonds, and the formation of ion-dipole interactions between ions and solvent.

4.5.A.1 Because atoms must be conserved during a chemical process, it is possible to calculate product amounts by using known reactant amounts, or to calculate reactant amounts given known product amounts.

4.5.A.2 Coefficients of balanced chemical equations contain information regarding the proportionality of the amounts of substances involved in the reaction. These values can be used in chemical calculations involving the mole concept.

4.5.A.3 Stoichiometric calculations can be combined with the ideal gas law and calculations involving molarity to quantitatively study gases and solutions.

4.6.A.1 Titrations may be used to determine the amount of an analyte in solution. The titrant has a known concentration of a species that reacts specifically and quantitatively with the analyte. The equivalence point of the titration occurs when the analyte is totally consumed by the reacting species in the titrant. The equivalence point is often indicated by a change in a property (such as color) that occurs when the equivalence point is reached. This observable event is called the endpoint of the titration.

4.7.A.1 Acid-base reactions involve transfer of one or more protons (H+ ions) between chemical species.

4.7.A.2 Oxidation-reduction(redox) reactions involve transfer of one or more electrons between chemical species, as indicated by changes in oxidation numbers of the involved species. Combustion is an important subclass of oxidation-reduction reactions, in which a species reacts with oxygen gas. In the case of hydrocarbons, carbon dioxide and water are products of complete combustion.

4.7.A.3 In a redox reaction, electrons are transferred from the species that is oxidized to the species that is reduced.

> *Exclusion Statement: The meaning of the terms “reducing agent” and “oxidizing agent” will not be assessed on the AP Exam.*

4.7.A.4 Oxidation numbers may be assigned to each of the atoms in the reactants and products; this is often an effective way to identify the oxidized and reduced species in a redox reaction.

4.7.A.5 Precipitation reactions frequently involve mixing ions in aqueous solution to produce an insoluble or sparingly soluble ionic compound. All sodium, potassium, ammonium, and nitrate salts are soluble in water.

> *Exclusion Statement: Rote memorization of “solubility rules” other than those implied in 4.7.A.5 will not be assessed on the AP Exam.*

4.8.A.1 By definition, a Brønsted-Lowry acid is a proton donor and a Brønsted-Lowry base is a proton acceptor.

4.8.A.2 Only in aqueous solutions, water plays an important role in many acid-base reactions, as its molecular structure allows it to accept protons from and donate protons to dissolved species.

4.8.A.3 When an acid or base ionizes in water, the conjugate acid-base pairs can be identified and their relative strengths compared.

> *Exclusion Statement: Lewis acid-base concepts will not be assessed on the AP Exam. The emphasis in AP Chemistry is on reactions in aqueous solution.*

4.9.A.1 Balanced chemical equations for redox reactions can be constructed from half-reactions.

AP Chemistry Unit 5 - Kinetics

Next Generation Science Standards (NGSS)

NGSS-HS-PS 1-1: 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.

NGSS-HS-PS 1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

NGSS-HS-PS 1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

NGSS-HS-PS 1-4: 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.

NGSS-HS-PS 1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

NGSS-HS-PS 1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

NGSS-HS-PS 1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

NGSS-HS-PS 2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

NGSS-HS-PS 3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other components(s) and energy flows in and out of the system are known.

NGSS-HS-PS 3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.

NGSS-HS-PS 3-4: 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).

NGSS-HS-ESS 2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
NGSS-HS-ESS 3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

NGSS-HS-ESS 3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.	
Learning Goal The student will be able to: 5.1.A Explain the relationship between the rate of a chemical reaction and experimental parameters. 5.2.A Represent experimental data with a consistent rate law expression 5.3.A Identify the rate law expression of a chemical reaction using data that show how the concentrations of reaction species change over time. 5.4.A Represent an elementary reaction as a rate law expression using stoichiometry. 5.5.A Explain the relationship between the rate of an elementary reaction and the frequency, energy, and orientation of particle collisions. 5.6.A Represent the activation energy and overall energy change in an elementary reaction using a reaction energy profile. 5.7.A Identify the components of a reaction mechanism. 5.8.A Identify the rate law for a reaction from a mechanism in which the first step is rate limiting. 5.9.A Identify the rate law for a reaction from a mechanism in which the first step is not rate limiting. 5.10.A Represent the activation energy and overall energy change in a multistep reaction with a reaction 5.11.A Explain the relationship between the effect of a catalyst on a reaction and changes in the reaction mechanism.	**Proficiency Scale** 4: Student demonstrates innovation, in depth inference(s), or advanced application(s) with the learning goal (can have multiple bullets underneath) 3: Student demonstrates evidence of the learning goal (define, give an example, assessment, etc.) (can have multiple bullets underneath) 2: Student demonstrates overall proficiency with the objectives and essential vocabulary (included here or in objectives below) (can have multiple bullets underneath) 1: Student demonstrates limited proficiency with the objectives and essential vocabulary

Learning Targets

Specific content or skills taught in order to achieve mastery of the learning goal

5.1.A.1 The kinetics of a chemical reaction is defined as the rate at which an amount of reactants is converted to products per unit of time.

5.1.A.2 The rates of change of reactant and product concentrations are determined by the stoichiometry in the balanced chemical equation.

5.1.A.3 The rate of a reaction is influenced by reactant concentrations, temperature, surface area, catalysts, and other environmental factors.

5.2.A.1 Experimental methods can be used to monitor the amounts of reactants and/or products of a reaction over time and to determine the rate of the reaction.

5.2.A.2 The rate law expresses the rate of a reaction as proportional to the concentration of each reactant raised to a power.

5.2.A.3 The power of each reactant in the rate law is the order of the reaction with respect to that reactant. The sum of the powers of the reactant concentrations in the rate law is the overall order of the reaction.

5.2.A.4 The proportionality constant in the rate law is called the rate constant. The value of this constant is temperature dependent and the unitsreflecttheoverallreactionorder.

5.2.A.5 Comparing initial rates of a reaction is a method to determine the order with respect to each reactant.

5.3.A.1 The order of a reaction can be inferred from a graph of concentration of reactant versus time.

5.3.A.2 If are action is first order with respect to a reactant being monitored, a plot of the natural log (ln) of the reactant concentration as a function of time will be linear.

5.3.A.3 If a reaction is second order with respect to a reactant being monitored, a plot of the reciprocal of the concentration of that reactant versus time will be linear.

5.3.A.4 The slopes of the concentration versus time data for zeroth, first, and second order reactions can be used to determine the rate constant for the reaction.

Zeroth order: EQN: $[A]t - [A]0 = -kt$
First order: EQN: $\ln[A]t - \ln[A]0 = -kt$
Second order: EQN: $1/[A]t - 1/[A]0 = kt$

5.3.A.5 Half-life is a critical parameter for first order reactions because the half-life is constant and related to the rate constant for the reaction by the equation:

EQN: $t1/2 = 0.693/k$.

5.3.A.6 Radioactive decay processes provide an important illustration of first order kinetics.

5.4.A.1 The rate law of an elementary reaction can be inferred from the stoichiometry of the particles participating in a collision.

5.4.A.2 Elementary reactions involving the simultaneous collision of three or more particles are rare.

5.5.A.1 For an elementary reaction to successfully produce products, reactants must successfully collide to initiate bond-breaking and bondmaking events.

5.5.A.2 In most reactions, only a small fraction of the collisions leads to a reaction. Successful collisions have both sufficient energy to overcome the activation energy requirements and orientations that allow the bonds to rearrange in the required manner.

5.5.A.3 The Maxwell-Boltzmann distribution curve describes the distribution of particle energies; this distribution can be used to gain a qualitative estimate of the fraction of collisions with sufficient energy to lead to a reaction, and also how that fraction depends on temperature.

5.6.A.1 Elementary reactions typically involve the breaking of some bonds and the forming of new ones.

5.6.A.2 The reaction coordinate is the axis along which the complex set of motions involved in rearranging reactants to form products can be plotted.

5.6.A.3 The energy profile gives the energy along the reaction coordinate, which typically proceeds from reactants, through a transition state, to products. The energy difference between the reactants and the transition state is the activation energy for the forward reaction.

5.6.A.4 The rate of an elementary reaction is temperature dependent because the proportion of particle collisions that are energetic enough to reach the transition state varies with temperature. The Arrhenius equation relates the temperature dependence of the rate of an elementary reaction to the activation energy needed by molecular collisions to reach the transition state.

> *Exclusion Statement: Calculations involving the Arrhenius equation will not be assessed on the AP Exam.*

5.7.A.1 A reaction mechanism consists of a series of elementary reactions, or steps, that occur in sequence. The components may include reactants, intermediates, products, and catalysts.

5.7.A.2 The elementary steps when combined should align with the overall balanced equation of a chemical reaction.

5.7.A.3 A reaction intermediate is produced by some elementary steps and consumed by others, such that it is present only while a reaction is occurring.

5.7.A.4 Experimental detection of a reaction intermediate is a common way to build evidence in support of one reaction mechanism over an alternative mechanism.

> *Exclusion Statement: Collection of data pertaining to detection of a reaction intermediate will not be assessed on the AP Exam.*

5.8.A.1 For reaction mechanisms in which each elementary step is irreversible, or in which the first step is rate limiting, the rate law of the reaction is set by the molecularity of the slowest elementary step(i.e., the rate-limiting step).

> *Exclusion Statement: Collection of data pertaining to detection of a reaction intermediate will not be*

assessed on the AP Exam.

5.9.A.1 If the first elementary reaction is not rate limiting, approximations (such as pre-equilibrium) must be made to determine a rate law expression.

5.10.A.1 Knowledge of the energetics of each elementary reaction in a mechanism allows multistep reaction.

5.11.A.1 In order for a catalyst to increase the rate of a reaction, the addition of the catalyst must increase the number of effective collisions and/ or provide a reaction path with a lower activation energy relative to the original reaction coordinate.

5.11.A.2 In a reaction mechanism containing a catalyst, the net concentration of the catalyst is constant. However, the catalyst will frequently be consumed in the rate-determining step of the reaction, only to be regenerated in a subsequent step in the mechanism.

5.11.A.3 Some catalysts accelerate a reaction by binding to the reactant(s). The reactants are either oriented more favorably or react with lower activation energy. There is often a new reaction intermediate in which the catalyst is bound to the reactant(s). Many enzymes function in this manner.

5.11.A.4 Some catalysts involve covalent bonding between the catalyst and the reactant(s). An example is acid-base catalysis, in which a reactant or intermediate either gains or loses a proton. This introduces a new reaction intermediate and new elementary reactions involving that intermediate.

5.11.A.5 In surface catalysis, a reactant or intermediate binds to, or forms a covalent bond with, the surface. This introduces elementary reactions involving these new bound reaction intermediate(s).

AP Chemistry Unit 6 - Thermodynamics

Next Generation Science Standards (NGSS)

NGSS-HS-PS 1-1: 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.

NGSS-HS-PS 1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

NGSS-HS-PS 1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

NGSS-HS-PS 1-4: 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.

NGSS-HS-PS 1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

NGSS-HS-PS 1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

NGSS-HS-PS 1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

NGSS-HS-PS 2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

NGSS-HS-PS 3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other components(s) and energy flows in and out of the system are known.

NGSS-HS-PS 3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.

NGSS-HS-PS 3-4: 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).

NGSS-HS-ESS 2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

NGSS-HS-ESS 3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

NGSS-HS-ESS 3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Learning Goal	**Proficiency Scale**
The student will be able to: 6.1.A Explain the relationship between experimental observations and energy changes associated with a chemical or physical transformation. 6.2.A Represent a chemical or physical transformation with an energy diagram. 6.3.A Explain the relationship between the transfer of thermal energy and molecular collisions. 6.4.A Calculate the heat q absorbed or released by a system undergoing heating/ cooling based on the amount of the substance, the heat capacity, and the change in temperature.	4: Student demonstrates innovation, in depth inference(s), or advanced application(s) with the learning goal (can have multiple bullets underneath) 3: Student demonstrates evidence of the learning goal (define, give an example, assessment, etc.) (can have multiple bullets underneath) 2: Student demonstrates overall proficiency with the objectives and essential vocabulary (included here or in objectives below) (can have multiple bullets underneath) 1: Student demonstrates limited proficiency with the objectives and essential vocabulary

6.5.A Explain changes in the heat q absorbed or released by a system undergoing a phase transition based on the amount of the substance in moles and the molar enthalpy of the phase transition. 6.6.A Calculate the heat q absorbed or released by a system undergoing a chemical reaction in relationship to the amount of the reacting substance in moles and the molar enthalpy of reaction. 6.7.A Calculate the enthalpy change of a reaction based on the average bond energies of bonds broken and formed in the reaction. 6.8.A Calculate the enthalpy change for a chemical or physical process based on the standard enthalpies of formation. 6.9.A Represent a chemical or physical process as a sequence of steps. 6.9.B Explain the relationship between the enthalpy of a chemical or physical process and the sum of the enthalpies of the individual steps.	

