Appendix III – Louisiana State Science Standards

From: Louisiana Department of Education - Louisiana Student Standards for Science

The Louisiana Student Standards for Science were created by over eighty content experts and educators with input from parents and teachers from across the state. Educators envisioned what students should know and be able to do to compete in our communities and create standards that would allow students to do so. The LSSS provide appropriate content for all grades or courses, maintain high expectations, and create a logical connection of content across and within grades.

The LSSS represents the knowledge and skills needed for students to successfully transition to postsecondary educations and the workplace. The standards call for students to:

- Apply content knowledge
- Investigate, evaluate and reason scientifically
- Connect ideas across disciplines

The LSSS do not dictate curriculum or teaching methods. Decisions about how to teach these expectations are left to local districts, schools, and teachers.

Structure and Components of the Standards

The LSSS are arranged by grade levels from kindergarten to high school. The standards include:

- *Performance Expectations* – define what students should be able to do by the end of the year.

- *Science and Engineering Practices* – the practices that scientists and engineers use when investigating real -world phenomena and designing solutions to problems. There are eight science and engineering practices that apply to all grade levels and content areas.
    1. Asking questions and defining problems
    2. Developing and using models
    3. Planning and carrying out investigations
    4. Analyzing and interpreting data
    5. Using mathematical and computational thinking
    6. Constructing explanations and designing solutions
    7. Engaging in an argument with evidence
    8. Obtaining, evaluating and communicating information

- *Disciplinary Core Ideas* – the most essential ideas (content) in major science disciplines that students will learn. Disciplinary Core Ideas are grouped into 5 science domains.
    1. Physical Science (PS)
    2. Life Science (LS)
    3. Earth and Space Science (ESS)
    4. Environmental Science (EVS)
    5. Engineering, Technology and Applications of Science (ETS)

- *Crosscutting Concepts* – common themes that have applications across all disciplines of science and allow students to connect learning within and across grade levels or content areas. The 7 crosscutting concepts apply to all grade levels and content areas.
    1. Patterns
    2. Cause and effect
    3. Scale, proportion and quantity
    4. Systems and System Models
    5. Energy and matter
    6. Structure and function
    7. Stability and change
- *Clarification Statements* – provide examples or additional explanation to the performance expectation.

Overview of standards covered by NFC lesson plans

6^{th} Grade

Physical Science (PS):

6-MS-PS1-1

Performance Expectation: Develop models to describe the atomic composition of simple molecules and extended structures.

Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include carbon dioxide and water. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular -level models could include drawings, 3-D models, or computer representations showing different molecules with different types of atoms.

Science and Engineering Practices:

2. Developing and using models: Develop and/or use a model to predict and/or describe phenomena. Modeling in 6-8 builds on K-5 and progresses to developing, using, and revising models to describe, test and predict more abstract phenomena and design systems.

Disciplinary Core Ideas:

Structure and Properties of Matter: Substances are made from different types of atoms, which combine with one another in various ways. Atoms from form molecules that range in size from two to thousands of atoms. Solids may be formed from molecules, or they may be extended structures with repeating subunits.

Crosscutting Concepts

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

Life Science (LS):

6-MS-LS1-1

Performance Expectation: Conduct an investigation to provide evidence that living things are made of cells, either one or many different numbers, and types.

Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and nonliving things, and understanding that living things may be made of one or many cells, including specialized cells. Examples could include animal cells (blood, muscle, skin, nerve, bone, or reproductive) or plant cells (root, leaf, or reproductive).

Science and Engineering Practices:

3. *Planning and carrying out investigations*: Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meets the goals of the investigation. Planning and carrying out investigations to answer questions or test solutions to problems in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.

Disciplinary Core Ideas:

Structure and Function: All living things are made up of cells, which are the smallest living unit. An organism may consist of one single cell (unicellular) or many different types/numbers of cells (multicellular).

Crosscutting Concepts

Scale, Proportion, and Quantity: Phenomena that can be observed at one scale may not be observable at another scale.

