FORSYTH PUBLIC SCHOOLS

SCIENCE CURRICULUM

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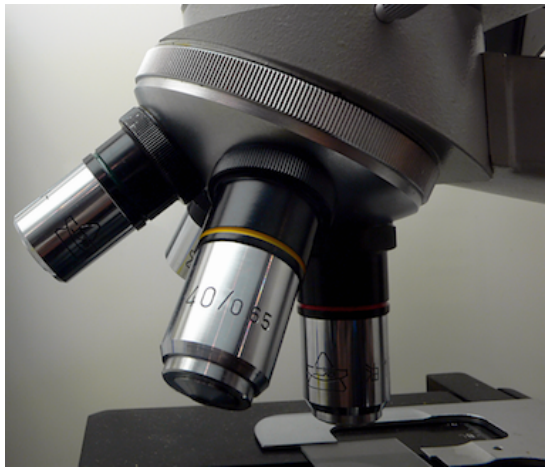

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Aligned to Montana State Science Standards
National Next Generation Science Standards

Adopted July 2017

Science
Kindergarten

STRAND	**Physical Science**
STANDARDS	**GOALS and PERFORMANCE OBJECTIVES**
K.PS.A	**Students will 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.** 1. Demonstrate pushes and pulls can have different strengths and directions 2. Demonstrate pushing or pulling on an object can change the speed or direction of its motion and can start or stop it 3. Understand when objects touch or collide, they push on one another and can change motion
K.PS.B	**Students will analyze data to determine whether a design solution works as intended to change speed or direction of an object with a push or a pull.** 1. Demonstrate a bigger push or pull makes things speed up or slow down more quickly
K.PS.C	**Students will construct an explanation based on observations of the effect of sunlight on earth's surface** 1. Demonstrate knowledge that sunlight warms the Earth's surface (i.e. sand, soil, rocks and water)
K.PS.D	**Students will use tools and materials to design and build a structure to reduce the warming effects of sunlight on an area.** 1. Demonstrate how to build or use structures to reduce the effects of the sun (i.e. umbrellas, canopies or tents)
STRAND	**Life Science**
STANDARDS	**GOALS and PERFORMANCE OBJECTIVES**
K.LS.A	**Students will use observations to describe patterns of what plants and animals, including humans, need to survive**

1. Learn that all animals need food, air and water
2. Understand that animals obtain their food from plants or from other animals
3. Learn plants need water and light to live and grow

STRAND **Earth and Space Science**

STANDARDS	**GOALS and PERFORMANCE OBJECTIVES**
K.ESS.A	**Students will construct an argument supported by evidence for how plants and animals, including humans, can change the environment to meet their needs.** 1. Understand plants and animals can change their environment (i.e. squirrels dig in the ground to hide their food and tree roots can break concrete) 2. Understand humans can change their environment (people can make choices that reduce their impacts on the land, water, air, and other living things)
K.ESS.B	**Students will use a model to represent the relationship between the needs of different plants or animals, including humans, and the places they live** 1. Know that living things need water, air and resources from the land, and they live in places that have the things they need 2. Know people use natural resources for everything they do
K.ESS.C	**Students will communicate ideas about the impact of humans on the land, water, air or other living things in the local environment.** 1. Know people make choices that impact the land, water, air and other living things (i.e. recycling, reusing, reducing waste and not polluting our land, water or air are choices) 2. Communicate solutions that will reduce the impact of humans on the land, water, air and other living things in local environment
K.ESS.D	**Students will use and share observations of local weather conditions to describe patterns over time.** 1. Describe the weather conditions 2. Observe weather to gather quantitative data to determine a pattern 3. Observe and describe the weather associated with the seasons and months
K.ESS.E	**Students will ask questions to obtain information about the purpose of weather forecasting to predict, prepare for, and respond to weather.** 1. Know that weather scientists forecast severe weather so that the communities can prepare for and respond to these events.

2. Describe severe weather associated with the local area

Science

1st Grade

STRAND	PHYSICAL SCIENCE
STANDARDS	**GOALS and PERFORMANCE OBJECTIVES**
1-PS-A	**Students will plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.** 1. Demonstrate sound can make matter vibrate. 2. Explain vibrating matter can make sound
1-PS-B	**Students will make observations to construct an evidence-based explanation that objects can be seen only when illuminated.** 1. Identify that light makes it possible to see objects. 2. Recognize that objects that give off light can be used to help us see
1-PS-C	**Students will plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a light beam.** 1. Recognize that objects can be seen only when there is light. 2. Define that a clear object will allow light through 3. Describe materials that allow only light to pass through them 4. Describe materials that block all light 5. Describe how some materials a beam of light
1-PS-D	**Students will design a solution or build a device that facilitates communication over distance using light or sound.** 1. Describe how people communicate in many different ways 2. Identify devices that enable communication over long distance 3. Observe and record evidence that information can be communicated using various devices 4. Design and build a device that uses light or sound that solves the problem of communicating over a distance

5. Test and revise a device based on results and feedback

STRAND LIFE SCIENCE

STANDARDS GOALS and PERFORMANCE OBJECTIVES

1-LS-A **Students will use materials to design a solution to a human problem by mimicking plant and animal structures and functions that help them survive, grow, and meet their needs.**

1. Learn animals are living things
2. Explain how plants and different animals use their body parts to survive and grow
3. Explain that animals use their body parts in different ways to see and hear to protect themselves and survive
4. Identify and describe parts and functions of a plant
5. Explain how animals use their body parts to move from place to place
6. Understand how an animal uses its senses to understand the environment around them needed for growth and survival

1-LS-B **Students use information from print and other media to identify patterns in behavior of parents and offspring that help offspring survive.**

1. Identify that adult plants/animals can make new/young plants/animals
2. Describe the life cycle of a plant
3. Identify that plants/animals of the same variety are similar and also different
4. Observe plants/animals of the same variety are similar and also different
5. Describe how some animals engage in behaviors that help offspring survive

1-LS-C **Students will make an evidence-based explanation of how young plants and animals are like, but not exactly like, their parents.**

1. Explain young animals are very much, but not exactly, like their parents.
2. Explain plants are very much, but not exactly, like their parents.
3. Understand individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.

STRAND	EARTH AND SPACE SCIENCE
STANDARDS	**GOALS and PERFORMANCE OBJECTIVES**
1-ESS-A	**Students will use observations of the sun, moon, and stars to describe patterns that can be predicted.** 1. Describe how day and night make a pattern 2. Explain the pattern of the sun's motion in the sky 3. Predict the future pattern of the moon and sun in the sky 4. Describe when the moon is visible 5. Describe the pattern of the moon's motion in the sky 6. Describe and explain why and when you can see stars
1-ESS-B	**Students will make observations at different times of the year to relate the amount of daylight to the time of year.** 1. Describe the pattern of the seasons 2. Conclude that each season happens once a year 3. Explain how daylight changes with the seasons 4. Predict how sunrise and sunset will change from one day to the next

Science
2nd Grade

STRAND	Physical Science
STANDARDS	GOALS and PERFORMANCE OBJECTIVES

2-PS-A **Students will plan and conduct an investigation to describe and classify various materials by their observable properties.**

1. Observe the different color, texture, hardness, and flexibility of rocks
2. Determine similar properties that different rocks, shells and soil share
3. Identify objects and matters as a solid, liquid and gas
4. Recognize that matter exists in three states

2-PS-B **Students will conduct an investigation and analyze data to determine which materials have the properties best suited for an intended purpose**

1. Investigate the properties of strength, flexibility, hardness, texture, and absorbency of materials
2. Predict that the rock will break apart or wear away when it is shaken in water
3. Observe slow changes to earth materials caused by processes such as weathering by water
4. Predict and infer how weathering changes rocks
5. Describe what happens to sandstone when it is shaken in a jar with water
6. Conduct an experiment where a seed is planted in three different types of soil and observe effects (clay, sandy and humus soil)

2-PS-C **Students will make observations to construct an evidence-based claim of how an object made of a small set of pieces can be disassembled and made into a new object.**

1. Describe how a variety of objects can be built up from a small set of pieces
2. Observe and conclude that objects may break into smaller pieces and be put together into larger pieces or change shape

2-PS-D **Students will construct an argument with evidence that some changes caused by heating and cooling can be reversed and some cannot.**

1. Describe how liquid can change into a solid or gas
2. Describe how heat can change solids; melt or misshape
3. Describe how ice changes when it is heated
4. Explain how freezing and melting can happen over and over
5. Investigate reversible changes such as heating and cooling water or butter
6. Investigate irreversible changes such as cooking an egg, freezing a plant or heating paper.

STRAND **Life Science**

STANDARDS **GOALS and PERFORMANCE OBJECTIVES**

2-LS-A **Students will plan and conduct a cause and effect investigation to determine whether plants need sunlight and water to grow.**

1. Describe the way all plants grow and change and die as part of their life cycle
2. Identify what plants need to live and grow
3. Conduct an investigation comparing where plants grow (windowsill, yard, garden)
4. Identify what plants depend on to live and grow (water and light)
5. Explain how plants grow inside where it does not rain

2-LS-B **Students will develop a simple model that mimics the structure and function of an animal in dispersing seeds or pollinating plants.**

1. Learn plants depend on animals for pollination or to move their seeds around
2. Explain why pollination is important to plants
3. Develop through sketches, drawings or models how animals pollinate and move seeds around

2-LS-C **Students will make observations of plants and animals to compare the diversity of life in different habitats.**

1. Discover there are many different kinds of living things in any area
2. Discover living things exist in different places on land and in water
3. Observe the changes from caterpillar, pupa to butterfly
4. List things that plants need to live and grow
5. Observe and describe different stages in the life cycle of plants
6. Define and observe the life span of plants
7. Explain how seeds travel

STRAND **Earth and Space Science**

STANDARDS **GOALS and PERFORMANCE OBJECTIVES**

2-ESS-A **Students will use information from several sources to provide evidence that earth events can occur quickly or slowly.**

1. Explain what happens during earthquakes, hurricanes, volcanoes and tsunamis
2. Explain how wind and water can change the shape of the land
3. Describe how wind, water and ice can change rocks and other earth materials
4. Explain the process of weathering
5. Explain why weathering needs to occur before erosion
6. Predict and infer how weathering changes rocks
7. Discover that events such as volcanic explosions and earthquakes cause quick earth changes
8. Discover that events such as wind and water erosion cause slow earth changes

2-ESS-B **Students will construct explanations to compare multiple physical and naturally built designs which impact wind and water's effect on the shape of the land.**

1. Learn wind and water can change the shape of the land
2. Provide ways in which we can slow or prevent wind or water from changing the shape of the land
3. Construct solutions such as dikes and windbreaks to hold back wind and water such as a levy or windbreak

2-ESS-C **Students will develop a model to represent the shapes and kinds of land and bodies of water in an area.**

1. Compare streams and rivers
2. Explain how rivers form and connect to the ocean
3. Explain that water is found in lakes and ponds
4. Describe how lakes and ponds form
5. Develop a model to show the shapes and kinds of land and water in any area.

2-ESS-D **Students will obtain information to identify where water is found on Earth and that water can be solid, liquid or gas.**

1. Understand water can be found in the ocean, rivers, lakes and ponds
2. Learn that water exists as solid ice and in liquid form
3. Explain where Earth's water can be found as ice
4. Explain how a glacier may get smaller
5. Describe two forms of water on Earth
6. Explain 2 places on Earth that are frozen all year

Science
3rd Grade

STRAND **Physical Science**

STANDARD	**GOALS and PERFORMANCE OBJECTIVES**
3.PS.A	**Students will plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.** 1. Investigate and prove why an unbalanced force on one side of a ball can start it moving 2. Investigate and prove balanced forces pushing on a box do not produce any motion at all
3.PS.B	**Students will observe and record qualitative and quantitative data about an object's motion to provide evidence that a pattern can be used to predict future motion** 1. Make predictions using patterns of change 2. Make observations and/or measurements to produce data to serve as the basis of evidence for an explanation of a phenomenon 3. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. Examples of motion with a predictable pattern include: a child swinging in a swing, a ball rolling back and forth in a bowl, two children on a seesaw.
3.PS.C	**Students will ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.** 1. Find a relationship between electrically charged balloon and hair. 2. Find a relationship between two permanent magnets 3. Find a relationship between an electromagnet and steel paperclips 4. Find a relationship between the force of one magnet and the force exerted by two magnets. 5. Find the relationship between the distance between objects and strength of the force. 6. Find the relationship between the orientation of the magnet and the direction of the force.

3.PS.D **Students will define a simple design problem that can be solved by applying scientific ideas about magnets.**

1. Create a device to keep two moving objects from touching each other
2. Define a simple problem that can be solved through the development of a new or improved object or tool
3. Define a simple design problem that can be solved by applying scientific ideas about magnets
4. Define a simple design problem that can be solved through the development of an object, tool, process, or system, and include several criteria for success and constraints on material, time or cost
5. Define a simple design problem reflecting a need or a want that includes specific criteria for success and constraints on materials, time or cost

STRAND Life Science

STANDARD GOALS and PERFORMANCE OBJECTIVES

3.LS.A **Students will 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.**

1. Determine the needs and characteristics of the organisms and habitats involved.
2. Determine that the organisms and their habitat make up a system in which the parts depend on each other.

3.LS.B **Students will make a claim about the effectiveness of a solution to a problem caused when the environment changes and that the types of plants and animals that live there may change.**

1. Describe a system in terms of its components and interactions
2. 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 a problem
3. 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 (i.e. land characteristics, water distribution, temperature, food, other organisms)
4. Explain what plants or animals might do if their environment changes (i.e. changing food supply or habitat due to fire, human impact, and sudden weather-related changes)
5. Describe how seasonal changes can affect a food chain

3.LS.C **Students will construct a cause and effect argument communicating some animals, including humans, form groups and communities that help members survive.**

1. Learn being a part of a group helps animals and humans obtain food, defend themselves and cope with changes.
2. Demonstrate how groups may serve different functions and vary dramatically in size.

3.LS.D **Students will analyze and interpret data from fossils to provide evidence of the organisms and the environment in which they lived long ago.**

1. Learn some kinds of plants and animals that once lived on Earth are no longer found anywhere
2. Learn fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environment
3. Analyze data, which could include type, size, and distributions of fossil organisms. Analyze fossils and environments which could include marine fossils found on dry land, tropical plants found in Artic areas, fossils of extinct organisms, etc.

3.LS.E **Students will develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.**

4. Create a model to show changes organisms go through during their life.
5. Create a model to show plant life cycles (limited to those of flowering plants)
6. Learn changes organisms go through during their life form a pattern

3.LS.F **Students will analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variations of these traits exist in a group of similar organisms.**

1. Learn many characteristics of organisms are inherited from their parents
2. Understand different organisms vary in how they look and function because they have different inherited information
3. Show that patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings.