Learning Targets

Specific content or skills taught in order to achieve mastery of the learning goal

6.1.A.1 Temperature changes in a system indicate energy changes.

6.1.A.2 Energy changes in a system can be described as endothermic and exothermic processes such as the heating or cooling of a substance, phase changes, or chemical transformations.

6.1.A.3 When a chemical reaction occurs, the energy of the system either decreases (exothermic reaction), increases (endothermic reaction), or remains the same. For exothermic reactions, the energy lost by the reacting species (system) is gained by the surroundings, as heat transfer from or work done by the system. Likewise, for endothermic reactions, the system gains energy from the surroundings by heat transfer to or work done on the system.

6.1.A.4 The formation of a solution may be an exothermic or endothermic process, depending on the relative strengths of intermolecular/interparticle interactions before and after the dissolution process.

6.2.A.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process

6.3.A.1 The particles in a warmer body have a greater average kinetic energy than those in a cooler body.

6.3.A.2 Collisions between particles in thermal contact can result in the transfer of energy. This process is called “heat transfer,” “heat exchange,” or “transfer of energy as heat.”

6.3.A.3 Eventually, thermal equilibrium is reached as the particles continue to collide. At thermal equilibrium, the average kinetic energy of both bodies is the same, and hence, their temperatures are the same.

6.4.A.1 The heating of a cool body by a warmer body is an important form of energy transfer between two systems. The amount of heat transferred between two bodies may be quantified by the heat transfer equation: EQN: $q = mc\Delta T$. Calorimetry experiments are used to measure the transfer of heat.

6.4.A.2 The first law of thermodynamics states that energy is conserved in chemical and physical processes.

6.4.A.3 The transfer of a given amount of thermal energy will not produce the same temperature change in equal masses of matter with differing specific heat capacities.

6.4.A.4 Heating a system increases the energy of the system, while cooling a system decreases the energy of the system.

6.4.A.5 The specific heat capacity of a substance and the molar heat capacity are both used in energy calculations.

6.4.A.6 Chemical systems change their energy through three main processes: heating/cooling, phase transitions, and chemical reactions.

6.4.A.7 In calorimetry experiments involving dissolution, temperature changes of the mixture within the calorimeter can be used to determine the direction of energy flow. If the temperature of the mixture increases, thermal energy is released by the dissolution process (exothermic). If the temperature of the mixture decreases, thermal energy is absorbed by the dissolution process (endothermic).

6.5.A.1 Energy must be transferred to a system to cause a substance to melt (or boil). The energy of the system therefore increases as the system undergoes a solid-to-liquid (or liquid-to-gas) phase transition. Likewise, a system releases energy when it freezes (or condenses). The energy of the system decreases as the system undergoes a liquid-to-solid (or gas-to-liquid) phase transition. The temperature of a pure substance remains constant during a phase change.

6.5.A.2 The energy absorbed during a phase change is equal to the energy released during a complementary phase change in the opposite direction. For example, the molar enthalpy of condensation of a substance is equal to the negative of its molar enthalpy of vaporization. Similarly, the molar enthalpy of fusion can be used to calculate the energy absorbed when melting a substance and the energy released when freezing a substance.

6.6.A.1 The enthalpy change of a reaction gives the amount of heat energy released (for negative values) or absorbed (for positive values) by a chemical reaction at constant pressure.

6.6.A.2 When the products of a reaction are at a different temperature than the surroundings, they exchange energy with the surroundings to reach thermal equilibrium. Thermal energy is transferred to the surroundings as the reactants convert to products in an exothermic reaction. Thermal energy is transferred from the surroundings as the reactants convert to products in an endothermic reaction.

6.6.A.3 The chemical potential energy of the products of a reaction is different from that of the reactants because of the breaking and forming of bonds. The energy difference results in a change in the kinetic energy of the particles, which manifests as a temperature change.

Exclusion Statement: The technical distinctions between enthalpy and internal energy will not be assessed on the AP Exam. Most reactions studied at the AP level are carried out at constant pressure, where the enthalpy change of the process is equal to the heat (and by extension, the energy) of reaction.

6.7.A.1 During a chemical reaction, bonds are broken and/or formed, and these events change the potential energy of the system.

6.7.A.2 The average energy required to break all of the bonds in the reactant molecules can be estimated by adding up the average bond energies of all the bonds in the reactant molecules. Likewise, the average energy released in forming the bonds in the product molecules can be estimated. If the energy released is greater than the energy required, the reaction is exothermic. If the energy required is greater than the energy released, the reaction is endothermic.

6.8.A.1 EQN: ΔH° Tables of standard enthalpies of formation can be used to calculate the standard enthalpies of reactions. reaction = ΣΔH f ° products − ΣΔH f ° reactants

6.9.A.1 Many processes can be broken down into a series of steps. Each step in the series has its own energy change.

6.9.B.1 Because total energy is conserved (first law of thermodynamics), and each individual reaction in a sequence transfers thermal energy to or from the surroundings, the net thermal energy transferred in the sequence will be equal to the sum of the thermal energy transfers in each of the steps. These thermal energy transfers are the result of potential energy changes among the species in the reaction sequence; thus, at constant pressure, the enthalpy change of the overall process is equal to the sum of the enthalpy changes of the individual steps.

6.9.B.2 The following are essential principles of Hess's law:

i. When a reaction is reversed, the enthalpy change stays constant in magnitude but becomes reversed in mathematical sign.
ii. When a reaction is multiplied by a factor c, the enthalpy change is multiplied by the same factor c.
iii. When two (or more) reactions are added to obtain an overall reaction, the individual enthalpy changes of each reaction are added to obtain the net enthalpy change of the overall reaction.

Exclusion Statement: The concept of state functions will not be assessed on the AP Exam.

AP Chemistry Unit 7 - Equilibrium

Next Generation Science Standards (NGSS)

NGSS-HS-PS 1-1: 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.

NGSS-HS-PS 1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

NGSS-HS-PS 1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

NGSS-HS-PS 1-4: 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.

NGSS-HS-PS 1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

NGSS-HS-PS 1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

NGSS-HS-PS 1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

NGSS-HS-PS 2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

NGSS-HS-PS 3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other components(s) and energy flows in and out of the system are known.

NGSS-HS-PS 3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.

NGSS-HS-PS 3-4: 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).

NGSS-HS-ESS 2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
NGSS-HS-ESS 3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

NGSS-HS-ESS 3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Learning Goal	**Proficiency Scale**
The student will be able to: 7.1.A Explain the relationship between the occurrence of a reversible chemical or physical process, and the establishment of equilibrium, to	4: Student demonstrates innovation, in depth inference(s), or advanced application(s) with the learning goal (can have multiple bullets underneath) 3: Student demonstrates evidence of the learning goal

experimental observations. 7.2.A Explain the relationship between the direction in which a reversible reaction proceeds and the relative rates of the forward and reverse reactions. 7.3.A Represent the reaction quotient Qc or Qp, for a reversible reaction, and the corresponding equilibrium expressions Kc = Qc or Kp = Qp 7.4.A Calculate Kc or Kp based on experimental observations of concentrations or pressures at equilibrium. 7.5.A Explain the relationship between very large or very small values of K and the relative concentrations of chemical species at equilibrium. 7.6.A Represent a multistep process with an overall equilibrium expression, using the constituent K expressions for each individual reaction. 7.7.A Identify the concentrations or partial pressures of chemical species at equilibrium based on the initial conditions and the equilibrium constant. 7.8.A Represent a system undergoing a reversible reaction with a particulate model. 7.9.A Identify the response of a system at equilibrium to an external stress, using Le Châtelier's principle. 7.10.A Explain the relationships between Q, K, and the direction in which a reversible reaction will proceed to reach equilibrium. 7.11.A Calculate the solubility of a salt based on the value of Ksp for the salt.	(define, give an example, assessment, etc.) (can have multiple bullets underneath) 2: Student demonstrates overall proficiency with the objectives and essential vocabulary (included here or in objectives below) (can have multiple bullets underneath) 1: Student demonstrates limited proficiency with the objectives and essential vocabulary

Learning Targets

Specific content or skills taught in order to achieve mastery of the learning goal

7.1.A.1 Many observable processes are reversible. Examples include evaporation and condensation of water, absorption and desorption of a gas, or dissolution and precipitation of a salt. Some important reversible chemical processes include the transfer of protons in acid-base reactions and the transfer of electrons in redox reactions.

7.1.A.2 When equilibrium is reached, no observable changes occur in the system. Reactants and products are simultaneously present, and the concentrations or partial pressures of all species remain constant.

7.1.A.3 The equilibrium state is dynamic. The forward and reverse processes continue to occur at equal rates, resulting in no net observable change.

7.1.A.4 Graphs of concentration, partial pressure, or rate of reaction versus time for simple chemical reactions can be used to understand the establishment of chemical equilibrium.

7.2.A.1 If the rate of the forward reaction is greater than the reverse reaction, then there is a net conversion of reactants to products. If the rate of the reverse reaction is greater than that of the forward reaction, then there is a net conversion of products to reactants. An equilibrium state is reached when these rates are equal.

7.3.A.1 The reaction quotient Qc describes the relative concentrations of reaction species at any time. For gas phase reactions, the reaction quotient may instead be written in terms of partial pressures as Qp. The reaction quotient tends toward the equilibrium constant such that at equilibrium Kc = Qc and Kp = Qp. As examples, for the reaction
a A + b B c C + d D

the law of mass action indicates that the equilibrium expression for (Kc, Qc) is [ ] c d C D
EQN: [ ] Kc = [ ] a b A B [ ]
and that for (Kp , Qp) is ( )
EQN: P P c d ( ) Kp = C D ( ) P P a b ( ) A B

> *Exclusion Statement: Conversion between Kc and K p will not be assessed on the AP Exam. Students should be aware of the conceptual Exclusion Statement: Equilibrium calculations on systems where a dissolved species is in equilibrium with that species in the gas phase will not be assessed on the AP Exam.*

7.3.A.2 The reaction quotient does not include substances whose concentrations (or partial pressures) are independent of the amount, such as for solids and pure liquids.

7.4.A.1 Equilibrium constants can be determined from experimental measurements of the concentrations or partial pressures of the reactants and products at equilibrium.

7.5.A.1 Some equilibrium reactions have very large K values and proceed essentially to completion. Others have very small K values and barely proceed at all.

7.6.A.1 When a reaction is reversed, K is inverted.

7.6.A.2 When the stoichiometric coefficients of a reaction are multiplied by a factor c, K is raised to the power c.

7.6.A.3 When reactions are added together, the K of the resulting overall reaction is the product of the K's for the reactions that were summed.

7.6.A.4 Since the expressions for K and Q have identical mathematical forms, all valid algebraic manipulations of K also apply to Q

7.7.A.1 The concentrations or partial pressures of species at equilibrium can be predicted given the balanced reaction, initial concentrations, and the appropriate K.

7.7.A.2 When Q < K, the reaction will proceed with a net consumption of reactants and generation of products.

When Q > K, the reaction will proceed with a net consumption of products and generation of reactants. When Q = K, the system is at dynamic equilibrium; both forward and reverse reactions proceed at the same rate, and the proportion of reactants and products remains constant.

7.8.A.1 Particulate representations can be used to describe the relative numbers of reactant and product particles present prior to and at equilibrium, and the value of the equilibrium constant

7.9.A.1 Le Châtelier's principle can be used to predict the response of a system to stresses such as addition or removal of a chemical species, change in temperature, change in volume/ pressure of a gas-phase system, or dilution of a reaction system.

7.9.A.2 Le Châtelier's principle can be used to predicttheeffectthatastresswillhaveon experimentally measurable properties such as pH, temperature, and color of a solution.

7.10.A.1 A disturbance to a system at equilibrium causes Q to differ from K, thereby taking the system out of equilibrium. The system responds by bringing Q back into agreement with K, thereby establishing a new equilibrium state.

7.10.A.2 Some stresses, such as changes in concentration, cause a change in Q only. Achangeintemperaturecausesachangein K. In either case, the concentrations or partial pressures of species redistribute to bring Q and K back into equality.

7.11.A.1 The dissolution of a salt is a reversible process whose extent can be described by Ksp , the solubility-product constant.

7.11.A.2 The solubility of a substance can be calculated from the Ksp for the dissolution process. This relationship can also be used to predict the relative solubility of different substances.

7.11.A.3 The solubility rules (see 4.7.A.5) can be quantitatively related to Ksp, in which K values >1 sp correspond to soluble salts.

7.11.A.4 The molar solubility of one or more species in a saturated solution can be used to calculate the Ksp of a substance.

7.12.A.1 The solubility of a salt is reduced when it is dissolved into a solution that already contains one of the ions present in the salt. The impact on the concentration of a common ion already present in solution. Of this"common-ion effect" on solubility can be understood qualitatively using Le Châtelier's principle or calculated from the Ksp for the dissolution process.