6-MS-LS2-1

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

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

Science and Engineering Practices:

4. *Analyzing and Interpreting Data*: Analyze and interpret data to provide evidence for phenomena. Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

Disciplinary Core Ideas:

Interdependent Relationships in Ecosystems: Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. Growth of organisms and population increases are limited by access to resources.

Crosscutting Concepts

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

6-MS-LS2-2

Performance Expectation: Construct an explanation that predicts patterns of interaction among organisms across multiple ecosystems.

Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems and relationships among and between biotic and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, mutually beneficial, or other symbiotic relationships.

Science and Engineering Practices:

6. *Constructing explanations and designing solutions*: Construct an explanation that includes qualitative or quantitative relationships between variables that predicts and/or describes phenomena. Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

Disciplinary Core Ideas:

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

Crosscutting Concepts

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

6-MS-LS2-3

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

Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.

Science and Engineering Practices:

2. Developing and using models: Develop and/or use a model to predict and/or describe phenomena. Modeling in 6-8 builds on K-5 and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

Disciplinary Core Ideas:

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

Crosscutting Concepts

Energy and Matter: The transfer of energy can be tracked as energy flows through a designed or natural system.

Earth and Space Science (ESS):

6-MS-ESS3-4

Performance Expectation: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Clarification Statement: Examples of evidence include grad-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, minerals, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions.

Science and Engineering Practices:

7*.* *Engaging in argument from evidence*: Construct, use and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.

Disciplinary Core Ideas:

Human Impacts on Earth Systems: Typically, as human populations and

per-capita consumption of natural resources increases, so does the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Biogeology: Living organisms interact with Earth materials resulting in changes of the Earth.

Resource Management for Louisiana: Responsible management of Louisiana's natural resources promotes economic growth, a healthy environment, and vibrant productive ecosystems.

Crosscutting Concepts

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

Overview of standards covered by NFC lesson plans

7th Grade

Physical Science (PS):

7-MS-PS1-2

Performance Expectation: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, or mixing zinc with hydrogen chloride. Examples of chemical and physical properties to analyze include density, melting point, boiling point, solubility, flammability, or odor.

Science and Engineering Practices:

4. *Analyzing and Interpreting Data*: Analyze and interpret data to determine similarities and differences in findings. Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

Disciplinary Core Ideas:

Structure and Properties of Matter: Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) under normal conditions that can be used to identify it.
Chemical Reactions: Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

Crosscutting Concepts

Patterns: Macroscopic patterns are related to the nature of microscopic and atomic-level structure.

7-MS-PS3-4

Performance Expectation: Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in average kinetic energy of the particles as measured by the temperature of the sample.

Clarification Statement: Emphasis is on observing change in temperature as opposed to calculating total thermal energy transferred. Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.

Science and Engineering Practices:

3*.* *Planning and Carrying Out Investigations*: Plan an investigation individually and collaboratively, and in the design; identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many much data is are needed to support a claim. Planning and carrying out investigations to answer questions or test solutions to problems in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.

Disciplinary Core Ideas:

Definitions of Energy: Temperature is a measure of the average kinetic energy; the relationship between the temperature and the total energy of the system depends on the types, states, and amounts of matter present.
Conservation of Energy and Energy Transfer: The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the mass of the sample, and the environment. Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

Crosscutting Concepts

Scale, Proportion, and Quantity: Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

Life Science (LS):

7-MS-LS1-3

Performance Expectation: Use an argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems. Systems could include circulatory, excretory, digestive, respiratory, muscular, endocrine, or nervous systems.

Science and Engineering Practices:

7*.* *Engaging in argument from evidence*: Construct, use and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.

Disciplinary Core Ideas:

Structure and Function: In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions in order to maintain homeostasis.

Information Processing: Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.

Crosscutting Concepts

Systems and System Models: Subsystems may interact with other systems; they may have subsystems and be a part of larger complex systems.

7-MS-LS1-6

Performance Expectation: Construct a scientific explanation based on evidence for the role of photosynthesis and cellular respiration in the cycling of matter and flow of energy into and out of organisms.

Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.

Science and Engineering Practices:

2. Developing and using models: Develop a model to describe unobservable mechanisms. Modeling in 6-8 builds on K-5 and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

Disciplinary Core Ideas:

Organization for Matter and Energy Flow in Organisms: Within individual organisms, food (energy) 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 through aerobic and anaerobic respiration. Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.