3.LS.G **Student will use evidence to support the explanation that traits can be influenced by the environment.**

1. Learn other characteristics result from individuals' interactions with the environment, which can range from diet to learning (a pet dog given too much food and not enough exercise will become overweight)

2. Learn the environment also affects the traits that an organism develops (normally tall plants grown with insufficient water are stunted)

3.LS.H **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.**

1. Learn sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates and reproducing.
2. Understand the cause and effect relationship between various characteristics and advantages in surviving, finding mates and reproducing. (i.e. plants that have larger thorns than other plants are less likely to be eater by predators; or animals that have better camouflage coloration than other animals may be more likely to survive and more likely to leave offspring).

STRAND Earth Science

STANDARD GOALS and PERFORMANCE OBJECTIVES

3.ESS.A **Students will obtain and represent data using tables and graphical displays to describe observed and predicted weather conditions during a particular season.**

1. Make predictions using patterns of change
2. Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationships
3. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season (i.e. average temperature, precipitation, wind direction)

3.ESS.B **Students will obtain and combine information to describe climate patterns in different regions of the world.**

1. Learn climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years.
2. Explore and describe the climate from a specific region of the world

3.ESS.C **Students will make a claim based on information about the merit of a design solution that reduces the impacts of a weather-related hazard.**

1. Learn a variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.
2. Demonstrate a design solution to a weather-related hazard such as barriers to prevent flooding, wind resistant roofs, and lightning rods.

SCIENCE
4TH GRADE

STRAND **Physical Science**

STANDARDS **GOALS and PERFORMANCE OBJECTIVES**

4-PS-A **Students will use evidence to describe the relationship between the speed of an object and the energy of that object.**

1. Explain that energy can move in different ways
2. Explain that the speed of an object depends on the time it takes the object to move a certain distance
3. Explain that slower moving objects have less energy than faster moving objects

4-PS-B **Students will make observations to provide evidence of transferred of energy from place to place by sound, light, heat and electric currents.**

1. Understand that energy is conserved in the universe
2. Observe and describe basic forms of energy, including sound, light, heat and electrical
3. Describe motion as the result of energy being used
4. Define energy as the source of motion or change
5. Identify and describe heat as the flow of energy from a warmer object to a cooler object
6. Describe that heat flows between objects until they are both the same temperature
7. Describe heat as energy produced when substances burn or certain kinds of materials rub against each other
8. Identify and describe light as a form of energy
9. Explain that energy can change from one form to another
10. Understand that energy exist in various forms, including sound
11. Recognize that vibrating objects make sound, and sound can make things vibrate
12. Understand that electric circuits may produce or use light, heat, sound, motion and magnetic energy
13. Explain how electrical energy is transferred and changed through the use of a simple circuit

4-PS-C **Students will ask questions and predict outcomes about the changes in energy that occur when objects collide.**

1. Understand that the faster an object moves, the more energy it possesses
2. Explore ways in which energy can be transferred
3. Investigate the relationship between speed and energy
4. Observe objects colliding and be able to ask questions that lead to further investigation (i.e. changes in direction of motion, speed, type of energy and type of motion
5. Recognize their investigations will help them understand that energy: can be transferred in various ways and between objects, is present whenever there are moving objects and can be transferred from place to place by moving objects
6. Recognize when objects collide, some energy may be changed or transferred into other types of energy
7. Recognize that motion can be changed in response to magnetic fields
8. Recognize that friction is a force that slows motion when objects are touching

4-PS-D **Students will apply scientific ideas to design, test, and refine a device that converts energy from one form to another.**

1. Understand that electric currents may have been produced to begin with by transforming the energy of motion into electrical energy.
2. Understand the expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use.

4-PS-E **Students will develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move**

1. Learn 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.
2. Understand waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks)

4-PS-F **Students will develop a model communicating that light reflected from objects into the eye allows objects to be seen.**

1. Demonstrate an object can be seen when light reflected from its surface enters the eyes.
2. Develop a model that gives a conceptual understanding of the role that light plays in allowing us to see objects
3. Differentiate between reflect and refract
4. Determine what kinds of objects light can pass through

4-PS-G **Students will generate and compare multiple solutions that use patterns to transfer information**

1. Sort and classify natural phenomena using similarities and differences in patterns
2. Develop a model using an analogy, example or abstract representation to describe a scientific principle
3. Develop a model of waves to describe patterns in terms of amplitude and wavelength, and that waves can cause objects to move
4. Understand relevant scientific concepts and research findings is important in engineering
5. Recognize that engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands
6. Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution
7. Generate and compare multiple possible solutions to a problem based on how will each is likely to meet the criteria and constraints of the problem

STRAND Life Science

STANDARD GOALS and PERFORMANCE OBJECTIVES

4-LS-A **Students will construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.**

1. Describe the internal and external structures of a plant and animal and the function of each of those structures
2. Explain how each structure serves various functions in growth, survival, behavior, and/or reproduction
3. Describe the interactions that occur among the structures within the plant or animal system
4. Use evidence from observations of the structures of an animal or plant, to explain the function of each, and how their structures help the animal grow and survive

4-LS-B **Students will 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.**

1. Learn how a model is used to explain that animals receive information through their senses
2. Learn how a model is used to explain that sensory information is processed in the brain
3. Explain that an animal responds to sensory information in different ways
4. Understand animals are able to use their perceptions and memories to guide their actions

STRAND EARTH and SPACE SCIENCE

STANDARD GOALS and PERFORMANCE OBJECTIVES

4-ESS-A **Students will obtain and combine information from a variety of sources to communicate that energy and fuels are derived from natural resources and their uses affect the environment.**

1. Understand that energy and fuels that humans use are derived from natural sources
2. Understand that the use of energy and fuels from natural sources affects the environment in multiple ways
3. Understand that some resources are renewable over time and others are not
4. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment

4-ESS-B **Students will identify evidence from patterns in rock formation and fossils in rock layers to support an explanation for changes in a landscape over time.**

1. Understand that cause-and-effect relationships are routinely identified, tested and used to explain change
2. Understand that water, ice, wind, living organisms and gravity break rocks, soil and sediments into smaller particles and move them around
3. Understand rainfall helps to shape the land and affects the types of living things found in a region
4. Understand that living things affect the physical characteristics of their regions
5. Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time

4-ESS-C **Students will make observations or measurements to provide evidence of the effects of the weathering or the rate of erosion by water, ice wind, or vegetation**

1. Make observations and/or measurements to produce evidence of phenomenon, such as the effects of weathering or the rate of erosion by water, ice, wind or vegetation. Examples of variable to test could include: angle of slope in the downhill movement of water, amount of vegetation, speed of the wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling and volume of water flow
2. Understand that local, regional and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes
3. Understand the presence and location of certain fossil types indicate the order in which rock layers were formed

4-ESS-D **Students will analyze and interpret data from maps as evidence to make a claim about patterns of Earth's features.**

1. Learn the locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes and volcanoes occur in patterns.
2. Learn most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans.
3. Learn major mountain chains form inside continents or near their edges.
4. Learn maps can help locate different land and water features areas of Earth.
5. Analyze and interpret data from maps to describe patterns of Earth's features. Maps can include topographic maps of Earth's land and ocean floor and locations of mountains, continental boundaries, volcanoes and earthquakes

4-ESS-E **Students will generate and compare multiple solutions to reduce the impacts of natural earth processes on humans.**

1. Learn a variety of hazards result from natural processes (e.g. earthquakes, tsunamis, volcanic eruptions).
2. Understand humans cannot eliminate the hazards but can take steps to reduce their impacts.
3. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans (i.e. design an earthquake resistant building, improve monitoring of volcanic activity)
4. Generate multiple possible solutions to a problem and compare them based on how well each is likely to meet the criteria and constraints of the problem
5. 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
6. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved

SCIENCE
5th GRADE

STRAND **Physical Science**

STANDARDS **GOALS and PERFORMANCE OBJECTIVES**

5-PS-A **Students will develop a model to communicate that matter is made of particles too small to be seen.**

1. Explain that matter is the "stuff" that makes up all objects and substances in the Universe
2. Explain that mass is the amount of matter in an object
3. Explain volume as the amount of space that an object takes up
4. Describe gasses as having no definite shape and no definite volume
5. Classify that substances exist in three states: solid, liquid, gas
6. Describe solids as having a definite shape and definite volume
7. Describe liquids as having a definite volume, but no shape of its own
8. Understand that a model is a simplified representation to understand a concept: world maps, mobile for the solar system, sculpture
9. Demonstrate that matter exists even if it cannot be seen

5-PS-B **Students will measure and graph quantities to provided evidence that the total mass of matter is conserved regardless of the type of change that occurs when heating, cooling or mixing.**

1. Understand that matter is not gained or lost with any change; particles are rearranged
2. Understand that conserve means to keep the same
3. Understand phase changes: melting, boiling, condensing, freezing
4. Understand that rearranging particles has no effect on the total weight of particles
    a. Heating-spreads particles out, but weighs the same
    b. Cooling-brings particles together, but weighs the same
    c. Mixing-rearranges particles, but weighs the same
5. Model changes (i.e. dissolve salt in water, melt ice cubes, baking soda and vinegar)
6. Measure, record, graph the weight of substance before and after changes

5-PS-C **Students will observe and record qualitative and quantitative evidence to support identification of materials based on their properties.**

1. Learn measurements of a variety of properties can be used to identify materials
2. Identify properties such as color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility

5-PS-D **Students will conduct an investigation that produces quantitative and qualitative data to analyze whether the mixing of two or more substances results in new substances.**

1. Define a mixture as a combination of two or more substances together in the same place that are not chemically combined (i.e. sand at the beach, salt and pepper)
2. Understand that a substance is a physical material
3. Recognize that a new substance has new properties
4. Distinguish between physical and chemical changes
5. Recognize the signs of chemical change: color change, temperature change, produces a gas
6. Understand that sometimes when mixing two substances together a new substance is created and other times it does not result in a new substance
7. Understand that when two substances are mixed something new is created

5-PS-E **Students will use models to describe that energy in animals' food was once energy from the sun.**

1. Describe the sun as the major source of energy for life on Earth
2. Trace a pathway of energy from the sun to an animal in a way that they are using energy
3. Understand that energy is the ability to cause movement or create change
4. Recognize that the energy released from food was once energy from the sun that was captured by plants in the chemical process that forms plant matter
5. Know that energy transformations are changes in the types of energy
6. Recognize that the sun's light energy is transformed to chemical energy
7. Classify the kinds of energy as chemical, light or heat energy
8. Identify the different uses of energy by organisms

5-PS-F **Students will support an argument that the gravitational force exerted by earth on objects is directed toward the center of the earth.**

1. Define a force as a push or pull
2. Identify gravity as a force that exists in nature that pulls objects toward each other
3. Understand that the pull between objects and Earth is very strong because Earth has a lot of mass
4. Understand that "down" points toward the center of the spherical Earth
5. Provide multiple pieces of evidence of a force that pulls objects to the center of the Earth
6. Recognize that some things push against the force of gravity
7. Support an argument with evidence, data or a model, that gravitational force directs things down

STRAND **Life Science**

STANDARDS **GOALS and PERFORMANCE OBJECTIVES**

5-LS-A **Students will support an argument that plants get the materials they need for growth chiefly from air and water.**

1. Understand that air is a mixture of gasses
2. Understand that plants can make their own food (photosynthesis)
3. Know that plant food is sugar and that sugar is made by combining water and carbon dioxide
4. Observe and record that a plant can germinate from air and water alone

5-LS-B **Students will develop and critique a model to describe the movement of matter among plants, animals, decomposers, and the environment.**

1. Describe the sun as the major source of energy for life on Earth
2. Define a producer as an organism that makes its own food using energy from the sun
3. Define a consumer as an organism that feeds on other organisms to obtain its energy
    a. Herbivore-eats producers
    b. Carnivore eats consumers
    c. Omnivores-eat producers and consumers
4. Define a decomposer as an organism that breaks down waste and dead organisms returning important nutrients to the environment
5. Construct a food chain to demonstrate the flow of the sun's energy through the organisms of an ecosystem
6. Interpret a food web to describe the relationships between various species of an ecosystem
7. Develop a model of feeding relationships that traces the flow of energy and matter through a given ecosystem

STRAND **Earth and Space Science**

STANDARDS **GOALS and PERFORMANCE OBJECTIVES**

5-ESS-A **Students will develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and or atmosphere interact.**

1. Identify the Earth's major systems as the: geosphere, hydrosphere, atmosphere, biosphere
2. Provide examples to describe how these systems interact in multiple ways to affect Earth's surface materials and processes
    a. Recognize the ocean supports a variety of ecosystems and organisms, shapes of landforms and influences climate
    b. Comprehend that winds and clouds in the atmosphere interact with the landforms to determine patterns of weather
3. Create a model that demonstrates how these systems interact in multiple ways

5-ESS-B **Students will graph and explain the proportions and quantities of water and fresh water in various natural and human-made reservoirs to provide evidence about the distribution of water on Earth.**

1. Identify where water is located on Earth
2. Explain the difference between water and fresh water
3. Understand that nearly all of Earth's available water is in the ocean
4. Recognize that most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands and the atmosphere
5. Graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth

5-ESS-C **Students will obtain and combine information from various sources about ways individual communities use science ideas to protect the Earth's resources, environment, and systems and describe examples of how American Indians use scientific knowledge and practices to maintain relationships with the natural world.**

1. Understand that human activities in agriculture, industry and everyday life have had major effects on the land, vegetation, streams, ocean, air and even outer space
2. Identify that individuals and communities are doing things to help protect Earth's resources and environments
3. Research a current environmental issue (i.e. landfill, oil spill) that shows how communities use science ideas to protect the environment
4. Research practices of the American Indians to maintain relationships with the natural world

5-ESS-D **Students will use evidence or models to support the claim that differences in the apparent brightness of the sun compared to other stars is due to their relative distance from Earth.**

1. Recognize the biggest and only star in the Solar System is the sun
2. Recognize there are many other stars in our galaxy
3. Understand that the closer a star is to the observer the brighter it will appear
4. Understand that the farther a star is from the observer the dimmer it will appear
5. Compare the brightness of the sun to other stars
6. Explain the difference between apparent and relative size of an object based on distance of those objects
7. Understand that the apparent brightness of the sun and stars is due to their relative distances from Earth

5- ESS-E **Students will graph the daily changes in length, shape, and direction of shadows; lengths of day and night; and the seasonal appearance of select stars to communicate the patterns of earth's movement and describe how astronomical knowledge was used by American Indians.**

1. Recognize and describe that the Earth, moon and sun have predictable patterns of movement
2. Investigate the observable patterns of change the occur due to the position and motion of the Earth, sun, moon and stars
    a. Day and night
    b. The length and direction of shadows
    c. The position of the sun in the daytime sky
    d. The appearance of the moon in the night sky
    e. The position of the moon in the night sky
    f. The position of the stars in the night sky
3. Define and provide examples of graphical display methods (i.e. Venn diagram, pie chart, bar graph)
4. Collect data about the length and direction of a shadow
5. Collect data about the length of a day across time and graph it
6. Provide evidence to support the existence of the pattern
7. Research how astronomical knowledge was used by American Indians