AP Chemistry Unit 8 - Acids and Bases

Next Generation Science Standards (NGSS)

NGSS-HS-PS 1-1: 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.

NGSS-HS-PS 1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

NGSS-HS-PS 1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

NGSS-HS-PS 1-4: 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.

NGSS-HS-PS 1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

NGSS-HS-PS 1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

NGSS-HS-PS 1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

NGSS-HS-PS 2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

NGSS-HS-PS 3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other components(s) and energy flows in and out of the system are known.

NGSS-HS-PS 3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.

NGSS-HS-PS 3-4: 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).

NGSS-HS-ESS 2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
NGSS-HS-ESS 3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

NGSS-HS-ESS 3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Learning Goal	**Proficiency Scale**
The student will be able to: 8.1.A Calculate the values of pH and pOH, based on Kw and the concentration of all species	4: Student demonstrates innovation, in depth inference(s), or advanced application(s) with the learning goal (can have multiple bullets underneath)

present in a neutral solution of water 8.2.A Calculate pH and pOH based on concentrations of all species in a solution of a strong acid or a strong base. 8.3.A Explain the relationship among pH, pOH, and concentrations of all species in a solution of a monoprotic weak acid or weak base. 8.4.A Explain the relationship among the concentrations of major species in a mixture of weak and strong acids and bases. 8.5.A Explain results from the titration of a mono or polyprotic acid or base solution, in relation to the properties of the solution and its components. 8.6.A Explain the relationship between the strength of an acid or base and the structure of the molecule or ion. 8.7.A Explain the relationship between the predominant form of a weak acid or base in solution at a given pH and the pKa of the conjugate acid or the pKb of the conjugate base. 8.8.A Explain the relationship between the ability of a buffer to stabilize pH and the reactions that occur when an acid or a base is added to a buffered solution. 8.9.A Identify the pH of the buffer solution based on the identity and concentrations of the conjugate acid-base pair used to create the buffer. 8.10.A Explain the relationship between the buffer capacity of a solution and the relative concentrations of the conjugate acid and conjugate base components of the solution. 8.11.A Identify the qualitative effect of changes in pH on the solubility of a salt.	3: Student demonstrates evidence of the learning goal (define, give an example, assessment, etc.) (can have multiple bullets underneath) 2: Student demonstrates overall proficiency with the objectives and essential vocabulary (included here or in objectives below) (can have multiple bullets underneath) 1: Student demonstrates limited proficiency with the objectives and essential vocabulary

Learning Targets

Specific content or skills taught in order to achieve mastery of the learning goal

8.1.A.1 The concentrations of hydronium ion and hydroxide ion are often reported as pH and pOH, respectively. EQN: pH = −log[H3 O+] EQN: pOH = −log[OH−] The terms “hydrogen ion” and “hydronium ion” and the symbols H+(aq) and H3 O+(aq) are often used interchangeably for the aqueous ion of hydrogen. Hydronium ion and H3 O+(aq) are preferred, but H+(aq) is also accepted on the AP Exam.

8.1.A.2 Water autoionizes with an equilibrium constant Kw. EQN: Kw = [H3 O+][OH−] = 1.0 × 10−14 at 25°C

8.1.A.3 In pure water, pH = pOH is called a neutral solution.At25°C, pKw = 14.0 and thus pH=pOH= 7.0. EQN: pKw = 14 = pH + pOH at 25°C

8.1.A.4 The value of Kw is temperature dependent, so the pH of pure, neutral water will deviate from 7.0attemperaturesotherthan25°C.

8.2.A.1 Molecules of a strong acid (e.g., HCl, HBr, HI, HClO4, H2 SO4+, and HNO3) will completely ionize in aqueous solution to produce hydronium ions and the conjugate base of the acid. As such, the concentration of H3 O+ in a strong acid solution is equal to the initial concentration of the strong acid, and thus the pH of the strong acid solution is easily calculated.

8.2.A.2 When dissolved in solution, strong bases (e.g., group I and II hydroxides) completely dissociate to produce hydroxide ions. As such, the concentration of OH− in a strong base solution is equal to the initial concentration of a group I hydroxide and double the initial concentration of a group II hydroxide, and thus the pOH (and pH) of the strong base solution is easily calculated.

8.3.A.1 Weak acids react with water to produce hydronium ions. However, only a small percentage of molecules of a weak acid will ionize in this way. Thus, the concentration of H + 3 O is much less than the initial concentration of the molecular acid, and the vast majority of the acid molecules remain un-ionized.

8.3.A.2 A solution of a weak acid involves equilibrium between a nun-ionized acid and its conjugate base. The equilibrium constant for this reaction is Ka, often reported as pKa. The pH of a weak acid solution can be determined from the initial acid concentration and the pKa. EQN: [HO] + − [A] K 3 a = [HA] EQN: pKa = −log Ka

8.3.A.3 Weak bases react with water to produce hydroxide ions in solution. However, ordinarily just a small percentage of the molecules of a weak base in solution will ionize in this way. Thus, the concentration of OH- in the solution does not equal the initial concentration of the base, and the vast majority of the base molecules remain un-ionized.

8.3.A.4 A solution of a weak base involves equilibrium between an un-ionized base and its conjugate acid. The equilibrium constant for this reaction is Kb, often reported as pKb. The pH of a weak base solution can be determined from the initial base concentration and the pKb. EQN: [OH−][HB+] Kb = [B] EQN: pKb = −log Kb

8.3.A.5 The percent ionization of a weak acid (or base) can be calculated from its pKa (pKb) and the initial concentration of the acid (base). The percent ionization can also be calculated from the initial concentration of the acid (base) and the equilibrium concentration of any of the species in the equilibrium expression.

8.3.A.6 Foranyconjugateacid-basepair,the acid ionization constant and base ionization constant are related by Kw : EQN: Kw = Ka × Kb EQN: pKw = pKa + pKb

8.4.A.1 When a strong acid and a strong base are mixed, they react quantitatively in a reaction represented by the equation: H+(aq) + OH−(aq) → H2 O(l). The pH of the resulting solution may be determined from the concentration of excess reagent.

8.4.A.2 When a weak acid and a strong base are mixed, they react quantitatively in a reaction represented by the equation: HA(aq) + OH−(aq) A−(aq) H2 O(l). If the weak acid is in excess, then a buffer solution is formed, and the pH can be determinedfromtheHenderson-Hasselbalch (H−H)equation(see8.9.A.1).If the strong base is in excess, then the pH can be determined from the moles of excess hydroxide ion and the total volume of solution. If they are equimolar, then the (slightly basic) pH can be determined from the equilibrium represented by the equation: A−(aq) + H2 O(l) HA(aq) + OH−(aq).

8.4.A.3 When a weak base and a strong acid are mixed, they will react quantitatively in a reaction represented by the equation: B(aq) + H3 O+(aq) HB+(aq) + H2 O(l). If the weak base is in excess, then a buffer solution is formed, and the pH can be determined from the H−H equation. If the strong acid is in excess, then the pH can be determined from the moles of excess hydronium ion and the total volume of solution. If they are equimolar, then the (slightly acidic) pH can be determined from the equilibrium represented by the equation: HB+(aq) + H2 O(l) B(aq) + H3 O+(aq).

8.4.A.4 When a weak acid and a weak base are mixed, they will react to an equilibrium state whose reaction may be represented by the equation: HA(aq) + B(aq) A−(aq) + HB+(aq).

8.5.A.1 An acid-base reaction can be carried out under controlled conditions in a titration. A titration curve, plotting pH against the volume of titrant added,is useful for summarizing results from a titration.

8.5.A.2 At the equivalence point for titrations of monoprotic acids or bases, the number of moles of titrant added is equal to the number of moles of analyte originally present. This relationship can be used to obtain the concentration of the analyte. This is the case for titrations of strong acids/bases and weak acids/bases.

8.5.A.3 For titrations of weak acids/bases, it is useful to consider the point halfway to the equivalence point, that is, the half-equivalence point. At this point, there are equal concentrations of each species in the conjugate acid-base pair, for example, for a weak acid [HA] = [A−]. Because pH = pKa when the conjugate acid and base have equal concentrations, the pKa can be determined from the pH atthehalfequivalence point in a titration.| |
| :---- |

8.6.A.1 The protons on a molecule that will participate in acid-base reactions,and the relative strength of these protons, can be inferred from the molecular structure.

i. Strong acids (such as HCl, HBr, HI, HClO4, H2 SO4, and HNO3) have very weak conjugate bases that are stabilized by electronegativity, inductive effects, resonance, or some combination thereof.
ii. Carboxylic acids are one common class of weak acid.
iii. Strong bases (such as group I and II hydroxides) have very weak conjugate acids.
iv. Common weak bases include nitrogenous bases such as ammonia as well as carboxylate ions.

v. Electronegative elements tend to stabilize the conjugate base relative to the conjugate acid, and so increase acid strength.

8.7.A.1 The protonation state of an acid or base (i.e., the relative concentrations of HA and A−) can be predicted by comparing the pH of a solution to the pKa of the acid in that solution. When solution pH< acid pKa, the acid form has a higher concentration than the base form. When solution pH > acid pKa, the base form has a higher concentration than the acid form.

8.7.A.2 Acid-base indicators are substances that exhibit different properties (such as color)in their protonated versus deprotonated state, making that property respond to the pH of a solution.

8.7.A.3 To ensure accurate results in a titration experiment,acid-base indicators should be selected that have a pKa close to the pH at the equivalence point.8.8.A.1 A buffer solution contains a large concentration of both members in a conjugate acid-base pair. The conjugate acid reacts with added base and the conjugate base reacts with added acid. These reactions are responsible for the ability of a buffer to stabilize pH.

8.9.A.1 The pH of the buffer is related to the pKa the acid and the c of concentration ratio of the conjugate acid-base pair. This relation is a consequence of the equilibrium expression associated with the dissociation of a weak acid, and is described by the Henderson Hasselbalch equation. Adding small amounts of acid or base to a buffered solution does not significantly change the ratio of[A−]/[HA] and thus does not significantly change the solution pH. The change in pH on addition of acid or base to a buffered solution is therefore much less than it would have been in the absence of the buffer. EQN: [A−] pH = pKa + log [ ] HA

Exclusion Statement: Computation of the change in pH resulting from the addition of an acid or a base to a buffer will not be assessed on the AP Exam. Exclusion Statement: Derivation of the Henderson-Hasselbalch equation will not be assessed on the AP Exam.

8.10.A.1 Increasing the concentration of the buffer components (while keeping the ratio of these concentrations constant) keeps the pH of the buffer the same but increases the capacity of the buffer to neutralize added acid or base.

8.10.A.2 When a buffer has more conjugate acid than base, it has a greater buffer capacity for addition of added base than acid. When a buffer has more conjugate base than acid, it has a greater buffer capacity for addition of added acid than base.

8.11.A.1 The solubility of a salt is pH sensitive when one of the constituent ions is a weak acid, a weak base,or the hydroxide ion. These effects can be understood qualitatively using Le Châtelier’s principle.

Exclusion Statement: Computations of solubility as a function of pH will not be assessed on the AP Exam.

AP Chemistry Unit 9 - Applications of Thermodynamics

Next Generation Science Standards (NGSS)
NGSS-HS-PS 1-1: 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.

NGSS-HS-PS 1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

NGSS-HS-PS 1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

NGSS-HS-PS 1-4: 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.

NGSS-HS-PS 1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

NGSS-HS-PS 1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

NGSS-HS-PS 1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

NGSS-HS-PS 2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

NGSS-HS-PS 3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other components(s) and energy flows in and out of the system are known.

NGSS-HS-PS 3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.

NGSS-HS-PS 3-4: 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).

NGSS-HS-ESS 2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
NGSS-HS-ESS 3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

NGSS-HS-ESS 3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Learning Goal	Proficiency Scale
The student will be able to: 9.1.A Identify the sign and relative magnitude of the entropy change associated with chemical or physical processes. 9.2.A Calculate the standard entropy change for a chemical or physical process based on the absolute entropies (standard molar entropies) of the species involved in the process. 9.3.A Explain whether a physical or chemical process is thermodynamically favored based on an evaluation of ΔG 9.4.A Explain, in terms of kinetics, why a thermodynamically favored reaction might not occur at a measurable rate. 9.5.A Explain whether a process is thermodynamically favored using the relationships between K, ΔGo, and T 9.6.A Explain the relationship between the solubility of a salt and changes in the enthalpy and entropy that occur in the dissolution process. 9.7.A Explain the relationship between external sources of energy or coupled reactions and their ability to drive thermodynamically unfavorable processes. 9.8.A Explain the relationship between the physical components of an electrochemical cell and the overall operational principles of the cell. 9.9.A Explain whether an electrochemical cell is thermodynamically favored, based on its standard cell potential and the constituent half-reactions within the cell. 9.10.A Explain the relationship between deviations from standard cell conditions and changes in the cell potential. 9.11. A Calculate the amount of charge flow based on changes in the amounts of reactants and products in an electrochemical cell.	4: Student demonstrates innovation, in depth inference(s), or advanced application(s) with the learning goal (can have multiple bullets underneath) 3: Student demonstrates evidence of the learning goal (define, give an example, assessment, etc.) (can have multiple bullets underneath) 2: Student demonstrates overall proficiency with the objectives and essential vocabulary (included here or in objectives below) (can have multiple bullets underneath) 1: Student demonstrates limited proficiency with the objectives and essential vocabulary

Learning Targets

Specific content or skills taught in order to achieve mastery of the learning goal

9.1.A.1 Entropy increases when matter becomes more dispersed. For example, the phase change from solid to liquid or from liquid to gas results in a dispersal of matter as the individual particles become freer to move and generally occupy a larger volume. Similarly, for a gas, the entropy increases when there is an increase in volume (at constant temperature), and the gas molecules are able to move within a larger space.For reactions involving gas-phase

9.1.A.2 reactants or products, the entropy generally increases when the total number of moles of gas-phase products is greater than the total number of moles of gas-phase reactants. Entropy increases when energy is dispersed. According to kinetic molecular theory (KMT), the distribution of kinetic energy among the particles of a gas broadens as the temperature increases. As a result, the entropy of the system increases with an increase in temperature.