Crosscutting Concepts

Energy and Matter: Matter is conserved because atoms are conserved in physical and chemical processes.

7-MS-LS2-4

Performance Expectation: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

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

Science and Engineering Practices:

7. *Engaging in argument from evidence*: Construct, use and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.

Disciplinary Core Ideas:

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

Crosscutting Concepts

Stability and Change: Small changes in one part of a system might cause large changes in another part.

7-MS-LS2-5

Performance Expectation: Undertake a design project that assists in maintaining diversity and ecosystem services.

Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, habitat conservation, or soil erosion mitigation. Examples of design solution constraints could include scientific, economic, or social considerations.

Science and Engineering Practices:

6. *Constructing explanations and designing solutions*: Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

Disciplinary Core Ideas:

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

Crosscutting Concepts

Stability and Change: Small changes in one part of a system might cause large changes in another part.

7-MS-LS3-2

Performance Expectation: Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.

Science and Engineering Practices:

2. Developing and using models: Develop and/or use a model to predict and/or describe phenomena. Modeling in 6-8 builds on K-5 and progresses to developing, using and revising models to describe, test and predict more abstract phenomena and design systems

Disciplinary Core Ideas:

Growth and Development of Organisms: Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. Cells divide through the processes of mitosis and meiosis.
Inheritance of Traits: Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. In sexually reproducing organisms, each parent contributes to the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.

Crosscutting Concepts

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

Overview of standards covered by NFC lesson plans

8th Grade

Physical Science (PS):

8-MS-PS1-1

Performance Expectation: Develop models to describe the atomic composition of simple molecules and extended structures.

Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of extended structures could include minerals such as but not limited to halite, agate, calcite, or sapphire. Examples of molecular-level models could include drawings, 3-D models, or computer representations showing different molecules with different types of atoms.

Science and Engineering Practices:

2. Developing and using models: Develop and/or use a model to predict and/or describe phenomena. Modeling in 6-8 builds on K-5 and progresses to developing, using and revising models to describe, test and predict more abstract phenomena and design systems

Disciplinary Core Ideas:

Structure and Properties of Matter: Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

Crosscutting Concepts

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

8-MS-PS1-6

Performance Expectation: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride, calcium chloride, or a citric acid and baking soda (sodium bicarbonate) reaction in order to warm or cool an object.

Science and Engineering Practices:

6. *Constructing explanations and designing solutions*: Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

Disciplinary Core Ideas:

Chemical Reactions: Some chemical reactions release energy (exothermic reactions), others store energy (endothermic reactions).
Optimizing the Design Solution: Although one design may not perform the best across all tests, identifying the characteristics of the design that performs best in each test can provide useful information for the redesign process-that is, some of those characteristics may be incorporated in to the new design.

Crosscutting Concepts

Energy and Matter: Flows, Cycles, and Conservation: The transfer of energy can be tracked as energy flows through a designed or natural system.

Life Science (LS):

8-MS-LS1-4

Performance Expectation: Construct and use arguments based on empirical and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of survival and successful reproduction of animals and plants respectively.

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

Science and Engineering Practices:

7. *Engaging in argument from evidence*: Construct, use and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.

Disciplinary Core Ideas:

Growth and Development of Organisms: Animals engage in characteristic behaviors that increase the odds of reproduction. Plants (flowering and non-flowering) reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.

Crosscutting Concepts

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

8-MS-LS1-5

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

Clarification Statement: Examples of local environmental conditions could include the availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting the growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, or fish growing larger in large ponds than they do in small ponds.

Science and Engineering Practices:

6. *Constructing explanations and designing solutions*: Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

Disciplinary Core Ideas:

Growth and Development of Organisms: Genetic factors, as well as local conditions, affect the growth of the adult plant.

Crosscutting Concepts

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

8-MS-LS4-1

Performance Expectation: 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.

Clarification Statement: Emphasis is on finding a pattern of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.

Science and Engineering Practices:

4. *Analyzing and interpreting data*: Analyze and interpret data to determine similarities and differences in findings. Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

Disciplinary Core Ideas:

Evidence of Common Ancestry and Diversity: The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.