Earth Science
6th Grade

STRAND **Earth and Space Science**

STANDARDS **GOALS and PERFORMANCE OBJECTIVES**

6-ESS-A **Students will develop and use a model of the earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.**

1. Demonstrate patterns of the apparent motion of the sun, the moon, and the stars in the sky can be observed, described, predicted and explained with models
2. Demonstrate the basis of a day and the reason that different portions of the Earth exist in different time zones
3. Demonstrate the basis of a year
4. Understand the Earth's spin axis is fixed in direction over the short term, but is tilted relative to its' orbit around the sun
5. Demonstrate that sunlight strength is related to the angle of the sunlight
6. Demonstrate that the tilt of Earth's axis relative to the sun causes the sun angle, and therefore, the sunlight strength or intensity, to vary over the course of one revolution around the sun
7. Understand the seasons are a result of the variation in sunlight strength due to the tilt of Earth's axis relative to the sun in its' yearly orbit
8. Explain the phases of the moon as it orbits the Earth
9. Demonstrate an eclipse of the sun and moon

6-ESS-B **Students will develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.**

1. Understand that gravity is the force that holds small structures like solar systems and large structures like galaxies together and controls orbital motions within them
2. Understand Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe
3. Understand that the solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them
4. Understand that the solar system appears to have formed from a disk of dust and gas, drawn together by gravity

6-ESS-C **Students will analyze and interpret data to determine scale properties of objects in the solar system**

1. Understand time, space and energy phenomena can be observed at various scales using models to study systems that are too large or too small
2. Learn the solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them
3. Analyze data from Earth-based instruments, space-based telescopes and spacecraft to determine similarities and differences among solar system objects

6-ESS-D **Students will construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize earth's 4.6 billion-year old history.**

1. Learn the geologic time scale interpreted from rock strata provides a way to organize Earth's history
2. Learn rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history
3. Learn analyses of rock strata and the fossil record provide only relative dates, not an absolute scale

6- ESS-E **Students will construct an explanation based on evidence for how geoscience processes have changed earth's surface at varying time scales and spatial scales.**

1. Understand geoscience processes have changed Earth's surface at varying time and spatial scale
2. Learn processes change Earth's surface at time and spatial scales that can be large or small; many geoscience processes usually behave gradually but are punctuated by catastrophic events
3. Learn the planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years
4. Learn these interactions have shaped Earth's history and will determine its future
5. Learn water's movement, both on the land and underground, cause weathering and erosion, which change the land's surface features and create underground formations

6-ESS-F **Students will analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provided evidence of the past plate motions.**

1. Understand tectonic processes continually generate new sea floor at ridges and destroy old sea floor at trenches
2. Learn maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart
3. Understand patterns in rates of change and other numerical relationships can provide information about past plate motions.
4. Learn the distribution of fossils and rocks, continental shapes and sea floor structures provide evidence of past plate motions
5. Discover similarities of rock and fossil types on different continents, the shapes of the continents and the location of ocean structures provide evidence of past plate motions

6-ESS-G **Students will develop a model to describe the cycling of earth's materials and the flow of energy that drives this process.**

1. Understand energy drives the process that results in the cycling of Earth's materials
2. Understand the processes of melting, crystallization, weathering, deformation, and sedimentation act together to form minerals and rocks through the cycling of Earth's materials
3. Learn all Earth processes are the result of energy flowing and matter cycling within and among the planet's systems.
4. Learn this energy is derived from the sun and Earth's hot interior.
5. Learn the energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.

6-ESS-H **Students will develop a model to describe the cycling of water through earth's systems driven by energy from the sun and the force of gravity.**

1. Describe how water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization and precipitation, as well as downhill flows on land
2. Learn global movements of water and its changes in form are propelled by sunlight and gravity
3. Explain that the cycling of water through Earth's systems is driven by energy from the sun and the force of gravity
4. Understand that within Earth's systems, the transfer of energy drives the motion and/or cycling of water

6-ESS-I **Students will construct a scientific explanation based on evidence for how the uneven distributions of earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.**

1. Learn humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources
2. Understand all human activities draw on Earth's land, ocean, atmosphere, and biosphere resources and have both short and long-term consequences, positive as well as negative, for the health of people and the natural environment
3. Recognize that minerals, fresh water, and biosphere resources distributed unevenly around the planet as a result of past geologic processes
4. Know that resources that are unevenly distributed as a result of past processes include but are not limited to petroleum, metal ores and soil
5. Explain minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes

6- ESS-J **Students will collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.**

1. Learn the complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns
2. Learn because these patterns are so complex, weather can only be predicted probabilistically
3. Explain how the motions and complex interactions of air masses result in changes in weather conditions
4. Differentiate between warm fronts and cold fronts
5. Relate that air masses flow from regions of high pressure to regions of low pressure, causing weather at a fixed location to change over time
6. Explain how sudden changes in weather can result when different air masses collide

6-ESS-K **Students will 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.**

1. Learn variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.
2. Learn the ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.
3. Understand that interactions vary with latitude, altitude, and local and regional geography and that all affect oceanic and atmospheric flow patterns

6-ESS-L **Students will ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.**

1. Learn human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature.
2. Learn reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.

6-ESS-M **Students will analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.**

1. Discover natural hazards can be the result of interior processes, surface processes or severe weather events
2. Understand some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others such as earthquakes, occur suddenly and with no notice, and therefore are not yet predictable
3. Learn mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events
4. Discover data on natural hazards can be used to forecast catastrophic events and inform the development of technologies used to mitigate their effects
5. Learn this data could include the locations, magnitudes and frequencies of the natural hazards
6. Discover graphs, charts and images can be used to understand patterns of geologic forces that can help forecast the likelihood of locations and likelihoods of future events

6-ESS-N **Students will apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.**

1. Explain human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species
2. Infer changes to Earth's environments can have different impacts for different living things
3. Cite evidence why as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth, unless the activities and technologies involved are engineered otherwise

6- ESS-O **Students will construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact earth's systems including indigenous populations.**

1. Learn as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
2. Understand that the burning of fossil fuels by humans is causing Global climate change and global environmental change

Life Science
7th Grade

STRAND Life Science

Students will use crosscutting concepts, science and engineering practices, and technology while investigating the characteristics, structures, and functions of living things; the processes and diversity of life; and how living organisms interact with each other and their environments.

STANDARDS GOALS and PERFORMANCE OBJECTIVES

Structure, Function, and Information Processing

MS-LS1-1 **Students will conduct an investigation to provide evidence that living things are made of cells, either one cell or many different numbers and types of cells.**

1. Develop evidence that living things are made of cells
2. Distinguish between living and non-living things
3. Recognize that a cell has certain needs for survival that are the same as the needs of an organism
4. Understand that living things may be made of one cell or many different numbers and types of cells
5. Distinguish between living and nonliving things

MS-LS1-2 **Students will develop and use a model to describe the structure and function of a cell as a whole and ways parts of cells contribute to the function.**

1. Develop and use a model of a cell as a whole
2. Identify and explain the role of the parts of a cell: nucleus, chloroplast, cell wall, mitochondria, cell membrane
3. Explain the function of the cell as a system
4. Differentiate between a plant and animal cell
5. Explain how the structure of the cell membrane relates to its function
6. Identify and model the structure, function and relationships of parts of the cell

MS-LS1-3 **Students will use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.**

1. Develop understanding that cells form tissues
2. Understand how tissues form organs specialized for particular body functions
3. Understand how in multicellular organisms, the body is a system of multiple interacting subsystems
4. Develop a model displaying organization from cell to organism
5. Understand in multicellular organisms, the body is a system of multiple, interacting subsystems
6. Understand that systems may have subsystems and be part of larger complex systems
7. Understand that interactions are limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems

Matter and Energy in Organisms and Ecosystems

MS-LS1-6 **Students will construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.**

1. Understand photosynthesis has a primary role in the cycling of matter and flow of energy into and out of organisms
2. Trace the flow of energy and cycling of matter using a food chain or food web that includes producers, consumers and decomposers
3. Understand the chemical reaction by which plants produce complex food molecules requires an energy input to occur. In this reaction, carbon dioxide and water combine to form carbon-based molecules and release oxygen
4. Know plants, algae and many microorganisms use the energy from light to make sugars from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen
5. Learn sugars produced by plants can be used immediately or stored for growth or later use
6. Realize within a natural system, the transfer of energy drives the motion and/or cycling of matter
7. Construct a scientific explanation for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms

MS-LS1-7 **Students will develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth, release energy, or both, as this matter moves through an organism.**

1. Understand molecules are broken apart and put back together to form new substances, and in this process, energy is released
2. Learn cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy
3. Realize in cellular respiration, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials
4. Discover within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules to support growth or to release energy
5. Learn matter is conserved during cellular respiration because atoms are conserved in physical and chemical processes
6. Develop and use a model to describe how food is rearranged through chemical reactions

MS-LS2-1 **Students will analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem and analyze scientific concepts used by American Indians to maintain healthy relationships with environmental sources.**

1. Learn organisms and populations of organisms are dependent on biotic and abiotic factors in the environment
2. Realize in any ecosystem, organisms and populations with similar requirements for food, water, oxygen or other resources may compete with others for limited resources
3. Understand access to food, water, oxygen or other resources limit organisms' growth and reproduction
4. Use cause-and-effect relationships to predict effects of resources available on organisms and populations of organisms in ecosystems during periods of abundant and scarce resources
5. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem
6. Research scientific concepts used by American Indians to maintain healthy relationships with environmental sources

MS-LS2-3 **Students will develop a model describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.**

1. Understand food webs are models that demonstrate how matter and energy are transferred among producers, consumers and decomposers
2. Learn transfers of matter into and out of the physical environment occur at every level
3. Learn decomposers recycle nutrients from dead plant and animal matter back to the soil in terrestrial environments and to the water in aquatic environments
4. Know the atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem
5. Understand the transfer of energy can be tracked as energy flows through an ecosystem

Interdependent Relationships in Ecosystems

MS-LS2-2 **Students will construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.**

1. Understand predatory interactions may reduce the number of organisms or eliminate whole populations of organisms
2. Recognize mutually beneficial interactions may become so interdependent that each organism requires the other for survival
3. Know the patterns of interactions of organisms with their environment, both its living and nonliving components, are shared
4. Realize interactions within ecosystems have patterns that can be used to identify cause-and-effect relationships
5. Know patterns of interactions among organisms across multiple ecosystems can be predicted
6. Construct an explanation about interactions within ecosystems
7. Make predictions about the impact within and across ecosystems of competitive, predatory or mutually beneficial relationships as abiotic or biotic components change

MS-LS2-5 **Students will evaluate competing design solutions for maintaining biodiversity and ecosystem services.**

1. Understand biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems
2. Learn an ecosystem's biodiversity of often used as a measure of its health
3. Know changes in biodiversity can influence ecosystem services, such as food, energy and medicines
4. Understand there are systematic processes for evaluation solutions with respect to how well they meet the criteria and constraints of a problem
5. Recognize testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution
6. Understand small changes in one part of a system may cause large changes in another part
7. Construct a convincing argument that supports or refutes claims for solutions about the natural and designed worlds
8. Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs
9. Create design criteria for design solutions for maintaining biodiversity and ecosystem services
10. Evaluate competing design solutions based on jointly developed and agreed-upon design criteria

Growth, Development, and Reproduction of Organisms

MS-LS1-4 **Students will use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively**

1. Understand plans reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction
2. Define reproduction as the process in which organisms produce offspring
3. Explain how specialized structures for plants affect their probability of successful reproduction
4. Explain how animals engage in characteristic behaviors that affect the probability of successful reproduction
5. Explain that there are a variety of characteristic animal behaviors that affect the probability of successful reproduction
6. Explain how successful reproduction of animals and plants may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability

MS-LS1-5 **Students will construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth and development of organisms.**

1. Explain how genetic factors as well as local conditions affect the growth of organisms
2. Explain that the factors that influence the growth of organisms may have more than one cause
3. Recognize that cause-and-effect relationships in plant and animal systems can only be described using probability

MS-LS3-1 **Students will develop and use a model to describe why structural changes to genes, such as mutations, may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.**

1. Understand that genes are located on chromosomes of cells
2. Understand that chromosomes exist in pairs and each pair contains two variants of each of many distinct genes
3. Understand that each distinct gene chiefly controls the production of specific proteins which in turn affects the traits of an individual
4. Understand that mutations or changes to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits
5. Understand that in addition to variations that arise from sexual reproduction, variations can also occur due to the alteration of genetic information due to genetic mutation
6. Understand that mutations may result in changes to the structure and function of proteins
7. Understand that some changes to the structure and function of proteins may be beneficial, some may be harmful, and some may be neutral

MS-LS3-2 **Students will develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual production results in offspring with genetic variation.**

1. Learn organisms reproduce, either sexually or asexually and transfer their genetic information to their offspring
2. Understand the difference between asexual and sexual reproduction
3. Explain that variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes inherited
4. Explain that with sexually reproducing organisms, each parent contributes half of the genes acquired by the offspring
5. Understand that individuals have two of each chromosomes and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other

MS-LS4-5 **Students will gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.**

1. Understanding that in artificial selection humans have the capacity to influence certain characteristics of organisms by selective breeding
2. Understand that one can choose desired parental traits determined by genes, which are then passed on to offspring

Natural Selection and Adaptations

MS-LS4-1 **Students will analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction and change of life forms throughout the history of life on earth under the assumption that natural laws operate today as in the past.**

1. Understand that the fossil record consists of the collection of fossils and their placement in chronological order (e.g., through the location of sedimentary layers in which they are found or through radioactive dating)
2. Understand that the fossil record documents the existence, diversity, extinction and change of many life forms throughout the history of life on Earth
3. Explain how radioactive dating can be used to determine the age of a fossil
4. Understand how sedimentary rock forms and the significance of finding fossils in certain locations in sedimentary rock

MS-LS4-2 **Students will apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms between modern and fossil organisms and between modern and fossil organisms to infer evolutionary relationships.**

1. Recognize anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record enable the reconstruction of evolutionary history and the inference of line of evolutionary descent

MS-LS4-3 **Students will 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.**

1. Understand that the comparison of the embryological development of different species reveals similarities that show relationships not evident in the fully formed anatomy

MS-LS4-4 **Students will construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individual's probability of surviving and reproducing in a specific environment.**

1. Understand that certain traits give an advantage in a particular environment, while other traits may be less advantageous
2. Discover that changes in an environment may determine whether a given trait is advantageous or not
3. Learn that natural selection leads to the predominance of certain traits in a population, and the suppression of others

MS-LS4-6 **Students will use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in population over time.**

1. Understand that adaptation by natural selection over generations is one important process by which species change over time in response to changes in environmental conditions
2. Discover that traits that support successful survival and reproduction in the new environment become more common
3. Discover that traits that do not support successful survival and reproduction in the new environment become less common
4. Understand that the distribution of traits in a population changes over time

Physical Science
8th Grade

STRAND Physical Science

Students will use crosscutting concepts, science and engineering practices, and technology while investigating how matter and energy exist in a variety of forms and how physical and chemical interactions change matter and energy.