9.2.A.1 The entropy change for a process can be calculated from the absolute entropies of the species involved before and after the process occurs. EQN: ΔSo reaction = ΣSo Σ o products − Sreactants

9.3.A.1 The Gibbs free energy change for a chemical process in which all the reactants and products are present in a standard state (as pure substances, as solutions of 1.0 M concentration, or as gases at a pressure of 1.0 atm(or 1.0 bar))is given the symbol ΔGo.

9.3.A.2 The standard Gibbs free energy change for a chemical or physical process is a measure of thermodynamic favorability. Historically, the term "spontaneous" has been used to describe processes for which ΔGo < 0. The phrase "thermodynamically favored" is preferred instead so that common misunderstandings (equating "spontaneous" with "suddenly" or "without cause") can be avoided. When ΔGo < 0 for the process, it is said to be thermodynamically favored.

9.3.A.3 The standard Gibbs free energy change for a physical or chemical process may also be determined from the standard Gibbs free energy of formation of the reactants and products. EQN: ΔGre °action = ΣΔGf ° products − ΣΔ G f ° reactants

9.3.A.4 In some cases, it is necessary to consider both enthalpy and entropy to determine if a process will be thermo dynamically favored. The freezing of water and the dissolution of sodium nitrate are examples of such phenomena. 9.3.A.5 Knowing the values of ΔH° and ΔS° for a process at a given temperature allows ΔG° to be calculated directly. EQN: ΔG° = ΔH° − T ΔS°

9.3.A.6 In general, the temperature conditions for a process to be thermodynamically favored (ΔG° < 0) can be predicted from the signs of ΔH° and ΔS° as shown in the table below: ΔH° ΔS° Symbols ΔG° < 0, favored at: < 0 > 0 < > all T > 0 < 0 > < no T > 0 > 0 > > high T < 0 < 0 < < low T In cases where ΔH° < 0 and ΔS°>0, no calculation of ΔG° is necessary to determine that the process is thermo dynamically favored (ΔG° < 0). In cases where ΔH° > 0 and ΔS° < 0, no calculation of ΔG° is necessary to determine that the process is thermodynamically unfavored (ΔG° > 0

9.4.A.1 Many processes that are thermodynamically favored do not occur to any measurable extent, or they occur at extremely slow rates.

9.4.A.2 Processes that are thermodynamically favored, but do not proceed at a measurable rate, are under "kinetic control." High activation energy is a common reason for a process to be under kinetic control. The fact that a process does not proceed at a noticeable rate does not mean that the chemical system is at equilibrium. If a process is known to be thermodynamically favored, and yet does not occur at a measurable rate, it is reasonable to conclude that the process is under kinetic control.

9.5.A.1 The phrase “thermodynamically favored” ($\Delta Go < 0$) means that the products are favored at equilibrium ($K > 1$) under standard conditions.

9.5.A.2 The equilibrium constant is related to free energy by the equations EQN: $K = e-\Delta G°/RT$ and EQN: $\Delta G° = -RT \ln K$.

9.5.A.3 Connections between K and ΔG° can be made qualitatively through estimation. When ΔG° is nearzero,theequilibriumconstantwillbeclose to 1. When ΔG° is much larger or much smaller than RT, the value of K deviates strongly from 1.

9.5.A.4 Processes with $\Delta G° < 0$ favor products (i.e., $K > 1$) and those with $\Delta G° > 0$ favor reactants (i.e., $K < 1$

9.6.A.1 The free energy change (ΔG°) for dissolution of a substance reflects a number of factors: the breaking of the intermolecular interactions that hold the solid together, the reorganization of the solvent around the dissolved species, and the interaction of the dissolved species with the solvent. It is possible to estimate the sign and relative magnitude of the enthalpic and entropic contributions to each of these factors. However, making predictions for the total change in free energy of dissolution can be challenging due to the cancellations among the free energies associated with the three factors cited.

9.7.A.1 An external source of energy can be used to make a thermodynamically unfavorable process occur. Examples include: i. Electrical energy to drive an electrolytic cell or charge a battery. ii. Light to drive the overall conversion of carbon dioxide to glucose in photosynthesis.

9.7.A.2 A desired product can be formed by coupling a thermodynamically unfavorable reaction that produces that product to a favorable reaction (e.g., the conversion of ATP to ADP in biological systems). In the coupled system, the individual reactions share one or more common intermediates. The sum of the individual reactions produces an overall reaction that achieves the desired outcome and has S

9.8.A.1 Each component of an electrochemical cell (electrodes, solutions in the half-cells, salt bridge, voltage/current measuring device) plays aspecificroleintheoverallfunctioningofthe cell. The operational characteristics of the cell (galvanic vs. electrolytic, direction of electron flow, reactions occurring in each half-cell, change in electrode mass, evolution of a gas at an electrode, ion flow through the salt bridge) can be described at both the macroscopic and particulate levels.

9.8.A.2 Galvanic, sometimes called voltaic, cells involve a thermodynamically favored reaction, whereas electrolytic cells involve a thermodynamically unfavored reaction. Visual representations of galvanic and electrolytic cells are tools of analysis to identify where half-reactions occur and in what direction of current flows.

9.8.A.3 For all electrochemical cells, oxidation occurs at the anode and reduction occurs at the cathode.

Exclusion Statement: Labeling an electrode as positive or negative will not be assessed on the AP Exam.

9.9.A.1 Electrochemistry encompasses the study of redox reactions that occur within electrochemical cells. The reactions are either thermodynamically favored (resulting in a positive voltage) or thermodynamically unfavored (resulting in a negative voltage and requiring an externally applied potential for the reaction to proceed).

9.9.A.2 The standard cell potential of electrochemical cells can be calculated by identifying the oxidation and reduction half-reactions and their respective standard reduction potentials.

9.9.A.3 ΔGo (standard Gibbs free energy change) is proportional to the negative of the cell potential for the redox reaction from which it is constructed. Thus, a cell with a positive Eo involves a thermodynamically favored reaction, and a cell with a negative Eo involves a thermodynamically unfavored reaction. EQN: $\Delta G^o = -nFE^o$

9.10.A.1 In a real system under nonstandard conditions, the cell potential will vary depending on the concentrations of the active species. The cell potential is a driving force toward equilibrium; the farther the reaction is from equilibrium, the greater the magnitude of the cell potential.

9.10.A.2 Equilibrium arguments such as Le Châtelier's principle do not apply to electrochemical systems, because the systems are not in equilibrium.

9.10.A.3 The standard cell potential Eo corresponds to the standard conditions of $Q = 1$. As the system approaches equilibrium, the magnitude (i.e., absolute value) of the cell potential decreases, reaching zero at equilibrium (when $Q = K$). Deviations from standard conditions that take the cell further from equilibrium than $Q = 1$ will increase the magnitude of the cell potential relative to Eo. Deviations from standard conditions that take the cell closer to equilibrium than $Q = 1$ will decrease the magnitude of the cell potential relative to Eo. In concentration cells, the direction of spontaneous electron flow can be determined by considering the direction needed to reach equilibrium.

9.10.A.4 Algorithmic calculations using the Nernst equation are insufficient to demonstrate an understanding of electrochemical cells under nonstandard conditions. However, students should qualitatively understand the effects of concentration on cell potential and use conceptual reasoning, including the qualitative use of the Nernst equation: EQN: $E = E^o - (RT/nF) \ln Q$ to solve problems.

9.11.A.1 Faraday's laws can be used to determine the stoichiometry of the redox reaction occurring in an electrochemical cell with respect to the following:

i. Number of electrons transferred
ii. Mass of material deposited on or removed from an electrode (as in electroplating)
iii. Current
iv. Time elapsed
v. Charge of ionic species EQN: $I = q/t$

Forensics

Introduction and Crime Scenes

Missouri Grade-Level Expectations (or other standards)
This course is aligned to St. Louis University 1818 FRSC 2600 Introduction to Forensic Science

Learning Goal	Proficiency Scales
Students will be able to explain and perform some of the basic functions of a crime laboratory.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Comparing and contrasting Frye vs. US and Daubert vs Merrell Dow Pharmaceutical. ● Identifying sections of the crime lab that perform specific functions. ● Drawing conclusions about the time of death from information about rigor, livor and/or algor mortis of a cadaver. ● Organizing the information from a crime scene into a record of notes, sketch and evidence properly collected from the scene with a chain of custody log completed. ● Explaining chain of custody in terms of its importance for use of evidence in the courts. 2: Student demonstrates he/she is nearing proficiency by:

	● Recognizing or recalling specific vocabulary, such as: *Miranda Rights, fourth amendment, fifth amendment, warrant, Frye vs. US, Daubert vs. Merrell Dow, crime scene search, crime scene sketch, rigor mortis, livor mortis, and algor mortis notes, evidence container, labeling evidence, sealing evidence, chain of custody* ● Performing processes such as: ○ Evaluating types of containers to correctly collecting evidence. ○ Sketching a crime scene. ○ Note taking during the processing of a crime scene. 1: Student demonstrates limited understanding or skill with the learning goal.

Trace Evidence

Missouri Grade-Level Expectations (or other standards)
This course is aligned to St. Louis University 1818 FRSC 2600 Introduction to Forensic Science

Learning Goal	Proficiency Scales

Students will be able to identify the major types of trace evidence, and determine how to collect and examine each.	4: Student demonstrates in in-depth inference or advanced application or innovates with the learning goal.
	
	3: Student demonstrates mastery with the learning goal as evidenced by:
	
	● Explaining how type of glass is determined.
	● Citing evidence for determination of specie and whether or not death has occurred using hair.
	● Citing evidence for determination of fiber type.
	● Explaining the technique used to determine dye/pigment type.
	● Describing the technique used to examine soil evidence.
	● Explaining how type of paint is determined.
	● Identifying the correct procedures for collection of glass, hair, fiber, soil and paint.
	● Differentiating between class and individual characteristics for all types of trace evidence.
	
	2: Student demonstrates he/she is nearing proficiency by:
	
	● Recognizing or recalling specific vocabulary, such as: *refractive index, fracturing, first shot, medulla, medullary index, cuticle, cortex, distal, proximal, natural fiber, synthetic fiber, optical properties, polarized light, gas pyrolysis, pigment, layering, soil and density gradient tubes.*
	
	● Performing processes such as:
	    ○ Examining fiber to determine type.
	    ○ Examining hair to determine if human or not.
	    ○ Identifying the fracture that occurred first in a pane of glass.
	
	1: Student demonstrates a limited understanding or skill with the learning goal.

Fingerprints and Physical Evidence

Missouri Grade-Level Expectations (or other standards)
This course is aligned to St. Louis University 1818 FRSC 2600 Introduction to Forensic Science

Learning Goal	Proficiency Scales
Students will be able to analyze fingerprints and physical evidence.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by performing fingerprint analysis: ● differentiating between the types of fingerprint patterns; ● identifying the seven types of ridge characteristics; ● locating and identifying 4 points on a fingerprint; ● differentiating between a latent, visible and plastic print; ● differentiating between chemical and physical development of a print; ● differentiating between class and individual characteristics; ● and identifying the two steps in testing physical evidence.

	2: The student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as: *loop, whorl, arch, ridge characteristic, bifurcation, enclosure, latent print, plastic print, visible print, class characteristic and individual characteristic.* ● Performing processes such as: ○ Lifting and correctly labeling a latent fingerprint. ○ Rolling fingerprints and identifying the type of print. ○ Identifying ridge characteristics on a single fingerprint. 1: Student demonstrates a limited understanding or skill with the learning goal.