Crosscutting Concepts

Patterns: Graphs, charts, and images can be used to identify patterns in data.

8-MS-LS4-2

Performance Expectation: Apply scientific ideas to construct and explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms.

Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.

Science and Engineering Practices:

5. Constructing explanations and designing solutions: Apply scientific ideas, principles, and/or evidence to construct, revise, and/or use an explanation for real-world phenomena, examples, or events. Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

Disciplinary Core Ideas:

<u>*Evidence of Common Ancestry and Diversity:*</u> 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 lines of evolutionary descent.

Crosscutting Concepts

<u>*Patterns*</u>*:* Patterns can be used to identify cause and effect relationships.

<u>*8-MS-LS4-3*</u>

Performance Expectation: 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.

Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.

Science and Engineering Practices:

4. <u>*Analyzing and interpreting data*</u>: Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

Disciplinary Core Ideas:

<u>*Evidence of Common Ancestry and Diversity*</u>*:* 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 lines of evolutionary descent. A comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.

Crosscutting Concepts

<u>*Patterns*</u>*:* Graphs, charts, and images can be used to identify patterns in data.

<u>*8-MS-LS4-6*</u>

Performance Expectation: Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations of species over time.

Clarification Statement: Emphasis is on using mathematical models, probability statements and proportional reasoning to support explanations of trends in changes to populations over time. Students should be able to explain trends in data for the number of individuals with specific traits changing over time.

Science and Engineering Practices:

5. *Using mathematics and computational thinking*: Use mathematical representations to describe and/or support scientific conclusions and design solutions. Mathematical and computational thinking in 6-8 builds on K-5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to spurt explanations and arguments.

Disciplinary Core Ideas:

Adaptation: Adaptation by natural selection acting over generations is one important process by which populations change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment tend to become more common; those that do not become less common. Thus, the distribution of traits in a population changes.

Crosscutting Concepts

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

Earth and Space Science (ESS):

8-MS-ESS3-3

Performance Expectation: Apply scientific principles to design a method for monitoring and minimizing human impact on the environment.

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

Science and Engineering Practices:

6. *Constructing explanations and designing solutions*: Apply scientific ideas, principles, and/or evidence to construct, revise, and/or use an explanation for real-world phenomena, examples, or events. Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

Disciplinary Core Ideas:

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

Developing Possible Solutions: A solution needs to be tested to prove the validity of the design and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. Models of all kinds are important for testing solutions.

Crosscutting Concepts

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

Overview of standards covered by NFC lesson plans

<u>High School</u>

Physical Science (PS):

<u>HS-PS1-1</u>

Performance Expectation: 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 and the composition of the nucleus of atoms.

Clarification Statement:

<u>Physical Science</u>: Examples of properties that could be predicted from patterns could include reactivity of metals, nonmetals, metalloids, number of valence electrons, types of bonds formed, or atomic mass. Emphasis is on the main group elements.

<u>Chemistry</u>: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, atomic radius, atomic mass, or reactions with oxygen. Emphasis is on main group elements and qualitative understanding of the relative trends of ionization energy and electronegativity.

Science and Engineering Practices:

2. *<u>Developing and using models</u>*: Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems or between components of a system.

Disciplinary Core Ideas:

<u>Structure and Properties of Matter</u>: Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. The periodic table orders elements horizontally by the number of protons in the atom’s nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

<u>Types of Interactions</u>: Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

Crosscutting Concepts

<u>Patterns</u>: Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

HS-PS1-2

Performance Expectation: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

Clarification Statement:

Physical Science: Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen or hydrogen, and oxygen. Reaction classification includes synthesis, decomposition, single displacement, double displacement, and acid-based.

Chemistry: Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or carbon and hydrogen. Reaction classification includes synthesis, decomposition, single displacement, double displacement, and acid-based.

Science and Engineering Practices:

6. *Constructing explanations and designing solutions*: Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

Disciplinary Core Ideas:

Structure and Properties of Matter: The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

Chemical Reactions: The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

Crosscutting Concepts

Patterns: Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

HS-PS1-3

Performance Expectation: Plan and conduct an investigation to gather evidence to compare the structure of substances at the macroscale to infer the strength of electrical forces between particles.

Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole), Examples of particles could include ions, atoms, molecules and network solids (such as graphite). Examples of macro-properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.

Science and Engineering Practices:

3. *Planning and Carrying Out Investigations*: Plan and conduct an investigation individually and/or collaboratively to produce data to serve as the basis for evidence, and in the design; decide on types, how much and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time) and refine the design accordingly. Planning and carrying out investigations to answer questions or test solutions to problems in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Disciplinary Core Ideas:

Structure and Properties of Matter: The structure and interactions of matter at the macro scale are determined by electrical forces within and between atoms.
Types of Interactions: Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

Crosscutting Concepts

Patterns: Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

HS-PS1-4

Performance Expectation: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products and representations showing energy is conserved.

Science and Engineering Practices:

2. *Developing and using models*: Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems or between components of a system.

Disciplinary Core Ideas:

Structure and Properties of Matter: A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.

Chemical Reactions: Chemical processes, their rates and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms in to new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.

Crosscutting Concepts

Energy and Matter: Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within a system.

HS-PS1-6

Performance Expectation: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining the designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.

Science and Engineering Practices:

6. *Constructing explanations and designing solutions*: Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Disciplinary Core Ideas:

Chemical Reactions: In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.

Optimizing the Design Solution: Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

Crosscutting Concepts

Stability and Change: Much of science deals with constructing explanations of how things change and how they remain stable.

HS-PS3-1

Performance Expectation: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Clarification Statement:

Chemistry: Emphasis is on explaining the meaning of mathematical expressions used in the model. The focus is on basic algebraic expression or computations, systems of two or three components, and thermal energy.

Physics: Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations; systems of two or three components; and thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.

Science and Engineering Practices:

5. *Using mathematics and computational thinking*: Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions, including computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Disciplinary Core Ideas:

Definitions of Energy: Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system.
That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.

Conservation of Energy and Energy Transfer: Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. Mathematical expressions allow the concept of conservation of energy to be used to predict and describe system behavior. These expressions quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and velocity. The availability of energy limits what can occur in any system.

Crosscutting Concepts

Systems and System Models: Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Life Science (LS):

HS-LS1-3

Performance Expectation: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis in living organisms

Clarification Statement: Examples of investigations could include heart rate responses to exercise, stomate responses to moisture and temperature, root development in response to water levels or cell response to hypertonic and hypotonic environments.

Science and Engineering Practices:

3. *Planning and Carrying Out Investigations*: Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design; decide on types, how much and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time) and refine the design accordingly. Planning and carrying out investigations to answer questions or test solutions to problems in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Disciplinary Core Ideas:

Structure and Function: Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing the organism to remain alive and functional even as external conditions change within some range. Feedback mechanisms can promote (through positive feedback) or inhibit (through negative feedback) activities within an organism to maintain homeostasis.

Crosscutting Concepts

Stability and Change: Feedback (negative and positive) can stabilize or destabilize a system.

HS-LS1-4

Performance Expectation: Use a model to illustrate the role of the cell cycle and differentiation in producing and maintaining complex organisms.

Clarification Statement: Emphasis is on conceptual understanding that mitosis passes on genetically identical materials via replication, not on the details of each phase in mitosis.

Science and Engineering Practices:

2. *Developing and using models*: Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems or between components of a system.

Disciplinary Core Ideas:

Growth and Development of Organisms: In multicellular organisms, the cell cycle is necessary for growth, maintenance, and repair of multicellular organisms. Disruptions in the cell cycles of mitosis and meiosis can lead to diseases such as cancer. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation (stem cell) produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.

Crosscutting Concepts

Systems and System Models: Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions – including energy, matter, and information flows – within and between systems at different scales.

HS-LS2-1

Performance Expectation: Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity, biodiversity, and populations of ecosystems at different scales.

Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and completion. Examples of mathematical comparisons could include graphs, charts, histograms, or population changes gathered from simulations or historical data sets.