STANDARDS GOALS and PERFORMANCE OBJECTIVES

Structure and Properties of Matter

MS-PS1-1 **Students will develop and critique models that describe the atomic composition of simple molecules and extended structures.**

1. Learn atoms are the basic units of matter
2. Know all matter is made of one or more elements
3. Understand molecules are two or more atoms joined together
4. Learn atoms form molecules that range in size from two to thousands of atoms
5. Understand molecules can be simple or very complex
6. Realize solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g. crystals)

MS-PS1-3 **Students will gather information to describe that synthetic materials come from natural resources and impact society.**

1. Know each pure substance has characteristic physical and chemical properties that can be used to identify it
2. Learn substances react chemically in characteristic ways
3. Understand in a chemical process, the atoms that make up the original substances are regrouped into different molecules
4. Learn that the new substances (products) that result from chemical processes have different properties from those of the original substances (reactants)
5. Understanding natural resources can undergo a chemical process to form synthetic material
6. Obtain, evaluate and communicate information to show that synthetic materials come from natural resources and affect society

MS-PS1-4 **Students will develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.**

1. Understand changes in particle motion, temperature and state of a pure substance occur when thermal energy is added or removed
2. Learn gases and liquids are made of atoms/molecules that are moving about relative to each other
3. Know in a liquid, the atoms/molecules are constantly in contact with others
4. Know in a gas, the atoms/molecules are widely spaced except when they happen to collide
5. Know in a solid, atoms/molecules are closely spaced and may vibrate in position but do not change relative locations
6. Understand the changes of state that occur with variations in temperature or pressure can be described and predicted using models of matter

Chemical Reactions

MS-PS1-2 **Students will analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.**

1. Know each pure substance has characteristics physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it
2. Know substances react chemically in characteristic ways
3. Learn that in a chemical process, the atoms that make up the original substances are regrouped into different molecules; these new substances have different properties from those of the reactants
4. Understand the analysis of data on the properties of products and reactants can be used to determine whether a chemical process has occurred
5. Realize density, melting point, boiling point, solubility, flammability and odor are characteristic properties that can be used to identify a pure substance
6. Recognize macroscopic patterns are related to the nature of the atomic-level structure of a substance

MS-PS1-5 **Students will develop, use and critique a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.**

1. Understand substances react chemically in characteristic ways
2. Learn that in a chemical reaction, the atoms that make up the original substances are regrouped into different molecules
3. Know that new substances created in a chemical reaction have different properties from those of the original substances
4. Know that the total number of each type of atom in a chemical process is conserved, and thus the mass does not change
5. Understand that matter is conserved because atoms are conserved in physical and chemical processes

MS-PS1-6 **Students will undertake a design project to construct, test and modify a device that either releases or absorbs thermal energy by chemical processes.**

1. Understand some chemical reactions release energy, while others store energy
2. Learn a solution needs to be tested and then modified on the basis of the test results in order for it to be improved
3. Realize that although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process
4. Know that some of the characteristics identified as having the best performance may be incorporated into the new design
5. Understand the process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution

Forces and Interactions

MS-PS2-1 **Students will apply Newton's Third Law of Motion to design a solution to a problem involving the motion of two colliding objects.**

1. Know that for any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction
2. Analyze and explain the outcome of a collision
3. Realize that the outcome of a collision is determined by the speed and mass of the colliding objects

MS-PS2-2 **Students will plan 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.**

1. Understand the motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change
2. Know that the greater the mass of the object, the greater the force needed to achieve the same change in motion
3. Understand for any given object, a larger force causes a larger change in motion
4. Recognize that all positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared

MS-PS2-3 **Students will ask questions about data to determine the factors affecting electric and magnetic force strengths.**

1. Understand electric and magnetic forces can be attractive or repulsive
2. Understand electric and magnetic forces sizes depend on the magnitudes of the charges, currents or magnetic strengths involved
3. Understand electric and magnetic forces sizes depends on the distances between the interacting objects

MS-PS2-4 **Students will construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the mass of interacting objects.**

1. Know that gravity is an attractive force that exists between any two objects that have mass
2. Recognize that the strength of the gravitational force between two objects is determined by the relative masses of the two objects and the distance between them

MS-PS2-5 **Students will design and conduct an investigation to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.**

1. Recognize and define that a force is a push or a pull
2. Identify magnetism as a force that exists in nature
3. Realize that fields exist between objects and exert force on each other even though the objects are not in contact
4. Learn that forces that exist at a distance (electronic and magnetic) can be extended through space and can be mapped by their effect on a test object

Energy

MS-PS3-1 **Students will construct and interpret graphic displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.**

1. Learn that motion energy is properly called kinetic energy
2. Discover how motion energy is proportional to the mass of the moving object
3. Describe how motion energy increases with the speed of the object

MS-PS3-2 **Students will develop and critique models to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.**

1. Understand a system of objects may contain stored or potential energy, depending on their relative positions
2. Learn that when two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object

MS-PS3-3 **Students will apply scientific principles to design, construct, and test a device that minimizes or maximizes thermal energy transfer.**

1. Understand temperature is a measure of the average kinetic energy of particles of matter
2. Understand that the relationship between the temperature and the total energy of a system depends on the types, states and amounts of matter present
3. Discover how energy is spontaneously transferred out of hotter regions or objects and into colder ones
4. Understand how the transfer of energy can be tracked as energy flows through a designed or natural system
5. Recognize that the more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful
6. Recognize that specification of constraints include consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions

MS-PS3-4 **Students will plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles are measured by the temperature of the sample.**

1. Learn that temperature is a measure of the average kinetic energy of particles of matter
2. Know that the relationship between the temperature and the total energy of a system depends on the types, states and amounts of matter present
3. Realize how the amount of energy transfer needed to change the temperature of a matter sample depends on the nature of the matter, the size of the sample and the environment

MS-PS3-5 **Students will construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.**

1. Know energy occurs in different forms
2. Know energy transfers from one object to another
3. Understand that energy can transform from one type to another
4. Learn that when the motion energy of an object changes, there is inevitably some other changes in energy at the same time
5. Understand how kinetic energy is related to the mass of an object and to the speed of an object
6. Understand kinetic energy has a relationship to mass separate from its relationship to speed
7. Realize kinetic energy is proportional to the mass of the moving objects and grows with the square of the object's speed

Waves and Electromagnetic Radiation

MS-PS4-1 **Students will use mathematical representations to describe a simple model for waves that include how the amplitude and wavelength of a wave is related to the energy in a wave.**

1. Recognize that a mechanical wave is a disturbance in a medium
2. Understand that a simple wave has a repeating pattern that can be described by its wavelength, frequency and amplitude
3. Realize waves can interfere with each other

MS-PS4-2 **Students will develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.**

1. Learn that a simple wave has a repeating pattern that can be described by its wavelength, frequency and amplitude
2. Understand when a wave strikes an object, it can be absorbed, reflected, transmitted, or refracted or a combination of two or more of these conditions
3. Realize that the makeup/identity of the object determines the type of interactions that will take place between different transparent materials (e.g. air and water, air and glass) where the light path bends
4. Recognize that a wave model of light is useful for explaining brightness, color and the frequency-dependent bending of light at a surface between media

Biology
9th Grade

STRAND Life Science

Students will use crosscutting concepts, science and engineering practices, and technology while investigating the characteristics, structures, and functions of living things; the processes and diversity of life; and how living organisms interact with each other and their environments.

STANDARDS GOALS and PERFORMANCE OBJECTIVES

From Molecules to Organisms: Structures and Processes

HS-LS1-1 **Students will 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.**

1. Analyze the structure and function of cells and all cellular organelles:
    a. Ribosomes
    b. Endoplasmic reticulum
    c. Plasma membrane: membrane properties
    d. Nuclear envelope
    e. Nucleus
    f. Nucleolus
    g. Cytoplasm: protoplasm, nucleoplasm
    h. Peroxisome
    i. Mitochondrion: cristae, primary/secondary membrane, matrix
    j. Endoplasmic reticulum: rough/smooth
    k. Golgi apparatus: packaging of proteins
    l. Lysosome
    m. Ribosome
    n. Vacuole: contractile vacuole
    o. Cell wall
    p. Plastid: chloroplast (grana, stroma, thylakoid), leucoplast, chromoplast
    q. Cytoskeleton: microtubule/microfilament
    r. Centriole (centrosome)
    s. Secretory vesicle
    t. Cilium
    u. Flagellum

2. Analyze structure, function, and replication of DNA (nucleotides; purines; pyrimidines)
3. Understand the process of protein synthesis
    a. Transcription: mRNA codons
    b. Translation: rRNA/tRNA structure; tRNA anticodon
4. Use of the microscope
5. Differentiate between prokaryotic and eukayotic cells

HS-LS1-2 **Students will develop and use a model to illustrate the organizational structure of interacting systems that provide specific functions within multicellular organisms.**

1. Analyze the structure and function of cells and all cellular organelles:
    a. Ribosomes
    b. endoplasmic reticulum
    c. plasma membrane: membrane properties
    d. nuclear envelope
    e. nucleus
    f. nucleolus
    g. cytoplasm: protoplasm, nucleoplasm
    h. peroxisome
    i. mitochondrion: cristae, primary/secondary membrane, matrix
    j. endoplasmic reticulum: rough/smooth
    k. golgi apparatus: packaging of proteins
    l. lysosome
    m. ribosome
    n. vacuole: contractile vacuole
    o. cell wall
    p. plastid: chloroplast (grana, stroma, thylakoid), leucoplast, chromoplast
    q. cytoskeleton: microtubule/microfilament
    r. centriole (centrosome)
    s. secretory vesicle
    t. cilium
    u. flagellum

HS-LS1-3 **Students will plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.**

1. Apply concepts regarding the levels of organization in an organism (cell, tissue, organ, organ system, and organism).
2. Connect the functions of all human body systems.

HS-LS1-5 **Students will use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.**

1. Analyze the role of chlorophyll and other pigments in photosynthesis
2. Summarize the main events of the light reactions
3. Explain how ATP is made during the light reactions
4. Summarize the main events of the Calvin Cycle
5. Assess what happens to the compounds that are made in the Calvin Cycle
6. Summarize how the light reactions and the Calvin Cycle work together to create the continuous cycle of photosynthesis.
7. Critique how environmental factors influence photosynthesis

HS-LS1-6 **Students will construct an explanation based on evidence from multiple sources for how carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur may combine with other elements to form organic macromolecules with different structures and functions.**

1. Draw conclusions on the importance of carbon bonding in biological molecules
2. Identify functional groups in biological molecules
3. Compare and contrast the process of hydrolysis and dehydration synthesis

HS-LS1-7 **Students will use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.**

1. Analyze the input and output of the process of cellular respiration (in terms of compounds and energy)
2. Differentiate between the processes of cellular respiration and photosynthesis are opposite reactions
3. Explain the importance of carbon bonding in biological molecules
4. Identify and compare functional groups in biological molecules
5. Compare and contrast the process of hydrolysis and dehydration synthesis

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

HS-LS2-3 **Students will construct and revise an explanation based on evidence for the cycling of matter and flow of energy aerobic and anaerobic conditions.**

1. Analyze the role of chlorophyll and other pigments in photosynthesis
2. Summarize the main events of the light reactions
3. Explain how ATP is made during the light reactions
4. Summarize the main events of the Calvin Cycle
5. Assess what happens to the compounds that are made in the Calvin Cycle
6. Compare and contrast the light reactions and the Calvin Cycle as they relate to photosynthesis.
7. Draw conclusions about the importance of carbon bonding in biological molecules
8. Compare functional groups in biological molecules
9. Compare and contrast the process of hydrolysis and dehydration synthesis
10. Identify the input and output of the process of cellular respiration (in terms of compounds and energy)
11. Differentiate between the processes of cellular respiration and photosynthesis are opposite reactions

HS-LS2-4 **Students will use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.**

1. Compare and contrast the role of producers in an ecosystem
2. Analyze the role of several kinds of consumers in an ecosystem
3. Analyze the role of decomposers in an ecosystem
4. Compare the concept of a food chain with that of a food web
5. Hypothesize why ecosystems usually contain only a few trophic levels

HS-LS2-1 **Students will use mathematical or computational representations to support arguments about environmental factors that affect carrying capacity, biodiversity, and populations in ecosystems.**

1. Describe the main properties that scientists measure when they study populations
2. Identify the measurements used to describe changing populations
3. Compare the three general types of survivorship curves
4. Differentiate between the four processes that determine population growth
5. Compare the exponential model and the logistic model of population growth
6. Differentiate between density dependent and density independent regulation of populations

HS-LS2-6 **Students will 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.**

1. Summarize the role of producers in an ecosystem
2. Identify several kinds of consumers in an ecosystem
3. Explain the important role of decomposers in an ecosystem
4. Compare the concept of a food chain with that of a food web
5. Hypothesize why ecosystems usually contain only a few trophic levels

HS-LS2-7 **Students will design, evaluate, and refine a solution for reducing the direct and indirect impacts of human activities on the environment and biodiversity and analyze scientific concepts used by American Indians to maintain healthy relationships with environmental resources.**

1. Explain the difference between abiotic factors and biotic factors and how unfavorable conditions affect species.
2. Describe the interactions between the levels of biological communities.
3. Present the difference between an organism's habitat and its niche.
4. Define the producers and consumers in an ecosystem.
5. Diagram a food chain, food web and ecological pyramid model.
6. List the stages of primary and secondary succession.
7. Explain how ranges of tolerance affect the distribution of organisms.
8. List the major abiotic factors that determine the location of a terrestrial biome.
9. List the major abiotic factors that determine the aquatic ecosystems.
10. Explain the characteristics of populations and how they are distributed or growth is determined.

HS-LS3 Heredity: Inheritance and Variation of Traits

HS-LS3-1 **Students will construct an explanation using evidence from multiple sources to describe the role of cellular division and differentiation in producing and maintaining complex organisms.**

1. List the concepts of Mendelian genetics
2. Differentiate between sex chromosomes and autosomes
3. Analyze the role of sex chromosomes in sex determination
4. Analyze how an X or Y linked gene affects the inheritance of traits
5. Assess the effect of crossing over on the inheritance of genes in linkage groups
6. Differentiate between chromosome mutations and gene mutations
7. Analyze the different patterns of inheritance seen in genetic traits and genetic disorders

HS-LS3-2 **Students will make and defend a claim based on evidence from multiple sources that inheritable genetic variations may result from:**

- **new genetic combinations through meiosis,**
- **viable errors occurring during replication, or**
- **mutations caused by environmental factors.**

1. Summarize the structure of the chromosome; differentiate between sex chromosomes and autosomes
2. Compare numbers of chromosomes between different species
3. Compare between haploid and diploid cells
4. Assess the role of mitotic process in complex organisms
5. Draw conclusions about the creation of gametes as a result of meiosis
6. Describe the main properties that scientists measure when they study populations

HS-LS3-3 **Students will apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.**

1. Assess traits that vary in populations and can be studied
2. Analyze the significance of the bell curve to population genetics
3. Compare three causes of genetic variation in populations
4. Calculate allele frequency and phenotype frequency
5. Analyze Hardy-Weinburg genetic equilibrium
6. Apprise how migration can affect the genetics of a population
7. Assess how genetic drift can affect populations of different sizes

HS-LS4 Biological Evolution: Unity and Diversity

HS-LS4-1 **Students will evaluate and communicate scientific information about how common ancestry and biological evolution are supported by multiple lines of empirical evidence.**

1. Cite evidence that modern biologists use in classifying organisms
2. Draw conclusions from information in a phylogenetic diagram
3. Assess the criteria used in cladistic analysis
4. Hypothesize how proteins and chromosomes are used to classify organisms
5. Explain cladistic taxonomy, and cite examples that are in conflict with classical taxonomy.