Drug Evidence

<u>Missouri Grade-Level Expectations (or other standards)</u>
This course is aligned to St. Louis University 1818 FRSC 2600 Introduction to Forensic Science

<u>Learning Goal</u>	<u>Proficiency Scales</u>

Students will be able to evaluate a specific set of drugs for purposes of identification, physiological and psychological effects on humans, and legal penalties for illegal possession of each drug.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Determining the family, short-term effects, long-term effects, presumptive test, conclusive test, schedule and penalty for illegal possession for each of the following: morphine, heroin, codeine, oxycontin, fentanyl, marijuana, ketamine, LSD, PCP, alcohol, barbiturates, inhalants,methamphetamine, ecstasy, GHB, Cocaine, Crack Cocaine, and anabolic steroids. ● Determining the presumptive test used to identify each of the above drugs. ● Determining the confirmatory test for all of the drugs listed above ● Identifying the schedule and penalty for illegal possession for each of the drugs listed above. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as: *family, short-term effects, long-term effects, presumptive test. confirmatory test, index, schedules, morphine, heroin, codeine, oxycontin, fentanyl, methamphetamine, ketamine, ecstasy, marijuana, alcohol, GHB, inhalants and anabolic steroids.* ● Performing specific processes, such as: ○ Drawing conclusions about an unknown drug sample from procedures in a color test. ○ Recalling physiological and psychological effects of drug on humans ○ Identifying legal penalties for illegal possession of a drug 1: Student demonstrates a limited understanding or skill with the learning goal.

Body Fluid Evidence

Missouri Grade-Level Expectations (or other standards)
This course is aligned to St. Louis University 1818 FRSC 2600 Introduction to Forensic Science

Learning Goal	Proficiency Scales
Students will be able to draw conclusions about the source of body fluids from the analysis of stains collected from a crime scene.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery of the learning goal as evidenced by: ● Differentiating between mitochondrial and nuclear DNA. ● Identifying all parts of the body containing mtDNA and those containing nuclear DNA. ● Differentiating between PCR and STR DNA testing. ● Collecting and storing DNA evidence properly. ● Explaining what CODIS is and where the data in it comes from. ● Drawing conclusions about the events that occurred to create a blood stain or set of bloodstain patterns. ● Concluding which circumstances are best for the application of luminol and which are best for kastle-meyer reagents.

	2: The student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as: *mitochondrial DNA, nuclear DNA, PCR, STR, CODIS, angle of impact, direction, speed/velocity, distance, kastle-meyer, and luminol.* ● Performing processes such as: ○ Investigating the patterns from blood drops resulting from movements in various directions. ○ Use context cues to deduce information about an interactive online crime scene scenario. 1: Student demonstrates a limited understanding or skill with the learning goal.

Advanced Forensic Science

Questioned Documents and Crime Scenes

Missouri Grade-Level Expectations (or other standards)
This course is aligned to St. Louis University 1818 FRSC 2600 Introduction to Forensic Science

Learning Goal	Proficiency Scales
Students will be able to analyze basic crime scene and examine and identify sources of questioned documents.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery of the learning goal as evidenced by: ● Comparing and contrasting Frye vs. US and Daubert vs Merrell Dow Pharmaceutical. ● Explaining Miranda rights and their application to forensic science. ● Describing fourth and fifth amendment rights as they apply to forensic science. ● Analyzing information about a crime scene to determine if it is primary or secondary scene. ● Evaluating information about evidence to determine if it is primary or secondary transfer, transient, pattern, conditional or associative evidence. ● Examining a document to determine if it is possible for parts of it to be forged. ● Determining the source of a writing by examining the formation of the text.

	● Drawing conclusions about the authenticity of a document by examining the paper, print and application of the print to the document. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as: *miranda rights, fourth and fifth amendment, primary and secondary crime scenes, primary or secondary transfer, transient, pattern, conditional or associative evidence, questioned document, and exemplar* ● Performing processes such as: ○ Identifying the source of a handwriting. ○ Examining the pages of a document for print, text and paper type. 1: Student demonstrates limited understanding or skill with the learning goal.

Firearm Evidence Analysis

Missouri Grade-Level Expectations (or other standards)
This course is aligned to St. Louis University 1818 FRSC 2600 Introduction to Forensic Science

Learning Goal	Proficiency Scales
Students will be able to explain the	4: Student demonstrates an in-depth inference or advanced application

collection, examination and comparison of firearms and toolmark evidence.	or innovates with the learning goal. 3: The student demonstrates mastery of the learning goal as evidenced by: ● Differentiating between caliber and gauge. ● Identifying the areas of a bullet and cartridge case that will have tool marks on them from a firearm. ● Identifying the parts of a firearm that will leave marks on specific places on a bullet or cartridge case. ● Explaining how a barrel is rifled and what occurs to make the striations from rifling unique. ● Identifying which types of toolmarks are unique. ● Determining identity of a toolmark from a set of possible tools. ● Explaining how to collect firearms evidence. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as: *caliber, gauge, firing pin, extractor, ejector, primer cup, cartridge, cartridge case, breech face, striations and toolmark.* ● Performing processes such as: ○ identifying a specific tool that made a specific tool mark from a set of possible tools. ○ restoring the legibility of a damaged serial number using a metal block. 1: Student demonstrates a limited understanding or skill with the learning goal.

Death Investigation

Missouri Grade-Level Expectations (or other standards)
This course is aligned to St. Louis University 1818 FRSC 2600 Introduction to Forensic Science High School TILS Strand IV: Tools of the Trade: Students will be able to use appropriate digital tools within and across content areas in preparation for post-secondary experiences.

Learning Goal	Proficiency Scales
Students will be able to compare and contrast the work of a medical examiner, forensic anthropologist, forensic artist, and footwear examiner.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery of the learning goal as evidenced by: ● Differentiating among manner, cause and mechanisms of death. ● Identifying responsibilities of a forensic pathologists. ● Explaining the cause of rigor, livor and algor mortis and drawing conclusions from their stages about the time of death of a cadaver. ● Analyzing a corpse to establish its identity by ○ Determining the bones necessary to determine age, sex and race of a person; ○ Determining how to uniquely identify a person from bones; ○ Determining the race of a person from a skull;

	○ Determining the sex of a person from the pelvis or skull; ○ Identifying the types of bones required to determine the approximate height of a person from skeletal remains; ○ Identifying the areas of the bones necessary to determine the age of a person from skeletal remains; ○ Explaining how to use a 2-dimensional image of a skull to identify a person. ● Drawing correct conclusions about the source of an unknown footwear impression. ● Determining the characteristics required to make an outsole unique. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as: *forensic pathologist, manner, cause and mechanism of death, rigor, livor and algor mortis, forensic anthropologist, forensic art, 2-d and 3-d facial reconstruction, footwear impression, wear patterns, accidental marks, crepe and calendared outsoles.* ● Performing processes such as: ○ Identifying the bones needed to determine age, sex, and race of a person. ○ Explaining 2-dimensional facial reconstruction. ○ Drawing conclusions about the source unknown footwear impressions. 1: Student demonstrates a limited understanding or skill with the learning goal.

Crime Scene Investigation

Missouri Grade-Level Expectations (or other standards)

This course is aligned to St. Louis University 1818
FRSC 2600 Introduction to Forensic Science

- High School TILS Strand II: Information Literacy: Students will be able to research and synthesize information; use a variety of digital resources; retrieve and evaluate reliability and accuracy from appropriately cited sources; draw evidence-based conclusions in order to prove comprehension of course objectives.
- High School TILS Strand IV: Tools of the Trade: Students will be able to use appropriate digital tools within and across content areas in preparation for post-secondary experiences.

Learning Goal	Proficiency Scales
Students will be able to draw conclusions about the historical development of crime scene processing.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery of the learning goal as evidenced by: ● Researching and interpreting the information from multiple sources about the events that lead to a crime in a famous case in forensic science prior to 1989. ● Evaluating the information from resources about the famous case. ● Explaining thoroughly and concisely the details of the case and how the case would be investigated differently today.

	2: Student demonstrates he/she is nearing proficiency b: ● Recognizing or recalling specific vocabulary, such as: *chain of custody, digital evidence, investigators, crime scene, database, IAFIS, NIBIN, and CODIS.* ● Performing processes such as: ○ Researching information about a famous case ○ Outlining the information for the case 1: Student demonstrates a limited understanding or skill with the learning goal.

Genetics

Meiosis
DRAFT

Missouri Grade-Level Expectations (or other standards)
NGSS HS LS3-2: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

<table>
<tr><th>Learning Goal</th><th>Proficiency Scales</th></tr>
<tr><td>Students will be able to model sexual reproduction at a cellular level.</td><td>4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal.

3: The student demonstrates mastery of the learning goal by
● diagramming the process of meiosis.
● diagramming the process of crossing over.

2: The student demonstrates he/she is nearing the learning goal by
● recognizing or recalling specific vocabulary, such as: gametes, variation, karyotype, homologous chromosomes, zygote, meiosis I, meiosis II, crossing over, synapsis, independent assortment.
● performing specific processes, such as:
○ describing the process of meiosis.
○ defining the process of crossing over.
1: Student demonstrates a limited understanding or skill with the learning goal.</td></tr>
</table>

Large Biological Molecules

DRAFT

Missouri Grade-Level Expectations (or other standards)
NGSS: HS-LSI-1: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. **HS-LS1-6: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.**

Learning Goal	Proficiency Scales
Students will be able to explain the processes regulated by large biological molecules.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: The student demonstrates mastery of the learning goal by ● explaining the role of macromolecules in regulating chemical reactions in cells. ● explaining the storage of genetic information. 2: The student demonstrates he/she is nearing the learning goal by ● recognizing or recalling specific vocabulary, such as: protein, amino acid, peptide bond, 4 levels of protein structure,chaperonin,nucleic acids, DNA, RNA, nucleotide, purine, pyrimidine, and antiparallel.

	- performing specific processes, such as
	  - labeling major macromolecules in the cell.
	  - explaining the Central Dogma of Protein Synthesis.
	
	1: Student demonstrates a limited understanding or skill with the learning goal.

Inheritance

DRAFT

Missouri Grade-Level Expectations (or other standards)
NGSS HS-LS3-3: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Learning Goal	Proficiency Scales
Students will be able to mathematically demonstrate the inheritance of traits.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: The student demonstrates mastery of the learning goal by - applying advanced, discipline-specific vocabulary in describing Mendelian genetics. - solving genetics problems using Punnett Squares. - making mathematical predictions about phenotypes in future

	generations. 2: The student demonstrates he/she is nearing the learning goal by ● recognizing or recall specific vocabulary, such as: Gregor Mendel, dominant, recessive,independent assortment, law of segregation, Punnett square, probability, incomplete dominance, codominance, multiple alleles, epistasis, polygenic inheritance, pedigree. ● performing specific processes, such as: ○ demonstrating independent assortment during gamete formation. ○ completing a Punnett square. ○ analyzing genotype and phenotype probabilities. 1: Student demonstrates a limited understanding or skill with the learning goal.

Gene Expression
DRAFT

Missouri Grade-Level Expectations (or other standards)
NGSS Science and Engineering Practices **2. Developing and using models** **High School TILS Strand IV: Tools of the Trade: Students will be able to use appropriate digital tools within and across content areas in preparation for post-secondary experiences.**

Learning Goal	Proficiency Scales
Students will be able to model gene expression.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: The student demonstrates mastery of the learning goal by ● describing the regulation of gene expression in prokaryotic and eukaryotic organisms. ● building models that illustrate how bacterial operons work. ● performing bacterial gene transformation experimentally. ● demonstrating the regulation of gene expression. 2: The student demonstrates he/she is nearing proficiency by: ● recognizing or recalling specific vocabulary, such as: prokaryotic gene regulation, operon, promoter, operator, repressor, inducible, repressible, eukaryotic gene regulation, histones, methylation, acetylation, epigenetics, transposons, proto-oncogenes, oncogenes, tumor suppressor genes, differentiation, cytoplasmic determinants, homeotic genes, gene families. ● performing specific processes, such as: ○ labeling models that illustrate bacterial operons. ○ conducting bacterial gene transformation with limited success. 1: Student demonstrates a limited understanding or skill with the learning goal.

DNA to RNA of Protein

DRAFT

Missouri Grade-Level Expectations (or other standards)

NGSS: HS-LS-1: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.
HS-LS3-2: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurred during replication, and/or (3) mutations caused by environmental factors.

Learning Goal	Proficiency Scales
Students will be able to model the flow of genetic information from DNA to RNA to the protein.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: The student demonstrates mastery with the learning goal by ● applying the flow of genetic information to the synthesis of a protein. ● contrasting and comparing the processes of transcription and translation in prokaryotic and eukaryotic organisms. ● analyzing mutations to genetic material. 2: The student demonstrates he/she is nearing proficiency by ● recognizing and recalling specific vocabulary, such as: Beadle--Tatum experiment, RNA, mRNA, template strand, transcription, translation, codon, genetic code, tRNA, transcription factors, promoter, TATA box, introns, exons, spliceosome complex, anticodon, APE sites, mutations, mutagens. ● performing specific processes, such as: ● transcribing DNA into RNA.