Science and Engineering Practices:

5. *Using mathematics and computational thinking:* Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential, and logarithmic) and computational tools for statistical analysis to analyze, represent and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Disciplinary Core Ideas:

Interdependent Relationships in Ecosystems: Ecosystems have carrying capacities, which are limits to the number of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges as predation, competition, and disease that affect biodiversity, including genetic diversity within a population and species diversity within an ecosystem. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. Human activity directly and indirectly affects biodiversity and ecosystem health (e.g., habitat fragmentation, introduction of nonnative or invasive species, overharvesting, pollution, and climate change).

Crosscutting Concepts

Scale, Proportion, and Quantity: The significance of a phenomenon is depending on the scale, proportion, and quantity at which it occurs.

HS-LS2-4

Performance Expectation: Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen, and nitrogen being conserved as they move through an ecosystem.

Science and Engineering Practices:

5*. Using mathematics and computational thinking:* Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential, and logarithmic) and computational tools for statistical analysis to analyze, represent and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Disciplinary Core Ideas:

Cycles of Matter and Energy Transfer in Ecosystems: Energy is inefficiently transferred from one trophic level to another that affect the relative number of organisms that can be supported at each trophic level and necessitates a constant input of energy from sunlight or inorganic compounds from the environment. Photosynthesis, cellular respiration, decomposition, and combustion are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, hydrosphere, and geosphere through chemical, physical, geological and biological processes.

Crosscutting Concepts

Energy and Matter: Flows, Cycles, and Conservation: Energy cannot be created or destroyed – it only moves between one place and another place, between objects and/or fields or between systems.

HS-LS2-6

Performance Expectation: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood and extreme changes, such as volcanic eruption or sea -level rise. Emphasis should be on describing drivers of ecosystem stability and change, not on the organismal mechanisms or responses and interactions.

Science and Engineering Practices:

7*.* *Engaging in argument from evidence*: Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Disciplinary Core Ideas:

Ecosystem Dynamics, Functioning, and Resilience: The dynamic interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability and may result in new ecosystems.

Crosscutting Concepts

Stability and Change: Much of science deals with constructing explanations of how things change and how they remain stable.

HS-LS2-7

Performance Expectation: Design, evaluate and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Clarification Statement: Examples of human activities can include urbanization, building dams, or dissemination of invasive species.

Science and Engineering Practices:

6*.* *Constructing explanations and designing solutions*: Design, evaluate and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Disciplinary Core Ideas:

Ecosystem Dynamics, Functioning, and Resilience: Ecosystems with a greater biodiversity tend to have a greater resistance and resilience to change. Moreover, anthropogenic changes (induced by human activity) in the environment – including habitat destruction, pollution, the introduction of invasive species, overexploitation, and climate change – can disrupt an ecosystem and threaten the survival of some species.

Biodiversity and Humans: Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). Humans depend on the living world for the resources and other benefits provided by biodiversity. Human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, the introduction of invasive species, and climate change. Thus, sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

Developing Possible Solutions: When evaluating solutions, it is important to take into account a range of constraints including cost, safety, reliability, and aesthetics and to consider social, cultural, and environmental impacts.

Crosscutting Concepts

Stability and Change: Much of science deals with constructing explanations of how things change and how they remain stable.

Earth and Space Science (ESS):

HS-ESS2-5

Performance Expectation: Plan and conduct an investigation on the properties of water and its effects on Earth's materials and surface processes.

Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).

Science and Engineering Practices:

3. *Planning and Carrying Out Investigations*: Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations of phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation’s design to ensure variables are controlled. Planning and carrying out investigations to answer questions or test solutions to problems in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Disciplinary Core Ideas:

The Role of Water in Earth's Surface Processes: The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials and lower the viscosities and melting points of rocks.

Crosscutting Concepts

Structure and Function: The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

HS-ESS3-3

Performance Expectation: Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations and biodiversity.

Clarification Statement: Examples of factors that affect the management of natural resources include costs of resources extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.

Science and Engineering Practices:

5. *Using mathematics and computational thinking:* Create a computational model or simulation of a phenomenon, designed device, process, or system. Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential, and logarithmic) and computational tools for statistical analysis to analyze, represent and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Disciplinary Core Ideas:

Human Impacts on Earth Systems: The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

Crosscutting Concepts

Stability and Change: Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Environmental Science (EVS):

HS-EVS1-1

Performance Expectation: Analyze and interpret data to identify the factors that affect sustainable development and natural resource management in Louisiana.