HS-LS4-2 **Students will construct an explanation based on evidence that the process of evolution by natural selection primarily results from four factors:**

- **the potential for a species to increase in number,**
- **the heritable genetic variation of individuals in a species due to mutation and sexual reproduction,**
- **competition for limited resources, and**
- **the proliferation of those organisms that are better able to survive and reproduce in the environment.**

1. Cite evidence for the biological process of evolution
2. Compare the concepts of adaptation and fitness to the theory of natural selection
3. Cite evidence of how convergent evolution can result among different species
4. Cite evidence of how divergent evolution can lead to species diversity
5. Compare artificial selection and natural selection
6. Develop a logical argument for how organisms can undergo coevolution

HS-LS4-3 **Students will 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.**

1. Cite evidence for biological process of evolution
2. Compare the concepts of adaptation and fitness to the theory of natural selection
3. Cite examples of how convergent evolution can result among different species
4. Cite examples of how divergent evolution can lead to species diversity
5. Compare artificial selection and natural selection
6. Develop a logical argument for how organisms can undergo coevolution
7. Describe the main properties that scientists measure when they study populations
8. Differentiate between the measurements used to describe changing populations
9. Compare the three general types of survivorship curves
10. Differentiate between the four processes that determine population growth
11. Compare the exponential model and the logistic model of population growth
12. Differentiate between density dependent and density independent regulation of populations

HS-LS4-4 **Students will construct an explanation based on evidence for how natural selection leads to adaptation of populations over time.**

1. Describe the main properties that scientists measure when they study populations
2. Identify the measurements used to describe changing populations
3. Compare the three general types of survivorship curves
4. Differentiate between the four processes that determine population growth
5. Compare the exponential model and the logistic model of population growth
6. Differentiate between density dependent and density independent regulation of populations
7. Cite evidence for the biological process of evolution
8. Compare the concepts of adaptation and fitness to the theory of natural selection
9. Cite examples of how convergent evolution can result among different species
10. Explain how divergent evolution can lead to species diversity
11. Compare artificial selection and natural selection
12. Develop a logical argument for how organisms can undergo coevolution.

HS-LS4-5 **Students will evaluate the evidence supporting claims that changes in environmental conditions may result in:**

- **changes in the number of individuals of some species,**
- **the emergence of new species over time,**
- **the extinction of other species.**
- **investigate and explain American Indian perspectives on changes in environmental conditions and their impacts.**

1. Describe the main properties that scientists measure when they study populations
2. Identify the measurements used to describe changing populations
3. Compare the three general types of survivorship curves
4. Differentiate between the four processes that determine population growth
5. Compare the exponential model and the logistic model of population growth
6. Differentiate between density dependent and density independent regulation of populations
7. Cite evidence for the biological process of evolution
8. Compare the concepts of adaptation and fitness to the theory of natural selection
9. Cite evidence how convergent evolution can result among different species
10. Cite evidence how divergent evolution can lead to species diversity
11. Compare artificial selection and natural selection
12. Develop a logical argument for how organisms can undergo coevolution

Earth & Space Science
10th Grade

STRAND Earth & Space Science

Students will use crosscutting concepts, science and engineering practices, and technology while investigating the composition, history, and processes that shape earth, the solar system, and the universe.

STANDARDS GOALS and PERFORMANCE OBJECTIVES

Space Systems

HS-ESS1-1 **Students will 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.**

1. Identify which features of the Sun are typical of stars
2. Describe the outer layers of gas above the Sun's visible surface.
3. Classify the different types of spectra by how they are created.
4. Describe the process of fusion in the Sun.

HS-ESS1-2 **Students will 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.**

1. Explain how astronomers determined where Earth is located within the Milky Way.
2. Determine what measurements of the mass of the Milky Way indicate.
3. Analyze how Population I stars and Population II stars are different.
4. Summarize how variable stars are used to determine the distance to globular clusters.
5. Explain how astronomers discovered that there are other galaxies beyond the Milky Way.
6. Summarize why astonomers theorize that most of the matter in galaxies and clusters of galaxies is dark matter.
7. Explain why it is difficult for astronomers to accurately measure a value for the Hubble constant, H.
8. Explain the differences in appearance among normal spiral, barred spiral, elliptical, and irregular galaxies.
9. Describe how the age of the universe can be calculated using the Big Bang model
10. Explain why dark matter is important in determining the density of matter in the universe.
11. Deduce why the cosmic background radiation was an important discovery.

HS-ESS1-3 **Students will communicate scientific ideas about the way stars, over their life cycle, produce elements.**

1. Relate the stellar temperature to the classification of a star.
2. Explain the difference between apparent and absolute magnitudes.
3. Explain how parallax is used to measure the distance to stars.
4. Compare and contrast luminosity and magnitude.
5. Explain how mass determines a star's evolution.
6. Infer how hydrostatic equilibrium in a star is determined by mass.
7. Determine how the lifetimes of stars depend on their masses.
8. Determine why only the most massive stars are important contributors in enriching the galaxy with heavy elements.

HS-ESS1-4 **Students will use mathematical or computational representations to predict the motion of orbiting objects in the solar system.**

1. Describe the formation of the solar system.
2. Explain why retrograde motion is an apparent motion.
3. Describe how the gravitational force between two bodies is related to their masses and the distance between them.
4. Compare the shapes of two ellipses having eccentricities of 0.05 and 0.075.
5. Identify the reason that the inner planets are called terrestrial planets.
6. Summarize the characteristics of each of the terrestrial planets.
7. Compare the average surface temperature of Earth and Venus, and describe what causes them.
8. Describe the evidence that indicates there was once tectonic activity on Mercury, Venus, and Mars.
9. Create a table that lists the gas giant planets and their characteristics.
10. Compare the composition of the gas giant planets to the Sun.
11. Compare Earth's Moon with moons of the gas giant planets.
12. Identify the kinds of small solar system bodies and their compositions.
13. Compare plants and dwarf planets.
14. Distinguish among meteors, meteoroids, and meteorites.
15. Explain why a comet's tail always points away from the Sun.
16. Compare and contrast the asteroid belt and the Kuiper belt.

History of Earth

HS-ESS1-5 **Students will evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.**

1. Explain how ancient glacial deposits in Africa, India, Australia, and South America support the idea of continental drift.
2. Summarize how rocks, fossils, and climate provided evidence of continental drift.
3. Infer what the climate in ancient North America must have been like as a part of Pangaea.
4. Explain how ocean-floor rocks and sediments provided evidence of seafloor spreading.
5. Differentiate between the terms reversed polarity and normal polarity.
6. Describe the topography of the seafloor.
7. Describe how plate tectonics results in the development of Earth's major geologic features.
8. Summarize the processes of convergence in forming mountains.
9. List the geologic features associated with each type of convergent boundary.
10. Identify the type of location where transform boundaries most commonly occur.
11. Relate the process of convection to plate movement.
12. Restate the relationships among mantle convection, ocean ridges, and subduction zones.
13. Illustrate the tectonic processes of push and slab pull.
14. Explain the purpose of the geologic time scale
15. Distinguish among eons, eras, periods, and epochs, using specific examples.
16. Describe the importance of extinction events to geologists.
17. Summarize the principles that geologists use to determine relative ages of rocks.
18. Compare and contrast the three types of unconformities
19. Explain how geologists use fossils to determine the relative ages of rock layers within a large region.
20. Explain how the principle of uniformitarianism would help geologists determine the source of a layer of particular igneous rock.
21. Point out the difference between relative-age dating and absolute-age dating.
22. Explain how the process of radioactive decay can provide more accurate measurements of age compared to relative-age dating methods.
23. Compare and contrast the use of U-238 and C-14 in absolute-age dating.
24. Discuss the link between uniformitarianism and absolute-age dating.

HS-ESS1-6 **Students will 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.**

1. Describe how the fossil record helps scientists understand Earth’s history.
2. List ways in which fossils can form.
3. Explain how scientists might be able to determine the relative age of a layer of sediment if they find a fossilized trilobite in the layer.
4. Summarize the data that scientists use to determine Earth’s age.
5. Explain why scientists think that Moon rocks and meteorites are about the same age as Earth.
6. Explain how gravitational contraction, radioactivity, and asteroid and meteorite bombardment heated early Earth.
7. Describe the importance of zircon as an age-dating tool.
8. Describe how Earth’s continents formed.
9. Explain why pieces of Earth’s earliest crust do not exist today.
10. Deduce how a craton is like a continent’s root.
11. Explain why an atmosphere rich in oxygen was important for the evolution of life.
12. Explain how scientists conclude that ancient cyanobacteria produced oxygen.
13. Describe the relationship between banded-iron formations and oxygen gas.
14. Describe where the water in Earth’s oceans originated.

HS-ESS2-1 **Students will develop a model to illustrate how earth's internal and surface processes operate at different spatial and time scales to form continental and ocean-floor features.**

1. Distinguish between the characteristics of an unweathered rock and those of a highly weathered rock.
2. Describe the factors that control the rate of chemical weathering and those that control the rate of physical weathering.
3. Compare chemical weathering to mechanical weathering.
4. Analyze the relationship between surface area and weathering.
5. Discuss how weathering and erosion are related.
6. Describe how gravity is associated with many erosional agents.
7. Compare and contrast rill erosion and gully erosion.
8. Describe how soil forms.
9. Summarize the features of each horizon of soil.
10. Generalize the effect that topography has on soil formation.
11. Organize the following types of mass movements in order of increasing speed: slides, creep, flows, and rockfalls.
12. Identify the underlying force behind all forms of mass movement.
13. Analyze how water affects mass movements.
14. Distinguish the various types of landforms formed by wind and how these landforms are created.
15. Identify conditions that can contribute to an increase in wind erosion.
16. Examine why loess can travel much greater distanced than sand.
17. Differentiate between headlands and bays.
18. Describe sea stacks and how they are formed.
19. Explain how jetties and groins affect the longshore current.
20. Analyze the effect a seawall has on a beach.
21. Describe the feature of deep-ocean basins.
22. Summarize the differences between deep-sea mud and oozes.
23. Compare and contrast the characteristics of the three major areas of the continental margin.

Earth's Systems

HS-ESS2-2 **Students will analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other earth systems.**

1. Summarize how an air mass forms.
2. Explain the process that prevents the poles from steadily cooling off and the tropics from heating up over time.
3. Distinguish between the causes of weather and climate.
4. Differentiate among the five types of air masses.
5. Summarize information about the four types of fronts and explain how they form and lead to changes in weather.
6. Distinguish among the three main wind systems.
7. Describe the Coriolis effect.
8. Explain why most tropical rain forests are located near the equator.
9. Describe how a jet stream affect the movement of air masses.
10. Compare and contrast high-pressure and low-pressure systems.
11. Identify two important factors in collecting and analyzing weather data in the United States.
12. List the conditions needed for a thunderstorm's cumulus stage.
13. Explain how a thunderstorm is formed along a front.
14. Identify what causes a thunderstorm to dissipate.
15. Identify the characteristics of a severe storm.
16. Describe two characteristics of thunderstorms that lead to hail formation.
17. Compare and contrast a macroburst and a microburst.
18. Identify the steps that change wind shear into a tornado
19. Identify the three main stages of a tropical cyclone.
20. Identify two conditions that must exist for a tropical cyclone to form.
21. Explain how everyday weather can become recurrent and dangerous.
22. Compare and contrast a cold wave and a heat wave.
23. Describe two factors that cause variations in climate.
24. Compare and contrast temperatures in the tropics, temperate zones, and polar zones.
25. Describe the criteria on which the Koppen climate classification system is based.
26. Explain a microclimate.
27. Analyze how volcanic activity affects climate.
28. Explain the greenhouse effect.
29. List some possible consequences of global warming.
30. Reason why some scientists theorize that global warming might not be the result of increases in atmospheric carbon dioxide.

HS-ESS2-3 **Students will develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.**

1. Explain how the location of volcanoes is related to the theory of plate tectonics.
2. Discuss how the composition of magma determines an eruption's characteristics.
3. Restate how the viscosity of magma is related to its explosivity.
4. Describe the different types of plutons
5. Identify processes that expose plutons at Earth's surface.
6. Describe how the formation of a fault can result in an earthquake.
7. Explain why a stress-strain curve usually has two segments.
8. Compare and contrast the movement produced by each of the three types of faults.
9. Explain how P-waves and S-waves are used to determine the properties of Earth's core.
10. Summarize the ways that scientists can use seismic waves to measure and locate earthquakes.
11. Summarize the events that lead to a tsunami.
12. Relate density and crustal thickness to mountain building.
13. Explain why isostatic rebound slows down over time.

HS-ESS2-5 **Students will plan and conduct an investigation of the properties of water and its effects on earth materials and surface processes.**

1. Analyze ways in which moving water can carve a landscape.
2. Describe the three ways in which a stream carries its load.
3. Analyze the relationship between the carrying capacity of a stream and its discharge and velocity.
4. Describe how a V-shaped valley is formed.
5. Identify four changes that a stream undergoes before it reaches the ocean.
6. Compare the velocity on the inside of a meander curve with that on the outside of the curve.
7. Describe the conditions necessary for the formation of a natural lake.
8. Identify human activities that might affect the process of eutrophication in a lake near you.
9. Identify the acid that is most common in groundwater.
10. Analyze how limestone is weathered, and identify the features that are formed as a result of this dissolution.
11. Explain why hard water is more common in some areas than others.
12. Illustrate the difference between an artesian well and an ordinary well.

HS-ESS2-6 **Students will develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.**

1. Compare and contrast Earth's geology and geosphere.
2. Compare and contrast the hydrosphere and biosphere.
3. Explain how the movement of groundwater is related to the water cycle.
4. Illustrate how the relative positions of an aquifer and aquiclude can result in the presence of a spring.
5. Analyze the factors that determine flow velocity.
6. Rank the gases in the atmosphere in order from most abundant to least abundant.
7. Name the four types of particles found in the atmosphere.
8. Compare and contrast the five layers that make up the atmosphere.
9. Explain why temperature increases with height in the stratosphere.
10. Identify three properties of the atmosphere and describe how they vary with height in the atmosphere.
11. Describe how the motion of particles in a material changes when the temperature of the material increases.
12. Describe how precipitation forms.