	• translating RNA into protein by use of an mRNA codon chart. • recognizing mutations. 1: Student demonstrates a limited understanding or skill with the learning goal.

DNA
DRAFT

Missouri Grade-Level Expectations (or other standards)
NGSS: HS-LS-1: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

Learning Goal	Proficiency Scales
Students will be able to analyze key scientific experiments to trace the discovery of DNA as the molecular basis of inheritance, the structure of DNA, and the method of DNA replication.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: The student demonstrates mastery of the learning goal as evidenced by • labeling the components of the DNA molecule • modeling DNA replication. • evaluating the results of key scientific experiments.

	- predicting the results of key scientific experiments or alterations of key scientific experiments. 2: The student demonstrates he/she is nearing proficiency by - recognizing or recalling specific vocabulary, such as: - transformation, Hershey-Chase experiment, X-ray crystallography, Watson-Crick model of DNA, DNA replication, origin of replication, polymerases, leading strand, lagging strand, ligase, primer, primase, Okazaki fragments, nuclease, telomerase, histones, nucleosomes. - performing specific processes, such as: - outlining the history of the discovery of DNA. - describing the outcome of key scientific experiments. 1: Student demonstrates a limited understanding or skill with the learning goal.

Chromosomes
DRAFT

Missouri Grade-Level Expectations (or other standards)

NGSS HS-LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits from parents to offspring.
HS-LS-3: Apply concepts of statistics and probability to explain the variation in distribution of expressed traits in a population.

Learning Goal	Proficiency Scales
Students will be able to model the chromosomes relationship to genes and impact on traits.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: The student demonstrates mastery of the learning goal by: ● analyzing crossing over events to create gene maps. ● solving sex-linked genetic problems. ● analyzing pedigrees. ● analyzing karyotypes. ● tracing mitochondrial inheritance patterns. ● tracing non-Mendelian epigenetic inheritance patterns. 2: The student demonstrates he/she is nearing the learning goal by ● recognizing or recalling specific vocabulary, such as: chromosome theory of inheritance, Morgan, linked genes, sex-linked genes, recombinants, cytological maps, sex determination, Barr body, nondisjunction, aneuploidy, genomic imprinting, mitochondrial inheritance. ● performing specific processes, such as: ○ solving sex-linked problems. ○ describing chromosomal inheritance. ○ determining pedigrees. ○ analyzing karyotypes. 1: Student demonstrates a limited understanding or skill with the learning goal.

Cell Reproduction

DRAFT

Missouri Grade-Level Expectations (or other standards)
NGSS HS-LS1-4: Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

Learning Goal	Proficiency Scales
Students will be able to explain how cells reproduce and replace themselves by a process known as the cell cycle, including understanding the role the cell cycle plays in growth, repair, and cancer.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: The student demonstrates mastery of the learning goal by ● diagramming cell reproduction. ● explaining the regulation of cell reproduction. ● explaining how regulation goes awry to cause cancer. 2: The student demonstrates he/she is nearing the learning goal by ● recognizing or recalling specific vocabulary, such as: cell cycle, chromosome, chromatid, interphase, mitosis, cell plate, cleavage furrow, checkpoints, cyclin, cyclin dependent kinases, MPF, density dependent inhibition, cancer, HeLa, metastasis. ● performing specific processes, such as: ○ describing cell reproduction ○ discussing the regulation of cell division. ○ describing the development of cancerous cells. 1: Student demonstrates a limited understanding or skill with the learning

	goal.

Biotechnology
DRAFT

Missouri Grade-Level Expectations (or other standards)
<Cut and paste...what MGLE correlates to the unit> **<May also include AP or ACC information here>**

Learning Goal	Proficiency Scales
Students will be able to apply the concepts of biotechnology.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: The student demonstrates mastery with the learning goal as evidenced by ● analyzing DNA restriction fragments, including use of restriction enzymes, and electrophoresis. ● simulating DNA sequencing. ● analyzing gene expression by use of microarrays. 2: The student demonstrates he/she is nearing proficiency by ● recognizing or recalling specific vocabulary, such as: cloning, plasmids, ligase, sticky ends, restriction enzymes, DNA restriction fragments,

	antibiotic resistance, polymerase chain reaction, electrophoresis, DNA fingerprinting, DNA microarray, transgenic organisms, GMO. ● performing specific processes, such as: ● performing a restriction digest experiment. ○ analyzing a DNA fingerprint. ○ modeling restriction enzyme activity. 1: Student demonstrates a limited understanding or skill with the learning goal.

Human Anatomy and Physiology

Skeletal Systems and Articulation

Missouri Grade-Level Expectations (or other standards)
HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

Learning Goal	Proficiency Scales
Students will be able to describe how the skeleton is arranged to facilitate support, protection of vital organs, and movement via articulations.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: The student demonstrates mastery of the learning goal as evidences by ● formulating the functions of the skeletal system. ● comparing and contrasting the structure of compact and cancellous bone. ● investigating skeletal disorders and diseases, including causes, effects and treatment. ● describing the processes of bone formation, growth, and repair. ● identifying and naming all bones and markings of the skeletal system. ● describing the characteristics of the three major type of joints. ● comparing and contrasting the movements allowed by each type of joint. ● demonstrating and naming the different types of movements. 2: The student demonstrates he/she is nearing proficiency by ● recognizing or recalling specific vocabulary, such as major bones of skeletal system (ulna, humerus, etc..), osteoporosis, osteomalacia,

	osteomyelitis, scoliosis, kyphosis, lordosis, flexion, extension, abduction, adduction, supination, pronation, rotation, circumduction, inversion, eversion, dorsiflexion, plantarflexion, protraction, retraction, transverse fraction, segmented fracture, comminuted fracture, oblique angle fracture, spiral curvature fracture, open fracture vs. closed, incomplete fracture, synovial joint, fibrous joint, cartilaginous joint. ● performing specific processes, such as ○ identifying major bones of the skeletal system. ○ matching bone disorders with general descriptions. ○ listing the three basic type of joints. ○ matching movements with general descriptions. ○ identifying the three types of vertebrae and the function of each. 1: Student demonstrates a limited understanding or skill with the learning goal.

Muscular Systems

Missouri Grade-Level Expectations (or other standards)
HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

Learning Goal	Proficiency Scales

Students will be able to deduce why muscles are essential for movement and posture and the structure and function of muscles.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3. The student demonstrates mastery of the learning goal as evidenced by ● formulating the functions of the muscular system. ● comparing and contrasting the three types of muscle tissue. ● researching and presenting muscular disorders and diseases, including causes, effects and treatment. ● connecting the names of the muscles of the muscular system to their origins and insertion points. ● describing how action potential is initiated in a muscle cell and the events leading up to muscle contraction. ● describing the gross and microscopic anatomy of skeletal muscle and muscle fiber. ● describing the similarities and differences in the structure and function of muscles. 2. The student demonstrates he/she is nearing proficiency by ● recognizing or recalling specific vocabulary, such as motor neuron, motor unit, muscle fiber nucleus, neuromuscular junctions, skeletal muscle fibers, atrophy, myosin filaments, isotonic, isometric, muscle tone, antagonist, adenosinetriphosphate, glycogen, lactate, threshold, refractory period, relaxation period, cerebral palsy, muscular dystrophy, anabolic steroids. ● performing specific processes, such as ○ identifying the major muscles of the muscular system. ○ matching muscular disorders with general descriptions. ○ listing the three types of muscular tissue. ○ explaining the main difference between skeletal muscle and muscle fiber. ○ summarizing why muscles contract.

	1: Student demonstrates a limited understanding or skill with the learning goal.

Levels of Organization

Missouri Grade-Level Expectations (or other standards)
HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. **HS-LSI-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.**

Learning Goal	Proficiency Scales
Students will be able to summarize how homeostasis influences the human body.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3. The student demonstrates mastery of the learning goal by ● identifying and describing the function of organs included within each organ system. ● determining the relationship between Anatomy & Physiology. ● distinguishing among the epidermis, dermis, and the ● subcutaneous layers of the skin. ● contrasting the structure and function of the four major major tissue types (Epithelial, Connective, Nervous, Muscular). ● identifying the importance of homeostasis to health and describe homeostatic mechanisms.

	• determining the organizational levels in the human body and describe the ways in which they are related. • determining characteristics and functions of the skin and describe how each is accomplished. 2. The student demonstrates he/she is nearing proficiency by • recognizing or recalling specific vocabulary, such as anatomical position, homeostasis, epidermis, dermis, subcutaneous, sagittal, transverse, axial, appendicular, anterior, medial, distal, superior, lateral, inferior, superficial, posterior, cavity, receptor, effector, equilibrium, anatomy, and physiology. • performing specific processes, such as • identifying the organ systems and their primary functions. • listing the three layers and functions of the skin. • listing the four major tissue types. • labeling the levels of organization on a diagram. 1: Student demonstrates a limited understanding or skill with the learning goal.

Body Systems

Missouri Grade-Level Expectations (or other standards)
HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

Learning Goal	Proficiency Scales
Students will be able to distinguish the principal functions of each body system: nervous, endocrine, cardiovascular, lymphatic, urinary, digestive, respiratory and reproductive.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: The student demonstrates mastery of the learning goal as evidenced by • deducing the functions of each body system. • recognizing disorders and diseases, including causes, effects and treatments of of each body system. • describing the path of action throughout each body system. • diagramming and describing the gross anatomy of each body system. • describing the lifespan changes that occur within of each body system. 2: The student demonstrates he/she is nearing proficiency by • recognizing or recalling specific vocabulary, such as systemic, cardiac, pulmonary, steroid, hyposecretion, hypersecretion, negative feedback, positive feedback, hypothalamus, neuron, somatic, autonomic, sympathetic, parasympathetic, and nephron. • performing specific processes, such as ○ identifying the major anatomy and organs of the nervous, ○ endocrine, cardiovascular, lymphatic, urinary, digestive, ○ respiratory and reproductive systems. ○ matching nervous, endocrine, cardiovascular, lymphatic, ○ urinary, digestive, respiratory and reproductive system disorders with general descriptions. • 1: Student demonstrates a limited understanding or skill with the learning goal.

Oceanography

Life in The Ocean

Missouri Grade-Level Expectations (or other standards)
9-12.LS4.A.1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. 9-12.LS2.A.1 Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations. 9-12.LS2.B.2 Communicate the pattern of the cycling of matter and the flow of energy among trophic levels in an ecosystem Ocean Literacy Principles The ocean and life in the ocean shape the features of the Earth

Learning Goal	Proficiency Scales
Demonstrate the ability to summarize the basic principles of marine ecology. Characterize, identify, and explain the interconnectedness of marine life, plant and animal	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Describe the diversity of habitats available in the oceans. ● Discuss the need for organisms to be able to survive in the oceans, and how they are able to deal with physical parameters, including buoyancy, salinity, temperature, pressure, gas concentrations, nutrient availability, light availability, and circulation patterns. ● Identify organisms at each taxonomic level, both in a food chain and a food web. ● Discuss the importance of primary producers in maintaining the ocean food web. ● Review the process of photosynthesis and discuss primary productivity in terms of carbon dioxide

	- intake and oxygen output. 2: Student demonstrates he/she is nearing proficiency by: - Recognizing or recalling specific vocabulary, such as Aquaculture, Benthos, Benthic zone, Pelagic zone, Intertidal zone, Sublittoral zone, Bathyal zone, Abyssal zone, Hadal zone, Neritic zone, Oceanic zone, Food web, Coral reef, Plankton - Performing processes such as: - Classification of fauna and flora based on identification - Locating the various areas of the ocean and the species that would inhabit 1: Student demonstrates a limited proficiency with the objectives and essential vocabulary with help achieving partial success.

Humans and the Ocean

Missouri Grade-Level Expectations (or other standards)
9-12.ESS3.A.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. 9-12.ESS3.A.2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on economic, social, and environmental cost-benefit ratios. 9-12.ESS3.C.1 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. 9-12.ESS3.C.2 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems in order to restore stability and or biodiversity of the ecosystem as well as prevent their reoccurrences. 9-12.ESS3.D.2 Predict how human activity affects the relationships between Earth systems in both positive and negative ways. Ocean Literacy Principles The ocean and humans are inextricably interconnected.

Learning Goal	Proficiency Scales

Demonstrate the ability to explain how humans use resources from the marine environment and how human impact the marine environment.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: Explaining the ocean affects on the Earth's climate, how it influences our weather, and affects human health. ● Demonstrate understanding of the ocean as a resource for food, medicines, and mineral and energy. ● Explain and know examples of laws, regulations, and resource management affect what is taken out and put into the ocean. ● Analyze how human development and activity have led to pollution, changes to ocean chemistry, and physical modifications. ● Calculate and evaluate how natural hazards have impacted humans due to location near coastal areas. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as point source, nonpoint source, and noise pollution, ocean acidification, erosion, tsunami, hurricane, coral bleaching, climate change ● Performing processes such as: ○ Researching natural and anthropogenic events in the ocean ○ Identifying human impacts on the ocean 1: Student demonstrates a limited proficiency with the objectives and essential vocabulary with help achieving partial success.

