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ABSTRACT

This resource contains a listing of the Nebraska Science Standards. In the primary grades, students should learn science at their developmental level. Children develop concepts, vocabulary, and inquiry skills by observing common materials and organisms. They develop the ability to ask questions, investigate the world around them, and use their observations to create reasonable explanations for their questions. In the intermediate grades, students learn science concepts, vocabulary, and inquiry skills at their developmental level. Students should develop knowledge and process skills while engaged in inquiry. They should ask simple questions, design and conduct investigations, and present their results to others. At the middle school level, students should expand their scientific inquiry skills through knowledge, observations, ideas, and questions. Students will begin to recognize the relationship between explanation and evidence. They understand that background knowledge and theories guide the design of investigations, the types of observations made, and the interpretation of data. Student investigations will shape and modify students' background knowledge. Senior high school students should be able to understand scientific inquiry at increasingly higher levels of sophistication. Questions and issues should form the basis of investigations. Students should learn how to analyze evidence and evaluate their own explanations and those of scientists. (SAH)

Nebraska Science Standards
Grades K-1

In the primary grades, students should learn science at their developmental level. Young children develop concepts, vocabulary, and inquiry skills by observing common materials and organisms. When engaged in science inquiry, they develop the ability to ask questions, investigate the world around them, and use their observations to create reasonable explanations for their questions.

S 1.1 Unifying Concepts and Processes

Unifying concepts and processes help students think about and integrate a range of basic ideas which builds an understanding of the natural world.

S 1.1.1 By the end of first grade, students will develop an understanding of systems, order, and organization.

Student demonstrations:

- Use one or more of the five senses to observe objects within the student's environment.
- Use observations to sort objects by their characteristics.

S 1.1.2 By the end of first grade, students will develop an understanding of evidence, models, and explanation.

Student demonstration:

- Describe and record how a model, such as photos, maps, globes, illustrations, stuffed animals, toys, and building blocks can represent an object, living thing, or an event.

S 1.1.3 By the end of first grade, students will develop an understanding of change, constancy, and measurement.

Student demonstrations:

- Recognize that change can be noted and measured.
- Recognize that things change in some ways and stay the same in others.
- Compare two or more objects using direct comparisons of measurement, such as shorter, longer, taller, heavier, and lighter.
- Use both standard units of measurement, such as inches and centimeters, and nonstandard units of measurement, such as string and paper clips.
- Use appropriate measurement systems for different purposes.

S 1.1.4 By the end of first grade, students will develop an understanding of form and function.

Student demonstrations:

- Demonstrate how the shape of a tool is related to its use.
- Explain how living things interact with their environment because of specific characteristics, such as how the long neck of the giraffe helps it to reach its food.

S 1.2 Science as Inquiry

Science as inquiry requires students to combine processes and scientific knowledge with scientific reasoning and critical thinking to develop their understanding of science.

S 1.2.1 By the end of first grade, students will develop the abilities needed to do scientific inquiry.

Student demonstrations:

- Ask questions about their surroundings.
- Plan and conduct a simple investigation.
- Collect scientific information from careful observation.

- Use simple equipment and tools, such as magnifying glasses, thermometers, and balance scales, to extend the senses.
- Share findings with classmates, families, and community members.

S 1.3 Physical Science

Physical science focuses on science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

S 1.3.1 By the end of first grade, students will develop an understanding of the characteristics of materials.

Student demonstrations:
- Observe and describe characteristics of common materials, such as paper, wood, metal, and wool.
- Investigate how common materials will float, sink, mix, dissolve, or not dissolve in various liquids.
- Observe that materials can exist as a solid, liquid, or gas.

S 1.4 Life Science

Life science focuses on science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

S 1.4.1 By the end of first grade, students will develop an understanding of the characteristics of living things.