HS-ESS2-7 **Students will construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.**

1. List three hypotheses about the origin of life, and describe the evidence for each.
2. Explain why scientists think that life on Earth began after 3.9 bya.
3. Identify the ingredients that Miller and Urey thought made up Earth's early atmosphere.
4. Compare and contrast eukaryotes and prokaryotes.
5. Discuss why some scientists think that Ediacaran organisms do not represent present-day animal groups.
6. Explain how the formation of Pangaea affected the evolution of life-forms.
7. Compare transgression and regression.
8. Discuss the relationship between oil deposits and evaporites.
9. Assess the significance of the Cambrian explosion.
10. Discuss the significance of the Permo-Triassic Extinction Event for the animals that populated the Mesozoic.
11. Explain how rifts are related to the formation of oceans.
12. Discuss the evidence that suggests a meteorite impact was responsible for the extinctions at the end of the Mesozoic Era.
13. Describe why the Cenozoic is called the Age of Mammals.
14. Assess the extent of glaciation in North America.
15. Explain how the positions of the continents contributed to Cenozoic climate change.

Advanced Biology
Elective

STRAND Life Science

Students will use crosscutting concepts, science and engineering practices, and technology while investigating the characteristics, structures, and functions of living things; the processes and diversity of life; and how living organisms interact with each other and their environments.

STANDARDS GOALS and PERFORMANCE OBJECTIVES

HS-LS1 From Molecules to Organisms: Structures and Processes

HS-LS1-1 **Students will 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.**

1. List the roles of proteins in living organisms.
2. Describe how two amino acids are combined to forma polypeptide.
3. Summarize the differences among primary, secondary, tertiary, and quaternary structure.
4. Describe the consequences of incorrect protein folding.
5. Compare the structure and function of DNA and RNA nucleic acids.
6. Explain how adenosine triphosphate (ATP) is able to store energy.
7. Describe the properties a substance must possess in order to serve as the genetic material.
8. Explain the major features of DNA structure.
9. Describe the enzymes and proteins involved in DNA replication.
10. Contrast DNA replication in eukaryotes and prokaryotes.
11. Explain how the mRNA nucleotides determine the sequence of amino acids in a polypeptide.
12. Describe how eukaryotic mRNA molecules are processed and exported to the cytoplasm.
13. Describe the roles of mRNA, tRNA, and rRNA in translating the genetic code.
14. Describe the structure of an operon and state the role of each component of the operon.
15. List the levels of control of gene expression in eukaryotes.
16. Summarize how chromatin structure may be involved in regulation of gene expression in eukaryotes.
17. Identify the mechanisms of transcriptional, posttranscriptional, and translational control of gene expression.
18. Identify how mutations influence protein structure.
19. Explain the purpose of the polymerase chain reaction (PCR).
20. Identify the three types of tissue found in angiosperms.
21. Recognize the differences in the location, structure, and function among various angiosperm tissues.
22. List and describe the four major types of tissues found in animals.
23. Explain how specialization of cells in tissues enhances tissue function.

24. Compare and contrast the cellular, tissue, and organ states of embryonic development.

HS-LS1-2 **Students will develop and use a model to illustrate the organizational structure of interacting systems that provide specific functions within multicellular organisms.**

1. Identify the common locations of the various types of animal tissues.
2. List the major life processes carried out by each organ system in vertebrate animals.
3. Describe the two main cavities of the human body and the major organs found in each.
4. Distinguish between the functions of skin that are common to all animals and those that are unique to specific group.
5. Describe the makeup and function of the accessory structures of human skin.
6. Compare and contrast the open circulatory system of an arthropod with the closed system of an annelid.
7. Distinguish among the structure and functions of arteries, veins, and capillaries.
8. List the major components of the human heart, including the four chambers and four valves.
9. Trace the path of blood through the human heart, lungs, and major vessels leading to the lower leg.
10. List the major types of blood cells and their functions.
11. Define capillary exchange and describe the two major forces involved.
12. Compare the types of antigens recognized by the innate versus the adaptive immune systems.
13. Describe three major functions of the lymphatic system.
14. Explain some specific ways that the innate immune system interacts with and influences the adaptive immune system.
15. Discuss active and passive immune responses, giving specific examples of each.
16. Compare the structural features of incomplete versus complete digestive tracts.
17. List all the major components of the human digestive tract, from the mouth to the anus.
18. Describe the overall characteristic and functions of digestive enzymes.
19. List the major types of nutrients and provide examples of foods that are a good source of each.
20. Distinguish among ventilation, external respiration, and internal respiration.
21. Compare the mechanisms use by amphibians, mammals, and birds to inflate their lungs.
22. Describe the overall, specific function of animal excretion systems.
23. Compare and contrast the excretory organs of earthworms, arthropods, aquatic vertebrates, and terrestrial vertebrates.
24. Discuss the contributions of glomerular filtration, tubular reabsorption, and tubular secretion to the formation of urine.
25. Compare the nervous systems of cnidarians, planarians, and annelids.
26. Describe the essential features of a typical vertebrate nervous system.
27. Describe the basic structure of a neuron and compare the functions of the three types of neurons.
28. Describe the anatomy of the spinal cord and spinal nerves.
29. List the major regions of the human brain and describe some major functions of each.
30. Describe the overall anatomy of the peripheral nervous system, including the cranial nerves and spinal nerves.
31. Describe four types of sensory receptors and list examples of each.

32. Compare and contrast how the brain receives information about taste versus smell.
33. Discuss the distinct roles of rod cells, cone cells, and rhodopsin in converting a light stimulus into a nerve impulse.
34. Distinguish among the parts of the human ear that make up the outer, middle, and inner ear.
35. Compare and contrast the functions of proprioceptors, cutaneous receptors, and pain receptors.
36. Provide several examples of how mammalian skeletons are adapted to particular forms of locomotion.
37. Review the five major functions of the skeletal system.
38. List the major bones that constitute the human axial and appendicular skeletons.
39. Describe the macroscopic and microscopic structure of a muscle fiber.
40. Distinguish between the mode of action of a neurotransmitter and that of a hormone.
41. Identify the major endocrine glands of the human body.

HS-LS1-3 **Students will plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.**

1. Define homeostasis and explain why it is an essential feature of all living organisms.
2. Explain the difference between negative and positive feedback mechanisms in the regulation of homeostasis.
3. Evaluate the evolutionary benefits of regulating an internal variable, such as body temperature, versus the cost.
4. Differentiate between positive and negative feedback mechanisms and list one specific example of each in animals.
5. Summarize the four major functions of human kidneys in maintaining homeostasis.
6. Identify the structures and functions of various leaf tissues.
7. Identify the macronutrients and micronutrients that plants require.
8. Choose the correct order of mineral uptake across the plasma membrane within a plant cell wall.
9. Describe the mutualistic relationships that assist plants in acquiring nutrients from the soil.
10. Describe the relationship between water potential and root pressure.
11. Identify the properties of water that influence the upward movement of water in flowering plants.
12. Explain how environmental factors influence the opening and closing of stomata.
13. List the correct sequence of events for the movement of water in xylem, and sucrose in phloem.
14. Identify the major cellular and molecular events that result in a blood clot.
15. Describe the major factors that affect the rate of capillary exchange.
16. Explain how the circulatory, respiratory, and urinary systems specifically contribute to homeostasis.
17. Discuss how negative feedback is similar to the way a thermostat works.
18. Describe two external changes or stimuli that the human body and/or cells must respond to in order to survive.
19. List the three main functions of the lymphatic system that contribute to homeostasis.
20. Describe how sensory receptors are used to maintain homeostasis.

21. Explain how some hormones are regulated by negative feedback, and some by positive feedback.

HS-LS1-5 **Students will use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.**

1. Explain how plants have evolved the ability to capture solar energy and store it in carbon-based organic nutrients.
2. List the types of organisms that use photosynthesis to obtain the free energy necessary for life processes.
3. Explain how plants capture solar energy and convert it to chemical energy of food.
4. Define the relationship between photosynthesis and cellular respiration in terms of reactants and products.
5. Describe the components of a chloroplast.
6. Diagram the relationship of autotrophs to heterotrophs as photosynthetic organisms.
7. Write the overall process of photosynthesis as an equation.
8. Explain how redox reactions are used in photosynthesis.
9. Describe the role of enzymes during photosynthesis.
10. Explain the role of photosynthetic pigments in harnessing solar energy.
11. Examine how ATP and NADPH are produced from redox reactions and membrane gradients.
12. Describe the three major steps of the Calvin cycle.
13. Illustrate why it takes three turns of the Calvin cycle to produce one G3P.
14. Describe how the double-membraned structure of chloroplast allows cells to capture solar energy and convert it to chemical energy in photosynthesis.
15. Diagram how autotrophs take in carbon dioxide from the environment when they photosynthesize and autotrophs and heterotrophs return it to the atmosphere when they carry on cellular respiration.
16. Explain when carbon is converted from glucose into carbon dioxide during cellular respiration.

HS-LS1-6 **Students will construct an explanation based on evidence from multiple sources for how carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur may combine with other elements to form organic macromolecules with different structures and functions.**

1. Utilize the periodic table to evaluate relationships between atomic number and mass number.
2. Describe how variations in an atomic nucleus account for its physical properties.
3. Explain how two isotopes of an element vary with regard to their atomic structure.
4. Describe how elements are combined into molecules and compounds.
5. List the different types of bonds that occur between elements.
6. Explain the difference between a polar and a nonpolar covalent bond.
7. Describe how water associates with other molecules in solution.
8. Explain how hydrogen bonds relate to the properties of water.
9. Distinguish between an acid and a base.
10. Explain how the properties of carbon enable it to produce divers organic molecules
11. Explain the relationship between a functional group and the chemical reactivity of an organic molecule.
12. Explain why water is needed for the breakdown of a biomolecule.
13. Summarize the role of carbohydrates in a cell.
14. Compare the energy and structural uses of starch, glycogen, and cellulose.
15. Contrast the structures of fats, phospholipids, and steroids.
16. Compare the functions of phospholipids and steroids in cells.
17. Explain how a polypeptide is constructed from amino acids.
18. Understand the factors that affect protein structures and function.
19. Distinguish between a nucleotide and nucleic acid.

HS-LS1-7 **Students will use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.**

1. Summarize the phases of cellular respiration.
2. Explain why NAD^+ and FAD are needed during cellular respiration.
3. Describe the four phases of complete glucose breakdown.
4. Create a diagram that explains the process of Glycoloysis to include the energy-investment step and energy-harvesting steps.
5. Explain the fate of each carbon during the complete aerobic metabolism of glucose.
6. Examine which processes during glucose breakdown produce the most ATP.
7. Evaluate how catabolism and anabolism are balanced within a cell.
8. Compare the structure and function of chloroplasts and mitochondria.
9. Draw a model of mitochondrion and label at least two important features, as well as label the essential functions they provide for the cell.

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

HS-LS2-3 **Students will construct and revise an explanation based on evidence for the cycling of matter and flow of energy aerobic and anaerobic conditions.**

1. Compare potential and kinetic energy.
2. Describe the first and second laws of thermodynamics.
3. Examine how the organization and structure of living organisms are related to heat and entropy.
4. Describe how energy is stored in a molecule of ATP (adenosine diphosphate).
5. Examine how cells us ATP to drive energetically unfavorable reactions.
6. Recognize how enzymes influence the activation energy rates of a chemical reaction.
7. Distinguish between conditions and factors that affect an enzyme's rate of reaction.
8. Explain how autotrophs are able to produce their own food.
9. Compare the roles of oxygen and carbon dioxide in autotrophs and heterotrophs.
10. Describe the relationship between wavelength and energy in the electromagnetic spectrum.
11. Explain how different ways of achieving photosynthesis allow plants to adapt to particular environments.
12. Explain how the processes of photosynthesis and cellular respiration are interdependent.
13. Describe the role of glycolysis in cellular respiration.
14. List the inputs and outputs of glycolysis.
15. Summarize the two fermentation pathways.
16. Discuss the conditions under which organisms may switch between cellular respiration and fermentation.
17. Compare the pathways of carbohydrate, fat, and protein catabolism

HS-LS2-4 **Students will use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.**

1. Explain how the reactions for photosynthesis and cellular respiration represent oxidation-reduction reactions.
2. Summarize the relationship between the metabolic reactions of photosynthesis and cellular respiration.
3. Mathematically describe the overall process of photosynthesis.
4. Compare energy input and output of the light reaction.
5. Compare carbon input and output of the Calvin cycle reaction.
6. Describe the three steps of the Calvin cycle and when ATP and/or NADPH is needed.
7. Evaluate the significance of RuBP carboxylase enzyme to photosynthesis.
8. Explain how glyceraldehyde-3-phosphate (G3) is used to produce other necessary plant molecules.
9. Compare the internal location of photosynthesis in C_3 and C_4 plants.
10. Contrast C_3/C_4 modes of photosynthesis with CAM photosynthesis.
11. Describe how the formula for cellular respiration includes both oxidation and reduction reactions.
12. Examine the role of the NADH and $FADH_2$ redox reactions in cellular respiration.
13. Describe the four phases of complete glucose breakdown, including with release CO_2 and which produce H_2O.
14. Explain how energy-investment and energy-harvesting steps of glycolysis result in two net ATP.
15. Diagram how fermentation consists of glycolysis followed by a reduction of pyruvate.
16. Contrast substrate-level phosphorylation and chemiosmosis as methods of ATP synthesis.
17. Explain how the structure of mitochondria and chloroplasts enables a flow of energy through living organisms.

HS-LS2-1 **Students will use mathematical or computational representations to support arguments about environmental factors that affect carrying capacity, biodiversity, and populations in ecosystems.**

1. Interpret survivorship curves and life tables.
2. Recognize how the proportion of individuals at varying reproductive stages determines a population's age distribution.
3. Explain how carrying capacity (K) limits exponential growth.
4. Identify the features of logistic growth and the carrying capacity of a population.
5. Compare the density-independent and density-dependent factors that affect population size.
6. Describe the two factors that can cause predator and prey populations to cycle in a predictable manner.
7. Explain how the interactions between different species in a community and the landscape in which they live determine diversity.
8. Complete a graph that shows the cause of extinction for a species from most influential to least influential.

HS-LS2-6 **Students will 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.**

1. Provide an example of how living things respond to their environment.
2. Identify how the interactions among species organize a community.
3. Choose the correct sequence of events that occur during ecological succession.
4. Compare the two types of ecological succession.
5. Describe the interactions of organisms with their environment that comprise an ecosystem.
6. Identify the way autotrophs, photoautotrophs, and heterotrophs obtain nutrients.
7. Interpret the energy flow among and biogeochemical cycling with and among ecosystems.
8. Identify the various types of populations that are at the base of an ecological pyramid and the start of a food chain.
9. Compare the flow of energy to the flow of chemicals through an ecosystem.
10. Describe how solar radiation produces variations in Earth's climate.
11. Explain how global air circulation patterns and physical geographic features are associated with the Earth's temperature and rainfall patterns.
12. Recognize the geographic distribution of the major terrestrial biomes.
13. Identify the key characteristics of the major terrestrial biomes.
14. Compare the characteristics of freshwater and saltwater ecosystems.
15. Interpret the manner in which ocean currents affect the climate and weather over the continents.
16. Classify the causes of extinction.