History and Formation of the Ocean

Missouri Grade-Level Expectations (or other standards)
9-12.ESS1.C.1 Evaluate evidence of the past and current movements of continental and oceanic crust, the theory of plate tectonics, and relative densities of oceanic and continental rocks to explain why continental rocks are generally much older than rocks of the

ocean floor
9-12.ESS2.A.1 Develop a model to illustrate how Earth's interior and surface processes (constructive and destructive) operate at different spatial and temporal scales to form continental and ocean-floor features.
9-12.ESS2.A.3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

NOAA Ocean Literacy Standards: Understands the Essential Principles and Fundamental Concepts about the ocean

Learning Goal	Proficiency Scales
The student will demonstrate the ability to describe the geology of the ocean basins and explain the relationships among geologic history, structure of the ocean basins,and the geological characteristics of various marine environments.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Discuss plate tectonics and historical motion of the plates and the impact on the terrestrial and marine environments ● Identify and label the major oceans on a world map. ● Discriminate among the structures of the ocean floor (mid-ocean ridges, seamounts, subduction zones, abyssal plains, and trenches). ● Relate the theories of continental drift and plate tectonics to the evolution of the ocean basins. ● Describe the evolution of today's ocean basins. ● Identify the three major types of plate boundaries and explain the consequences of these interactions. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as Big Bang, oceanography, plate tectonics, ● Performing processes such as: ○ Motion of the movement of the plates (subduction, divergence, etc.)

	1: Student demonstrates a limited proficiency with the objectives and essential vocabulary with help achieving partial success.

Oceanic and Atmospheric Chemistry and Interaction

Missouri Grade-Level Expectations (or other standards)
6-8.ESS2.C.3 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. 9-12.ESS2.D.1 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. Ocean Literacy: Principle 3: The ocean is a major influence on weather and climate.

Learning Goal	Proficiency Scales
• Explain and identify patterns based on the chemical properties of the ocean and demonstrate the ability to explain the physical factors that affect waves, tides, and currents.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: • Discuss the basic physical properties of a sample of seawater (i.e., temperature, salinity, transparency, density, and pressure). • Explain the ability of water to act as a solvent of solids and gases. • Describe the basic chemical composition of seawater. • Discuss the sources of variations in the ocean's salinity. • Explain the major biogeochemical cycles that relate to the marine environment(carbon, nitrogen, water). • Identify the properties and types of ocean waves.

	• Explain how the Coriolis effect and wind patterns create ocean currents.
	• Describe how the gravitational pull from the Earth, Moon, and Sun create tides.
	• Describe how and why an El Nino event occurs and explain its effects.
	2: Student demonstrates he/she is nearing proficiency by:
	• Recognizing or recalling specific vocabulary, such as Wind-driven ocean circulation and upwelling. Density driven circulation. The great conveyor belt, circulation, pycnocline, thermocline, halocline. Temperature/salinity/density ...
	• Know the types of waves. Shallow vs. deep waves. Tsunamis. Tidal patterns and types
	• Describe the physical environment of the United States coastline...coasts, estuaries, beaches, waves, tides... trends in population development along the coast…
	• Performing processes such as:
	    ○ Following the currents through the ocean
	    ○ Demonstrate erosion and the impacts
	1: Student demonstrates a limited proficiency with the objectives and essential vocabulary with help achieving partial success.

Conceptual Physics

Waves

Missouri Grade-Level Expectations (or other standards)
NGSS-HS-PS: 4-1:Use mathematical representations to support a claim regarding relationships among the frequency, wavelength,and speed of waves traveling in various media. 4-2: Evaluate questions about the advantages of using a digital transmission and storage of information. 4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. 4-4:Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. 4-5: 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.*

Learning Goal	Proficiency Scales
Students will be able to deduce the function and purpose of a wave based on its physical characteristics and behavior.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Representing waves mathematically ($v=f\lambda$) and explaining the relationship of the variables. ● Relating the frequency to the wavelength on the electromagnetic spectrum. ● Describing the process by which energy (digital information) is

	transferred from source to receiver. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing and recalling specific vocabulary, such as: *reflection, refraction, diffraction, interference, crest, trough, medium, frequency, period, velocity, hertz, Doppler shift, electromagnetic, spectrum, wavelength, wave speed, longitudinal, tranverse, stationary, and amplitude.* ● Performing processes such as: ○ Labeling and defining all parts of a wave. ○ Describing the order of EM spectrum. 1: Student demonstrates a limited understanding or skill with the learning goal.

Learning Targets

- Describe the characteristics and properties of waves
- Describe how to calculate the speed of a wave
- Distinguish between the two types of waves
- Discriminate between sound waves and electromagnetic waves
- Explain the Doppler Effect
- Manipulate the electromagnetic spectrum based on frequency and wavelength
- Investigate waves as a means of digital storage and transmission and contrast with other means
- Summarize various types of interference

Learning Design

Forces and Interaction

Missouri Grade-Level Expectations (or other standards)

NGSS-HS-PS:
2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
2-2. 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.
2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*
2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

Learning Goal	Proficiency Scales
Students will be able to model the motion of an object.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by:

- Describing and manipulating mathematically the relationships among acceleration, mass, velocity, and force using
    - $v=d/t$
    - $d=1/2at^2$
    - $a= v_i-v_f/t$
    - $F=ma$
    - $p=mv$
    - Conservation of momentum, and
    - Law of Gravitation.
- Designing, evaluating, and refining a model that minimizes the force of a collision between objects.

2: Student demonstrates he/she is nearing proficiency by:

- Recognizing or recalling specific vocabulary, such as: *velocity*, *inertia, mass, newton, weight, force, acceleration, origin, equilibrium, conservation, momentum, impulse, change in momentum.*

- Performing processes such as:

    - Exhibiting an understanding of Newton's 3 laws of motion.
    - Constructing free-body diagrams.
    - Conceptualizing and categorizing collisions including conservation of momentum but are unsuccessful at analyzing the success or failure of the model.

1: Student demonstrates a limited understanding or skill with the learning goal.

Learning Targets
• Describe the relationship between mass and inertia • Explain how the law of inertia applies to objects in motion • State the relationship between acceleration and net force and mass in terms of Newton's 2nd law • List the factors that affect the movement of an object, such as friction and air resistance • Analyze the role of mass and force along with velocity in momentum through collisions • Explain why an impulse is greater when an object bounces than when the same object comes to a sudden stop • Describe and calculate how the conservation of momentum applies to collisions
Learning Design

Missouri Grade-Level Expectations (or other standards)

NGSS-HS-PS:

3-1:Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
3-3:Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*

Learning Goal	Proficiency Scales
Students will be able to categorize energy sources and demonstrate an understanding of the Law of Conservation of Energy	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Modeling multiple sources of energy. ● Modeling the Law of Conservation of Energy. ● Calculating the conservation of potential and kinetic energy in a given system. ● Demonstrating energy transfer. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as: *conservation, potential, kinetic, height, mechanical, nonmechanical, gravitational, efficiency, work, heat, sound, friction, static, and power.* ● Performing processes such as:

	○ Listing and describing sources and transfers of energy. ○ Describing Law of Conservation of Energy with teacher supplying terms. ○ Planning and building a device that demonstrates some energy transfer with some success. 1. Student demonstrates a limited understanding or skill with the learning goal.

Learning Targets
● Define and describe work ● Define and describe power ● State the two forms of mechanical energy and explain how energy is changed in a closed system ● State three forms of potential energy ● Describe how work and potential and kinetic energy are related verbally and mathematically ● State the law of conservation of energy and describe the transfer of energy in a system ● Build a model that demonstrates energy transfer
Learning Design

Electricity and Magnetism

Missouri Grade-Level Expectations (or other standards)

NGSS-HS-PS:
2-4:Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
2-5: 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.
3-5: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.

Learning Goal	Proficiency Scales
Students will be able to analyze the interaction of electrical and magnetic forces.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Using Coulomb's law to mathematically demonstrate electrostatic forces between particles. ● Using Ohm's law to explain the relationship between voltage, resistance, and current. ● Discriminating among the types of charges, ways to charge materials, and factors that affect charges, such as resistance etc. ● Demonstrating the essential relationship between electric current and magnetic fields ● Demonstrating that an electric current can produce an electric field and a changing magnetic field can produce an electric current. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as *domains,*

	poles, charge, conservation, excess, field, Coulomb's Law, inverse square, attraction, repulsion, electrons, protons, neutrons, nucleus, Ohm's Law, resistance, current, voltage, electric potential energy, power, circuit, conductor, insulator, generator, compass, induction, and mass.
	
	● Performing processes such as:
	    ● Explaining the essentials of the effects of the inverse square law on two charged particles.
	    ● Representing electric and magnetic fields using field lines.
	    ● Explaining how electrons flow through a circuit and how series and parallel circuit differ.
	    ● Describing magnetic and electric fields.
	
	1: Student demonstrates a limited understanding or skill with the learning goal.

Learning Targets

- Describe the fundamental rule at the base of all electrical phenomena
- Explain how an object becomes electrically charged
- Use Coulomb's law to understand the relationship among force, charge and distance
- Describe two ways electric charges can be transferred
- Describe what happens when a charged object is placed near a conducting surface
- Describe how to measure the strength of an electric field at different points
- Illustrate electric fields with vectors and by electric field lines
- Describe the flow of electric charge, magnetic field, and a current-carrying wire
- Give examples of voltage sources

- Analyze the relationship among the factors that affect the resistance of a wire
- Describe Ohm’s law
- Distinguish between DC and AC and how AC is converted to DC
- Explain how current can be turned on or off in a circuit, and how electrical devices can be connected in a circuit
- Describe the characteristics of a series and parallel circuit
- Explain how magnetic poles affect each other
- Describe the magnetic field in the space around a magnet
- Describe how a magnetic field exerts a force on a charged particle in the field
- Describe how current is affected by a magnetic field
- Create a motor

Learning Design

Physics A
Magnetism

Missouri Grade-Level Expectations (or other standards)
NGSS: HS-PS2-5: 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.

Learning Goal	Proficiency Scales
Students will be able to analyze the interaction of magnets and magnetic fields.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Determining the force experienced by a charged particle in a magnetic field. ● Understanding the force exerted on a current-carrying wire in a magnetic field. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as *domains, poles, magnetic field, magnetic force, attraction, repulsion, electrons, protons, right-hand rule.* ● Performing processes such as: ○ Demonstrating the essential relationship between electric current and magnetic fields. ○ Representing magnetic fields using field lines.

	○ Demonstrating that an electric current can produce an electric field and a changing magnetic field can produce an electric current. 1: Student demonstrates a limited understanding or skill with the learning goal.

Learning Targets
○ calculate the size and direction of the force in terms of q, v, and, B, and explain why the magnetic force can perform no work; ○ calculate the size and direction of a magnetic field from information about the forces experienced by charged particles moving through that field; and ○ describe the paths of charged particles moving in uniform magnetic fields. ○ calculate the magnitude and direction of the field at a point in the vicinity of such a wire; ○ use superposition to determine the magnetic field produced by two long wires; and ○ calculate the force of attraction or repulsion between two long current-carrying wires.
Learning Design

Waves

Missouri Grade-Level Expectations (or other standards)

NGSS-HS-PS:

4-1:Use mathematical representations to support a claim regarding relationships among the frequency, wavelength,and speed of waves traveling in various media.

4-2: Evaluate questions about the advantages of using a digital transmission and storage of information.

4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

4-4:Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

4-5: 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.*

Learning Goal	Proficiency Scales
Students will be able to deduce the function and purpose of a wave based on its physical characteristics and behavior.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Modeling the physical characteristics of a traveling wave. ● Describing the behavioral characteristics of a traveling wave. ● Describing the conditions under which the waves reaching an observation point from two or more sources will all interfere. ● Relating the amplitude produced by two or more sources that interfere to the amplitude produced by a single source. 2: Student demonstrates he/she is nearing proficiency by:

	• Recognizing and recalling specific vocabulary, such as: *reflection, refraction, diffraction, interference, frequency, period, velocity, Doppler shift, and amplitude.*
	
	• Performing processes such as:
	    • Labeling and define all parts of a wave.
	    • Describing the order of EM spectrum.
	    • Summarizing various types of interference.
	    • Describing the interaction of waves in terms of reflection, refraction and diffraction of a wave at a boundary between two media.
	
	1: Student demonstrates a limited understanding or skill with the learning goal.