Clarification Statement: Evidence of Louisiana's natural resource wealth is found in understanding the functions and values of varied ecosystems and environments, the supply of non-renewable mining products, and profitable agricultural commodities. Examples of key natural resources include state waterways (such as rivers, lakes, and bayous) and the aquatic life found in them, regions of agriculture (pine forests, sugar cane, and rice fields), and high concentrations of minerals and fossil fuels on and off shore. Factors to consider in reviewing the management of natural resources include a review of historical practices, costs of resource extraction and waste management, consumption of natural resources, ongoing research, and the advancements in technology.

Science and Engineering Practices:

4. Analyzing and interpreting data: Analyze data using tools, technologies and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Disciplinary Core Ideas:

Louisiana's Natural Resources: Ecosystem capital can be characterized as goods (removable products) and services such as the functions and values of wetlands.

Crosscutting Concepts

Stability and Change: Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

HS-EVS1-3

Performance Expectation: Analyze and interpret data about the consequences of environmental decision to determine the risk-benefit values of actions and practices implemented for selected issues.

Clarification Statement: Examples could be taken from system interactions: (1) loss of ground vegetation causing an increase in water runoff and soil erosion. (2) dammed rivers increasing ground-water recharge, decreasing sediment transport, and increasing coastal erosion. (3) loss of wetlands reducing storm protection buffer zones allowing further wetland reduction. (4) hydrological modification such as levees providing protection to infrastructure at a cost to ecosystems.

Science and Engineering Practices:

4. Analyzing and interpreting data: Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success. Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Disciplinary Core Ideas:

Resource Management for Louisiana: Some changes to our natural environment such as the building of levees and hydrological modification have provided for economic and social development but have resulted in unintended negative impacts.

Crosscutting Concepts

Cause and Effect: Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is knows about smaller scale mechanisms within the system.

HS-EVS2-2

Performance Expectation: Use a model to predict the effects that pollution as a limiting factor has on an organism's population density.

Clarification Statement: The law of limiting factors is often illustrated as a graphic tolerance curve and can be used to infer the range of tolerance a species has for specific pollution hazards. When combined with real-world data such as field measurements of abiotic factors, these models can be used to help predict the suitability of an ecosystem for a particular species.

Science and Engineering Practices:

2. *Developing and using models*: Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solves problems. Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing and developing models to predict and show relationships among variables between systems and their components in the natural and designed-world(s).

Disciplinary Core Ideas:

Pollution and the Environment: Different organisms have unique tolerances to pollution hazards. Many of the organisms most tolerant of pollution are the least desirable to humans (e.g., for food, for recreation, for ecosystem services).

Crosscutting Concepts

Cause and Effect: Cause and effect relationships can be suggested and predicted for complex natural and humna0designed systems by examining what is knows about smaller scale mechanisms within the system.

HS-EVS2-3

Performance Expectation: Use multiple lines of evidence to construct an argument addressing the negative impacts that introduced organisms have on Louisiana's native species.

Clarification Statement: The exotic organisms introduce in Louisiana include plants such as Chinese tallow, kudzu and water hyacinth and animals including nutria, Asian tiger mosquitoes, and zebra mussels. These organisms can have impacts on scales ranging from the level of the individual (e.g., competition) to that of landscape (e.g., the destruction of coastal marches by nutria).

Science and Engineering Practices:

7. *Engaging in argument from evidence*: Construct, use and/or present an oral and written argument or counterarguments based on data and evidence. Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Disciplinary Core Ideas:

Ecosystem Change: The introduction of exotic/invasive species causes a disruption in natural ecosystems and can lead to the loss of native species (i.e. threatened/ endangered). Changes in ecosystems impact the availability of natural resources (e.g., sediment starvation, climate change).

Crosscutting Concepts

Cause and Effect: Cause and effect relationships can be suggested and predicted for complex natural and humna0designed systems by examining what is knows about smaller scale mechanisms within the system.