HS-LS2-7 **Students will design, evaluate, and refine a solution for reducing the direct and indirect impacts of human activities on the environment and biodiversity and analyze scientific concepts used by American Indians to maintain healthy relationships with environmental resources.**

1. Describe the past and present growth patterns of the human population.
2. Identify the pressures the human population places on Earth's resources.
3. Explain how human activities contribute to the endangerment and possible extinction of other species.
4. Appraise what responsibility humans have for maintaining the Earth's biodiversity.
5. Identify the role of conservation biology with regard to biodiversity.
6. Describe how conservation biology is supported by variety of disciplines.
7. Compare the direct and indirect values of biodiversity.
8. Describe the role biodiversity plays in a natural ecosystem.
9. Compare natural and human-influenced causes of extinction.
10. Identify and explain the most useful procedures for habitat restoration.
11. Describe two human actions that threaten ecosystems and life on earth.

HS-LS3 Heredity: Inheritance and Variation of Traits

HS-LS3-1 **Students will construct an explanation using evidence from multiple sources to describe the role of cellular division and differentiation in producing and maintaining complex organisms.**

1. Understand the functions of proteins in cell.
2. Explain how genetic information is stored and transmitted in the form of specific sequences of DNA and RNA.
3. Describe the structure and function of the nucleus.
4. Describe the flow of information from DNA to a protein.
5. Explain the role of ribosomes in protein synthesis.
6. Describe the diverse role of proteins in membranes
7. Explain the purpose of a metabolic pathway and how enzymes help regulate it.
8. Recognize how enzymes influence the activation energy rates of a chemical reaction.
9. Distinguish between conditions and factors that affect an enzyme's rate of reaction.
10. Describe human diseases caused by changes in the number of sex chromosomes.
11. Characterize how changes in chromosome structure can lead to human diseases.
12. Contrast blending and Mendel's particulate concept of inheritance.
13. Explain the chemical structure of DNA as defined by the Watson and Crick model.
14. Explain why the replication of DNA is semi-conservative.
15. Explain the function of transcription and translation.
16. Distinguish among the events of transcription that occur during formation of an mRNA molecule.
17. Examine the stages of translation and the events that occur during each stage.
18. Describe the steps involved in making a recombinant DNA molecule.
19. Identify how PCR may be used to analyze DNA.
20. Describe the steps involved in the production of a transgenic animal.
21. Distinguish between in vivo and ex vivo gene therapy in humans.
22. Identify the function of repetitive elements, transposons, and unique noncoding DNA sequences in the human genome.
23. Explain how DNA microarrays are used in the study of genomics.
24. Describe how genetically modified organisms (GMOs), including transgenic and cloned animals and plants, have been engineered to add beneficial characteristics or to produce novel protein products such as pharmaceuticals.

HS-LS3-2 **Students will make and defend a claim based on evidence from multiple sources that inheritable genetic variations may result from:**

- **new genetic combinations through meiosis,**
- **viable errors occurring during replication, or**
- **mutations caused by environmental factors.**

1. List the stages of interphase, and describe the major events that occur during each stage in preparation for cell division.
2. List the checkpoints that regulate the progression of cells through the cell cycle.
3. Explain the mechanisms within the G, cell cycle checkpoint that evaluate growth signals, determine nutrient availability, and assess DNA integrity.
4. Explain how DNA becomes sufficiently compacted to fit inside a nucleus.
5. Distinguish between euchromatin and heterochromatin.
6. Explain how the cell prepares the chromosomes and centrosomes prior to nuclear division.
7. Summarize the major events that occur during mitosis and cytokinesis.
8. Discuss why human stem cells continuously conduct mitosis.
9. Describe the basic characteristics of cancer cells.
10. Explain the difference between a benign and malignant tumor.
11. Distinguish between the roles of the tumor suppressor genes and proto-oncogenes in the regulation of the cell cycle.
12. Contrast haploid and diploid chromosome numbers.
13. Explain what is meant by homologous chromosomes.
14. Summarize the process by which meiosis reduces the chromosome number.
15. Understand the importance of genetic variation to evolutionary change.
16. Explain how crossing-over contributes to genetic variation.
17. Examine how independent assortment contributes to genetic variation.
18. Describe the phases of meiosis and the major events that occur during each phase.
19. Understand how meiosis reduces the chromosome number from diploid to haploid.
20. Contrast changes in chromosome number, genetic variability, and number of daughter cells between meiosis and mitosis.
21. Explain Mendel's Cross as viewed by modern genetics.
22. Describe spermatogenesis and oogenesis in humans.
23. Distinguish between the introns and exons of a gene.
24. Explain the potential evolutionary benefits of alternative mRNA splicing.
25. Distinguish between spontaneous and induced mutations.
26. Explain the unique characteristic of viruses compared to living cells.
27. Describe the process of viral reproduction.
28. Explain how retroviruses use reverse transcriptase to transcribe DNA from RNA.
29. Describe how new virulence factors, or environmental factors may encourage the spread of emerging diseases.

HS-LS3-3 **Students will apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.**

1. Describe how Mendel's scientific approach enabled his genetic experiments to be successful.
2. Explain the difference between the particulate theory of inheritance and the blending concept.
3. Explain Mendel's law of segregation and law of independent assortment.
4. Compare and contrast dominant alleles with recessive alleles and their relation to genotype and phenotype.
5. Use a Punnett square and the law of probability to predict the chances of producing gametes and offspring.
6. Distinguish between an autosomal dominant and an autosomal recessive pattern of inheritance.
7. Identify the pattern of inheritance for selected single-gene human disorders.
8. Explain the inheritance pattern of traits when more than two alleles for the trait exits.
9. Contrast incomplete dominance and incomplete penetrance.
10. Describe the effects of pleiotropy on phenotypic traits.
11. Explain the concept of polygenic and multifactorial traits.
12. Understand how X-linked inheritance differs from autosomal inheritance.

HS-LS4 Biological Evolution: Unity and Diversity

HS-LS4-1 **Students will evaluate and communicate scientific information about how common ancestry and biological evolution are supported by multiple lines of empirical evidence.**

1. List several hypotheses about the natural origin of life on Earth.
2. Explain how changes in DNA sequences and the biomolecules for which they code lead to diversity in biological life.
3. Describe chemical evolution through the formation of organic monomers, and then polymers, from inorganic elements present on early Earth.
4. Differentiate between protocells, true cells, and multicellular organisms using metabolism to self-replicate.
5. Explain the processes of relative and absolute dating of fossils.
6. List three sources of evidence that support the endosymbiotic theory of organelle evolution.
7. Describe in chronological order the periods of Earth's history, and identify one major biological event that took place in each.
8. Describe plate tectonics and how it explains the drifting of continents.
9. Interpret biogeographical and geological evidence that supports continental drift.
10. Compare and contrast the archaea, eukarya and bacteria domains.
11. Argue how the overuse of antibiotics has led to selection of new variations of bacteria.
12. Critic how the phenomenon of emergent diseases supports present-day evolution.
13. Explain how phylogenetic trees and cladograms are graphical representation of evolutionary history that show common ancestors and descendants of groups of living organisms, including fungi.
14. Differentiate among taxonomy, classification, and systematic biology.
15. Utilizing the modified Linnaeus' classification system, fossil, anatomical and molecular data to categorize species into groups that reflect shared evolutionary relationships.
16. Compare and contrast algae with land plants.
17. List the traits that enabled plants to adapt to life on land.
18. List three common characteristics of animals that are not found in other multicellular eukaryotes.
19. Demonstrate with a phylogenetic tree how traits, such as opposable thumbs, the number of chambers in the heart, or legs in marine animals, develop or are lost as evolution occurs.
20. Construct a phylogenetic tree based on fossil, morphological, and molecular evidence to show the evolutionary history of primates and hominids.

HS-LS4-2 **Students will construct an explanation based on evidence that the process of evolution by natural selection primarily results from four factors:**

- **the potential for a species to increase in number,**
- **the heritable genetic variation of individuals in a species due to mutation and sexual reproduction,**
- **competition for limited resources, and**
- **the proliferation of those organisms that are better able to survive and reproduce in the environment.**

1. Explain the relationship between the process of natural selection and evolutionary change.
2. Understand the basics of taxonomic classification.
3. Explain the importance of genetic variation and mutation to evolutionary change.
4. Explain how cross-over contributes to genetic variation.
5. Examine how independent assortment contributes to genetic variation.
6. Compare chromosome alignment during meiosis I to mitosis.
7. Use a Punnett square and the law of probability to predict the chances of producing gametes and offspring.
8. Distinguish between spontaneous and induced mutations.
9. Identify how mutations influence protein structure.
10. Explain how a change in the nucleotide sequence of DNA, if expressed as a phenotype, is acted upon by natural selection.
11. List examples of the evidence Darwin gathered from fossils and biogeography that supported his growing idea of shared ancestry.
12. Summarize the components of Darwin's theory of evolution by natural selection.
13. Give examples of how the mechanisms of evolutionary change can be identified and studied.
14. Explain how evolution in populations is related to a change in allele frequencies.
15. List the five conditions necessary to maintain Hardy-Weinberg equilibrium and apply the principle to estimate equilibrium genotype frequencies.
16. Describe the agents of evolutionary change.
17. Compare stabilizing, directional, and disruptive selection.
18. List two examples of how diversity is maintained populations.
19. Describe why heterozygote advantage is a form of stabilizing selection.
20. Explain how the stability or instability of an environment affects the speed and direction of evolution.

HS-LS4-3 **Students will 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.**

1. Identify how polymerase chain reaction (PCR) can be used to analyze DNA.
2. Distinguish among the sciences of genomics, proteomics, and bioinformatics.
3. Explain how DNA microarrays are used in the study of genomics.
4. Summarize how modern technology allows comparisons of genomes of organisms from every domain, revealing interesting and sometimes unexpected relationships.
5. Apply the Hardy-Weinberg principle to estimate equilibrium genotype frequencies.
6. Determine the type of natural selection operating on a trait by the change in shape of a phenotype distribution.
7. Discriminate between ancestral and derived traits.
8. Interpret the evolutionary relationships depicted in a phylogeny.
9. Construct a cladogram from a list of the types of traits used to construct a phylogeny.

HS-LS4-4 **Students will construct an explanation based on evidence for how natural selection leads to adaptation of populations over time.**

1. Explain how modifications are passed down through generations.
2. Compare and contrast the structure of animal and plant cells.
3. Describe three specific examples of evidence from cells and the structures that support the concept of common ancestry for all organisms.
4. Define two modes of speciation and give examples of each.
5. Identify an example of adaptive radiation.
6. Distinguish between coevolution and convergent evolution.
7. Distinguish between the gradualistic and the punctuated equilibrium models of evolution.
8. Explain how gene expression can influence speciation.
9. Contrast evolution and natural selection based on need in a particular environment at a particular time.
10. Define natural selection and adaptation.
11. Defend Darwin's theory of natural selections based on observations that organisms competed for resources, and those best adapted survived and reproduced.
12. Identify the key components of the gymnosperm and angiosperm life cycles.
13. List the life cycle changes that have enabled pines to better adapt to life on land.
14. Describe how polyploidy allows plants to achieve rapid speciation.
15. Identify primate traits that are adaptive for living in trees.
16. Discuss some specific adaptations that are seen in omnivores, herbivores, and carnivores.
17. Compare and contrast microevolution and macroevolution.
18. Identify and compare features of prezygotic and postzygotic reproductive isolation.
19. Evaluate the differences in the alternation of generations of land plants.
20. Give an example of how humans impact evolution when they cause ecological stress.
21. Explain why the introduction of exotic species can be detrimental to biodiversity.

HS-LS4-5 **Students will evaluate the evidence supporting claims that changes in environmental conditions may result in:**

- **changes in the number of individuals of some species,**
- **the emergence of new species over time,**
- **the extinction of other species.**
- **investigate and explain American Indian perspectives on changes in environmental conditions and their impacts.**

1. Explain how the stability of an environment effects the rate of evolution within it.
2. Identify the ecological levels that exist within the field of ecology.
3. Describe the central goal of modern ecological studies.
4. Recognize how environmental conditions affect the density and distribution patterns of a population.
5. Distinguish between population density and population distribution.
6. Describe exponential population growth and the circumstances that encourage it.
7. Explain the conditions that would cause a population undergo logistic growth.
8. Defend the statement that the pace of evolution is tied to the stability of the environment.
9. Explain the difference between species richness and diversity.
10. Identify the difference between an organism's habitat and its niche.
11. Explain what happens to a species if it cannot coevolve along with the species it is interacting with.
12. Identify the events that occur during succession.
13. Explain the energy flow among populations through food webs and ecological pyramids.
14. Provide examples of how human activities can alter the biogeochemical cycles.
15. Describe what degree of DNA difference is necessary to qualify two organisms as different species.
16. Recognize the spectrum of biodiversity.
17. Describe the value of preserving biodiversity hotspots.
18. Distinguish between keystone species and flagship species.

CHEMISTRY
Science Elective

STRAND Physical Science

Students will use crosscutting concepts, science and engineering practices, and technology while investigating how matter and energy exist in a variety of forms and how physical and chemical interactions change matter and energy.

STANDARDS GOALS and PERFORMANCE OBJECTIVES

Structure and Properties of Matter

HS-PS1-1 **Students will 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.**

1. Describe the structure of a typical atom.
2. Compare and contrast Thomson's plum pudding atomic model with Rutherford's nuclear atomic model.
3. Evaluate the experiments that led to the conclusion that electrons are negatively charged particles found in all matter.
4. Compare the relative charge and mass of each of the subatomic particles.
5. Explain how the type of an atom is defined.
6. Recall which subatomic particle identifies an atom as that of a particular element.
7. Explain how the existence of isotopes is related to the fact that atomic masses are now whole numbers.
8. Explain how unstable atoms gain stability.
9. State what quantities are conserved when balancing a nuclear reaction.
10. Classify a chemical reaction versus a nuclear reaction.
11. Compare the dual nature of light
12. Describe the phenomena that can be explained only by the particle model of light
13. Compare and contrast continuous spectrum and emission spectrum.
14. Employ quantum theory to assess the amount of energy that matter gains and loses.
15. Explain the reason, according to Bohr's atomic model, why atomic emission spectra contain only certain frequencies of light.
16. Enumerate the sublevels contained in the hydrogen atom's first four energy levels.
17. Explain why the location of an electron in an atom is uncertain using the Heisenberg uncertainty principle and de Broglie's wave-particle duality.
18. Apply the Pauli exclusion principle, the aufbau principle, and Hund's rule to write out the electron configuration and draw the orbital diagram for elements.
19. Describe the development of the modern periodic table to include contributions by Lavoisier, Newlands, Mendeleev, and Moseley.
20. Describe the general characteristics of metals, nonmetals, and metalloids.