Learning Targets

- Describing the characteristics and properties of waves
- Describing how to calculate the speed of a wave
- Distinguishing between the two types of waves
- Discriminating between sound waves and electromagnetic waves
- Explaining the Doppler Effect
- Manipulating the electromagnetic spectrum based on frequency and wavelength
- Investigating waves as a means of digital storage and transmission and contrast with other means
- Identifying graphs that represent traveling waves and determine the amplitude, wavelength, and frequency of a wave from such a graph;
- Applying the relationship ($v=f\lambda$) among velocity, frequency, and wavelength for a traveling wave; and
- Describing qualitatively what factors determine the speed of waves through space in both longitudinal and transverse types.
- Understanding qualitatively the Doppler effect for waves in order to explain why there is a frequency shift in both the moving-

source and moving-observer case; and
Learning Design

Conceptual-Space Systems

DRAFT

Missouri Grade-Level Expectations (or other standards)
NGSS: 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. **NGSS: HS-ESS1-4:** Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

Learning Goal	Proficiency Scales
Students will be able to prove relational properties of objects in our solar system.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Demonstrating an understanding of Newton's Law of Universal

	Gravitation. ● Explaining the motion of an object in orbit under the influence of gravitational forces. ● Using mathematical representations (Kepler and Newtonian) to predict motion of orbiting objects. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as: *orbit, field, centripetal, force, acceleration, radius, circumference, Kepler, Newtonian, and period* ● Performing processes such as: ○ describing the motion and causes of orbiting objects without using mathematical representations. 1: Student demonstrates a limited understanding or skill with the learning goal.

Learning Targets

- Applying Kepler's Laws and Newton's Universal Law of Gravitation to planetary motion
- determining the gravitational force that one spherically symmetrical mass exerts on another; and
- determining the strength of the gravitational field at a specified point outside a spherically symmetrical mass.
- recognizing that the motion does not depend on the object's mass; describe qualitatively how the velocity, period of revolution, and centripetal acceleration depend upon the radius of the orbit; and derive expressions for the velocity and period of revolution in such an orbit; and
- deriving and applying the relations among kinetic energy, potential energy, and total energy for such an orbit.

Learning Design

Kinematics

Missouri Grade-Level Expectations (or other standards)

NGSS: HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object its mass, and its acceleration.

Learning Goal	Proficiency Scales
Students will be able to model motion of an object as it relates to its position, velocity, and acceleration.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Describing the relationships among position, velocity and acceleration. ● Analyzing displacement, velocity and acceleration vectors. ● Understanding the motion in a uniform gravitational field. 2: Student demonstrates he/she is nearing proficiency in the learning goal by: ● Recognizing or recalling specific vocabulary, such as *displacement, velocity, acceleration, vector, components, resultant, frame of reference.*

	- Performing processes such as: - Producing and extrapolating data from graphs of position vs. time and velocity vs. time. - Illustrating an understanding of motion with reference to kinematic equations. - Understanding the motion in a uniform gravitational field for projectiles launched horizontally as well as at angles regarding the horizontal and vertical components of position, velocity and acceleration. 1: Student demonstrates a limited understanding or skill with the learning goal.

Learning Targets

- Calculate displacement, velocity and acceleration of objects moving in one and two dimensions
    - graphically represent a moving object's position, velocity and acceleration as functions of time, and identify or sketch graphs of these motions;
    - use the kinematic equations to solve problems involving motion with constant velocity and constant acceleration; and
    - describe in words the motion, and subsequent changes in motion, for objects moving with a constant velocity or with constant acceleration.
    - add and subtract displacement, velocity and acceleration vectors in one and two dimensions to find the resultant vector; and
    - determine the components of a given displacement, velocity and acceleration vector along a specified, mutually perpendicular axes.
    - write down expressions for the horizontal and vertical components of position, velocity and acceleration as functions of time, and sketch or identify graphs of these components; and

○ use kinematic equations in analyzing the motion of a projectile that is projected with an arbitrary initial velocity.
Learning Design

Work, Energy, Power

Missouri Grade-Level Expectations (or other standards)
NGSS: HS-PS3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. **NGSS: HS-PS3-2:** Develop and use ;models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.

Learning Goal	Proficiency Scales
Students will be able to relate an object's energy to the amount of work performed on	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal.

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<td>or by the object.</td>
<td>3: Students demonstrate mastery with the learning goal as evidenced by:

Calculating the work performed by a specified constant force on an object that undergoes a specified displacement and relate the amount of work to energy transferred;
Determining the amount of mechanical energy transferred during work, when non-conservative forces are absent (The Principle of Conservation of Mechanical Energy).
Calculating the potential and kinetic forms of mechanical energy that an object has by virtue of its mass, speed and position; and
Calculate the power required to maintain the motion of an object.
Calculating the work performed by a force.
Applying the Law of Conservation of Energy to situations where change is occurring.

2: Student demonstrates he/she is nearing proficiency as evidenced by:

Recognizing or recalling specific vocabulary, such as: conservation, potential, kinetic, height, mechanical, nonmechanical, gravitational, efficiency, work, heat, sound, friction, static, and power.
Performing basic processes, such as:

Listing and partially describing sources and transfers of energy.
Describing LOCOE with teacher supplying terms.
Planning and building a device that demonstrates some energy transfer with some success.

1: Student demonstrates a limited understanding or skill with the learning goal.</td>
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Learning Targets

- Define and describe work
- Define and describe energy
- Define and describe power
- State the two forms of mechanical energy and explain how energy is changed in a closed system
- State three forms of potential energy
- Describe how work and potential and kinetic energy are related verbally and mathematically
- State the law of conservation of energy and describe the transfer of energy in a system
- Build model that demonstrates energy transfer

Learning Design

Electrostatics

Missouri Grade-Level Expectations (or other standards)

NGSS: 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.
NGSS: HS-PS2-5: 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.
NGSS: 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.

Learning Goal	Proficiency Scales
Students will be able to analyze the electrostatic interaction of electrical charges through electrical fields.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Students demonstrates mastery with the learning goal as evidenced by: ● Describing the types of charge and the attraction and repulsion of charges. ● Using Coulomb's law to calculate the size and direction of the electrical force on a positive or negative charge due to other specified point charges. ● Analyzing the motion of a specified charge and mass under the influence of an electrostatic force. ● Modeling the concept of an electric field. ● Modeling the concept of electric potential. 2: Student demonstrates he/she is nearing proficiency by: ● Recognizing or recalling specific vocabulary, such as *electric charge, electric force , Coulomb's Law, attraction, repulsion, electrons, protons, neutrons, electric potential, electric potential energy, potential difference, voltage.* ● Performing processes such as: ○ Explaining the essentials of the effects of the inverse square law on two charged particles. ○ Demonstrating the essential relationship between electric

	charge, electric field strength and electrostatic forces. ○ Representing electric fields using field lines. 1: Student demonstrates a limited understanding or skill with the learning goal.

Learning Targets

- Describe the fundamental rule at the base of all electrical phenomena
- Explain how an object becomes electrically charged
- Use Coulomb's law to understand the relationship among force, charge and distance
- Describe two ways electric charges can be transferred
- Describe what happens when a charged object is placed near a conducting surface
- Describe how to measure the strength of an electric field at different points
- Illustrate electric fields with vectors and by electric field lines
- define it in terms of the force on a test charge;
- describe and calculate the electric field of a single point charge;
- calculate the size and direction of the electric field produced by two or more point charges;
- calculate the size and direction of the force on a positive or negative charge placed in a specified field;
- interpret an electric field diagram; and
- analyze the motion of a specified charge and mass in a uniform electric field.
- understanding the concept of electric potential, so that they can
- determine the electric potential (in volts) in the vicinity of one or more electric charges;
- calculate the electrical work done on a charge or use conservation of energy to determine the speed of a charge that moves through a specified potential difference;
- determine the direction and approximate magnitude of the electric field at various positions given a sketch of equipotentials;
- calculate the potential difference between two points in a uniform electric field, and state which point is at the higher potential;
- calculate how much work is required to move a test charge from one location to another in the field of fixed point charges; and

- calculate the electrostatic potential energy of a system of two or more point charges, and calculate how much work is required to establish the charge system.

Learning Design

Dynamics

Missouri Grade-Level Expectations (or other standards)

NGSS: HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object its mass, and its acceleration.
NGSS: 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.

Learning Goal	Proficiency Scales
Students will be able to relate	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal.

acceleration to mass, velocity, and the forces that affect motion.	3: Student demonstrates mastery of the learning goal as evidenced by: ● Analyzing situations in which an object remains at rest or moves with a constant velocity and momentum (p=mv). ● Describing the relationship between the net force that acts on an object and the resulting change in the object's velocity and momentum. ● Identifying the action and reaction pairs of forces (impulses) on objects that are interacting. 2: Student demonstrates he/she is nearing proficiency in the learning goal by: ● Recognizing or recalling specific vocabulary, such as: *inertia, mass, force, net force, acceleration, momentum, equilibrium, conservation, momentum, impulse, change in momentum, free-body diagram, Newton's Laws of Motion.* ● Performing processes such as: ○ Constructing free-body diagrams. ○ Exhibiting an understanding of Newton's Three Laws of Motion. ○ Calculating the impulse applied to an object as it relates to the change in momentum. ○ Conceptualizing and categorizing collisions including conservation of momentum but are unsuccessful at analyzing the success or failure of the model. 1: Student demonstrates limited understanding or skill with the learning goal.

Learning Targets

- Calculate momentum of objects in motion (p=mv)
- Calculate the Impulse acting on objects while an object is undergoing a change in momentum (J=
- Describe the relationship between mass and inertia
- State the relationship between acceleration and net force and mass in terms of Newton's 2nd law
- List the factors that affect the movement of an object, such as friction and air resistance
- Analyze the role of mass and force along with velocity in momentum through collisions
- Explain why an impulse is greater when an object bounces than when the same object comes to a sudden stop
- Describe and calculate how the conservation of momentum applies to collisions
- draw a well-labeled, free-body diagram showing all forces that act on the object;
- determine a state of equilibrium as the absence of a net force or impulse;
- describe state of motion in terms of constant momentum and zero acceleration; and
- apply Newton's 1st Law of Motion (Law of Inertia).
- draw a well-labeled, free-body diagram showing an imbalance of forces that act on the object;
- understand how Newton's Second Law of motion($\Sigma F = ma$) applies to an object subject to forces such as gravity, the pull of strings, or contact forces;
- calculate the acceleration and the change in momentum that results when a constant net force acts over a specified time interval resulting from a impulse;
- determine the size and direction of the net force, or of one of the forces that makes up the net force, from kinematic measurements of an object in motion; and
- apply Newton's 2nd Law of Motion (Law of Force).
- explain the resulting changes in velocity and momentum of the objects interacting or involved in collisions;
- calculate the acceleration and momentum change of objects interacting or involved in collisions;
- apply linear momentum conservation to one-dimensional elastic, inelastic and perfectly inelastic collisions; and
- apply Newton's Third Law of Motion.

Learning Design

Current Electricity

Missouri Grade-Level Expectations (or other standards)

NGSS: Science and Engineering Practices: Analyze data using tools, technologies, and/or models (eg.computational, mathematical) in order to make valid and reliable scientific claims or create an optimal design decision.

Learning Goal	Proficiency Scales
The student will be able to analyze the movement of electrical charges and the resulting energy transferred by the current.	4: Student demonstrates an in-depth inference or advanced application or innovates with the learning goal. 3: Student demonstrates mastery with the learning goal as evidenced by: ● Predicting the rate and flow of positive and negative charges when given the size and direction of the electric current. ● Relating electric current and voltage for a resistor. ● Describing how the resistance of a resistor depends upon its length and cross-sectional area and applying this result in comparing current flow in resistors of different material or different geometry. ● Deriving expressions that relate the electric current, voltage, and resistance to the rate at which heat is produced when current passes through a resistor.

- Determining the ratio of the voltages across resistors connected in series or the ratio of the currents through resistors connected in parallel.
- Calculating the voltage, current, and power dissipation for any resistor with a single power supply.
- Showing correct methods of connecting voltmeters and ammeters into circuits.

2: Student demonstrates he/she is nearing proficiency by:

- Recognizing or recalling specific vocabulary, such as *electric current, electric resistance, electric power, voltage difference, amp, volt, ohm, Ohm's Law, circuit, series, parallel, watts.*

- Performing processes such as:

    - Building electrical circuits where the resistors are attached to a power source in both series and parallel configurations.
    - Measuring the voltage drops and electrical current using meters placed in an electrical circuit.
    - Calculating the electrical power used in running various resistors connected in both series and parallel configurations.
    - Applying Ohm's law.
    - Identifying on a circuit diagram whether resistors are in series or in parallel.

1: Student demonstrates a limited understanding or skill with the learning goal.

Learning Targets

- Describe the flow of electric charge in a current-carrying wire
- Give examples of voltage sources
- Analyze the relationship among the factors that affect the resistance of a wire
- Describe Ohm’s law
- Distinguish between DC and AC and how AC is converted to DC
- Explain how current can be turned on or off in a circuit, and how electrical devices can be connected in a circuit
- Describe the characteristics of a series and parallel circuit

Learning Design