21. Explain what determines the blocks in the periodic table.
22. Explain why elements within a group have similar chemical properties.
23. Explain how the period and group trends in atomic radii are related to electron configuration.
24. Explain why it takes more energy to remove the second electron from a lithium atom than it does to remove the fourth electron from a carbon atom.

HS-PS1-3 **Students will 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.**

1. Explain what determines a substance's state at a given temperature.
2. Compare and contrast intermolecular forces and describe intramolecular forces.
3. Contrast the arrangement of particles in solids and liquids.
4. Describe the factors that affect viscosity.
5. Explain how the addition or removal of energy can cause a phase change.
6. Compare and contrast deposition, sublimation and evaporation.
7. Relate collision theory to reaction rate.
8. Explain what the reaction rate indicates about a particular chemical reaction.
9. Describe the relationship between activation energy and the rate of a reaction.
10. Apply collision theory to explain why collisions between two reacting particles do not always result in the formation of a product.
11. Explain the difference between a catalyst and an inhibitor.
12. Explain what the rate law for a chemical reaction tells you about the reaction.
13. Explain the function of the specific rate constant in a rate-law equation.
14. Compare and contrast an elementary chemical reaction with a complex chemical reaction.

HS-PS1-4 **Students will 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.**

1. Explain how unstable atoms gain stability.
2. State what quantities are conserved when balancing a nuclear reaction.
3. Differentiate between a chemical reaction and a nuclear reaction.
4. List the different types of radiation and their charges
5. Compare the subatomic particles involved in nuclear and chemical reactions.
6. Describe what happens to unstable nuclei.
7. Explain how you can predict whether or not an isotope is likely to be stable if you know its number of neutrons and protons.
8. Describe the forces acting on the particles within a nucleus and explain why neutrons are the glue holding the nucleus together.
9. Compare and contrast nuclear fission and nuclear fusion reactions.
10. Explain how nuclear fission can be used to generate electric power.

HS-PS2-6 **Students will communicate through scientific and technical information roles of molecular-level structure in the functioning of designed materials.**

1. Classify examples of physical changes versus chemical changes.
2. List four indicators of chemical change.
3. Summarize the rules for naming binary molecular compounds.
4. Describe the information contained in a structural formula.
5. State the steps used to draw Lewis structures.
6. Summarize exceptions to the octet rule.
7. Summarize the VSEPR bonding theory.
8. Summarize how electronegativity difference is related to bond character.
9. Compare and contrast a polar covalent bond and a polar molecule.
10. Categorize bond types using electronegativity difference.

Chemical Reactions

HS-PS1-2 **Students will construct and revise an explanation for outcomes of simple chemical reactions based on outer electron states of atoms, trends in the periodic table, and patterns of chemical properties.**

1. Explain the stability of a lithium atom with that of its ion, Li^{+}.
2. Describe two different causes of the force of attraction in a chemical bond.
3. Summarize iconic bond formation.
4. Explain how an iconic compound made up of charged particles can be electrically neutral.
5. Identify three physical properties of ionic compounds that are associated with ionic bonds, and relate them to bond strength.
6. State the order in which the ions associated with a compound composed of potassium and bromine would be written in the chemical formula and the compound name.
7. Describe the difference between a monatomic ion and a polyatomic ion.
8. Contrast the structures of ionic compounds and metals.
9. Explain how the conductivity of electricity and the high boiling points of metals are explained by metallic bonding.
10. Contrast the cause of the attraction in ionic bonds and metallic bonds.
11. Identify the type of atom that generally forms covalent bonds.
12. Describe how the octet rule applies to covalent bonds.
13. Illustrate the formation of single, double, and triple covalent bonds using Lewis structures.
14. Compare and contrast ionic bonds, covalent bonds, sigma bonds and pi bonds.

HS-PS1-4 **Students will develop a model to illustrate that the release or absorption of energy from chemical reactions is dependent upon changes in total bond energy.**

1. Explain why it is important that a chemical equation be balanced.
2. List three types of physical evidence that indicate a chemical reaction has occurred.
3. Compare and contrast a skeleton equation and a chemical equation.
4. Describe the four types of chemical reactions and their characteristics.
5. Compare and contrast single-replacement reactions and double-replacement reactions.
6. List three types of products produced by reactions that occur in aqueous solutions.
7. Describe solvents and solutes in aqueous solutions.
8. Distinguish between a complete ionic equation and a net ionic equation.

HS-PS1-5 **Students will 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.**

1. Explain the kinetic theory as it relates to the behavior of gases.
2. Describe how the mass of a gas particle affects its rate of effusion and diffusion.
3. Explain how gas pressure is measured.
4. Explain how energy changes from one form to another in an exothermic and endothermic reactions.
5. Distinguish between kinetic and chemical potential energy.
6. Describe how you would calculate the amount of heat absorbed or released by a substance when its temperature changes.
7. Write a thermochemical equation.
8. Explain what is meant by Hess's law.
9. Compare and contrast spontaneous and nonspontaneous reactions.

HS-PS1-6 **Students will refine the design of a chemical system by specifying changes in conditions that would alter the amount of products at equilibrium.**

1. Explain how the size of the equilibrium constant relates to the amount of product formed at equilibrium.
2. Compare homogeneous and heterogeneous equilibria.
3. List three characteristics a reaction mixture must have if it is to attain a state of chemical equilibrium.
4. List factors that can be stresses on an equilibrium system.
5. List the information you would need in order to calculate the concentration of a product in a reaction mixture at equilibrium.
6. Explain how to use the solubility product constant to calculate the solubility of a sparingly soluble ionic compound.
7. Describe how the presence of a common ion reduces the solubility of an ionic compound.

8. Explain why many Lewis acids and bases are not classified as Arrhenius or Bronste-Lowry acids and bases.
9. Compare the physical and chemical properties of acids and bases.
10. Explain how the concentrations of hydrogen ions and hydroxide ions determine whether a solution is acidic, basic, or neutral.
11. Relate the strength of a weak acid to the strength of its conjugate base.
12. Explain why the pH of an acidic solution is always a smaller number than the pOH of the same solution.
13. Explain why the net ionic equation for the neutralization reaction of any strong acid with any strong base is always the same.
14. Explain the difference between the equivalence point and the end point of a titration.

HS-PS1-7 **Students will use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.**

1. Explain why chemists use the mole.
2. State the mathematical relationship between Avogardro's number and 1 mol.
3. List the conversion factors used to convert between particles and moles.
4. Summarize in terms of particles and mass, one-mole quantities of two different monatomic elements.
5. State the conversion factor needed to convert between mass and moles of the atom fluorine.
6. Explain how molar mass relates the mass of an atom to the mass of a mole of atoms.
7. Describe how to determine the molar mass of a compound.
8. Identify the conversion factors needed to convert between the number of moles and the mass of a compound.
9. Explain how you can determine the number of atoms or ions in a given mass of a compound.
10. Summarize the composition of a hydrate.
11. Compare the mass of the reactants and the mass of the products in a chemical reaction.
12. State how many mole ratios can be written for a chemical reaction involving three substances.
13. Categorize the ways in which a balanced chemical equation can be interpreted.
14. Explain why a balanced chemical equation is needed to solve a stoichiometric problem.
15. List the four steps used in solving stoichiometric problems.
16. Describe how a mole ratio is correctly expressed when it is used to solve a stoichiometric problem.
17. Describe the reason why a reaction between two substances comes to an end.
18. Differentiate between theoretical yield, actual yield, and percent yield.

Physics
Science Elective

STRAND Physical Science

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STANDARDS GOALS and PERFORMANCE OBJECTIVES

Forces and Interactions

HS-PS2-1 **Students will 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.**

1. Draw a motion diagram.
2. Plot a position-time graph.
3. Explain how average speed and average velocity are related to each other.
4. Explain how acceleration is different from velocity.
5. Explain the relationship among position, velocity, acceleration, and time.
6. Define the relationship between force and acceleration.
7. Explain how the weight and mass of an object are related.
8. Describe how actual weight and apparent weight differ.

HS-PS2-2 **Students will use mathematical representations to demonstrate how total momentum of a system is conserved when there is no net force on the system.**

1. Add vectors in two dimensions.
2. List the components of a vector.
3. Compare and contrast kinetic and static friction.
4. Explain how to find the force required for equilibrium in the x and y directions.
5. Define impulse, momentum and angular momentum.

HS-PS2-3 **Students will apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes forces on an object during collisions.**

1. Explain how the vertical and horizontal motions of a projectile are related.
2. Explain what causes centripetal acceleration.
3. Demonstrate centripetal acceleration in relation to an object's speed and the radius of the circle.
4. Define relative velocity.
5. Find the velocities of an object in different reference frames.
6. Describe angular motion using angular displacement, angular velocity and angular acceleration.
7. Define torque and the moment of inertia as they relate to rotational motion.
8. Explain Newton's second law for rotational motion.
9. Define the center of mass.
10. Explain how the location of the center of mass affects the stability of an object.
11. Explain how rotating frames of reference give rise to apparent forces.
12. Explain how Newton's third law relates to conservation of momentum.
13. List the conditions in which momentum is conserved.
14. Explain how the law of conservation of momentum and the law of conservation of angular momentum explain the motion of objects.

HS-PS2-4 **Students will use a mathematical representation of Newton's Law of Gravitation and Coulomb's Law to explain gravitational and electrostatic forces between objects.**

1. Summarize Newton's law of universal gravitation, and how it relates to Kepler's laws.
2. Know the gravitational force between two objects is proportional to the product of their masses divided by the square of the distance between them.
3. Describe orbital motion.
4. Compare and contrast gravitational mass and inertial mass.
5. Explain gravitational force and Einstein's proposal.
6. Demonstrate how charged objects exert forces, both attractive and repulsive.
7. Differentiate between conductors and insulators.
8. Define Coulomb's law and how it is used.
9. Explain how the electrostatic force depends on the distance between charges.
10. Relate charge, electric field and forces on charged objects.
11. Describe an electric field.

HS-PS2-5 **Students will plan and conduct investigations to provide evidence that electric currents can produce magnetic fields and changing magnetic fields can produce electric currents.**

1. Define electric current.
2. State Ohm's law.
3. Describe how electrical energy can be transformed to radiant energy, thermal energy and mechanical energy.
4. List the characteristics of series and parallel circuits.
5. Compare and contrast currents, potential differences and equivalent resistances in series and parallel circuits.
6. State the Kirchhoff's Rules as related to electric circuits.
7. Use a voltmeter and ammeter to measure potential differences and currents in circuits.
8. List the properties of magnets.
9. Explain the characteristics of magnetic fields.
10. Describe the relationship between magnetic fields and electric currents.
11. Explain what affects the force on a charged particle moving in a magnetic field.

Energy

HS-PS3-1 **Students will 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 and energy flows in and out of the system are known.**

1. Define work and energy and their relations.
2. Explain how power is related to work and energy.
3. Compare and contrast kinetic energy, gravitational potential energy, and elastic potential energy.
4. List how mass and energy are related.
5. Explain the condition necessary in a closed, isolated system for energy to be conserved.
6. Describe how momentum and kinetic energy are conserved or changed in a collision.
7. Explain how temperature and thermal energy are related.

HS-PS3-2 **Students will 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 and energy associated with the relative position of particles.**

1. Define periodic motion.
2. Describe how air particles collide to create sound waves.
3. Mathematically define the Doppler effect.
4. Define the origin of sound.
5. Describe the ray model of light.
6. Explain how diffraction demonstrates that light has wave properties.
7. Explain how phenomena such as polarization and the Doppler effect occur.
8. Use the Bohr model to represent the atom.
9. Define emission spectra and absorption spectra.
10. Explain how the radius and energy of electron orbitals depend on the principal quantum number.
11. List the characteristics of the quantum model of the atom.
12. List the properties of laser light.

HS-PS3-3 **Students will design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.**

1. Explain a machine and how it makes tasks easier.
2. Explain how mechanical advantage, the effort force, and the resistance force are related.
3. Define mechanical advantage and efficiency.
4. Describe the relationship among the pressure, volume and temperature of a gas.
5. Explain the gas law.
6. Compare and contrast cohesive and adhesive forces between particles of substances.
7. State Pascal's principle.
8. Demonstrate Archimedes' principle of buoyancy.
9. Explain the role of Bernoulli's principle in airflows.
10. Explain why solids expand and contract when the temperature changes.

HS-PS3-4 **Students will 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.**

1. List the ways thermal energy is transferred.
2. Recite the first and second law of thermodynamics.
3. Explain how heats of fusion and vaporization are related to changes in the state of matter.

HS-PS3-5 **Students will develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the change in energy of the objects due to the interaction.**

1. Define induced electromotive force in a wire in mathematical terms.
2. Explain how Lenz's law is related to induced electromotive force.
3. Determine the velocities of particles in electric and magnetic fields.
4. Find the charge-to-mass ratios of particles in electric and magnetic fields.
5. Describe how a mass spectrometer separates ions of different masses.
6. Explain how electromagnetic waves propagate through space.

Waves and Electromagnetic Radiation

HS-PS4-1 **Students will use mathematical representations to support a claim regarding relationships among the frequency, amplitude, wavelength, and speed of waves traveling in various media.**

1. Explain the relationship between wave speed, wavelength, and frequency.
2. Compare transverse and longitudinal waves.
3. Explain how waves are reflected and refracted at boundaries between mediums.
4. Explain the principle of superposition and the phenomenon of interference.
5. Analyze how the characteristics of resonance work in various musical instruments.

HS-PS4-3 **Students will 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.**

1. Define electromagnetic waves.
2. Analyze how electromagnetic wave propagate through space and the speed varies depending on the different materials.
3. Explain how electromagnetic waves transmit information.
4. Describe the characteristics of the electromagnetic spectrum emitted by an object.
5. State the photoelectric and the Compton effect.
6. Use De Broglie's theory of matter waves as a way to calculate the wavelength of any moving particle.
7. Define the Heisenberg uncertainty principle.

HS-PS4-4 **Students will evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.**

1. List the properties of the nucleus of an atom.
2. Differentiate between nuclei of isotopes.
3. Explain the force that hold the nucleus together.
4. Explain how the mass defect of a nucleus and the binding energy are related.
5. Give the characteristics of the alpha decay, beta decay and gamma decay.
6. Compare and contract nuclear fission and fusion in releasing energy.

HS-PS4-5 **Students will 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.**

1. State Snell's law of refraction.
2. Explain the index of refraction.
3. Demonstrate real and virtual images formed by single convex and concave lenses.
4. Use a ray diagram and an equation to show how images are formed by lenses.
5. Explain how an eye focuses light to form an image.
6. Analyze how the band theory of solids explains conduction.
7. Differentiate the energy levels in conductors, insulators, and semiconductors.
8. Compare and contrast n-type and p-type semiconductors.
9. Define a diode and some of its uses.
10. Generalize the major function of a transistor.