Student demonstrations:
- Differentiate between living and nonliving things.
- Investigate how living things need food, water, and air to survive.
- Describe how roots, stems, and leaves serve different functions for plants.
- Compare and contrast animals by specific characteristics, such as body covering, diet, and habitat.
- Observe and recognize that organisms live and survive in distinct habitats.

S 1.4.2 By the end of first grade, students will develop an understanding of the life cycles of organisms.

Student demonstrations:
- Describe how living things change as they grow.
- Describe how offspring resemble their parents.

S 1.5 Earth and Space Science

Earth and space science focuses on science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

S 1.5.1 By the end of first grade, students will develop an understanding of the characteristics of earth materials.

Student demonstrations:
- Observe that materials of the earth, such as water, support life.
- Observe that the earth's surface is made up of a variety of rocks, minerals, and soils.

S 1.5.2 By the end of first grade, students will develop an understanding of the objects in the sky.

Student demonstrations:
- Recognize objects in the sky, such as the sun, moon, and stars.
- Recognize that the sun provides heat and light.

S 1.5.3 By the end of first grade, students will develop an understanding of the changes in the earth and sky.

Student demonstrations:
- Describe daily weather changes.
- Describe seasonal weather changes.

S 1.6 Science and Technology

An understanding of science and technology establishes connections between the natural and designed world, linking science and technology.

S 1.6.1 By the end of first grade, students will develop an understanding of technological design.

Student demonstration:
- Explain how the use of common household tools is determined by their design.

S 1.6.2 By the end of first grade, students will develop an understanding of science and technology.

Student demonstrations:
- Use various tools, such as a magnifying glass, thermometer, or measuring tape, to improve observations and measurements.
- Identify, investigate, and solve a problem in the home or school.
- Identify the technology used in different occupations.

S 1.7 Science in Personal and Social Perspectives

A personal and social perspective of science helps a student to understand and act on personal and social issues. This perspective builds a foundation for future decision making.

S 1.7.1 By the end of first grade, students will develop an understanding of personal health.

Student demonstrations:
- Follow safety rules for home and school.
- Engage in personal care that will maintain and improve health.
- Describe a healthy diet.
- Explain that substances can benefit or damage the way the body functions.

S 1.7.2 By the end of first grade, students will develop an understanding of resources.

Student demonstration:
- Observe and describe how reducing, reusing, and recycling help our environment.

S 1.8 History and Nature of Science

The history and nature of science illustrates different aspects of scientific inquiry, the human aspects of science, and the role that science has played in the development of various cultures.

S 1.8.1 By the end of first grade, students will develop an understanding of science as a human endeavor.

Student demonstrations:
- Recognize the contributions to science made by men and women from many countries.
- Conduct an investigation as an individual.
- Conduct an investigation as part of a team.

Nebraska Science Standards
Grades 2-4

In the intermediate grades, students learn science concepts, vocabulary, and inquiry skills at their developmental level. Students should develop knowledge and process skills while engaged in science inquiry. They should ask simple questions, design and conduct investigations (in the form of a "fair" test), and present their results to others.

S 4.1 Unifying Concepts and Processes

Unifying concepts and processes help students think about and integrate a range of basic ideas which builds an understanding of the natural world.

S 4.1.1 By the end of fourth grade, students will develop an understanding of systems, order, and organization.

Student demonstrations:

- Describe the parts that make up a system.
- Relate how the parts of a system affect the whole system.

S 4.1.2 By the end of fourth grade, students will develop an understanding of evidence, models, and explanation.

Student demonstrations:

- Use evidence gathered from an investigation to develop a scientific explanation.
- Create a model, graph, or illustration that represents an object, living thing, or an event in the student's environment.
- Explain and answer questions about the model created and how it represents a part of their environment.
- Use a variety of ways, such as sketches, charts, and graphs, to explain procedures or ideas.

S 4.1.3 By the end of fourth grade, students will develop an understanding of change, constancy, and measurement.

Student demonstrations:

- Describe observable changes, such as speed, pattern, shape, position, and size.
- Measure a change using appropriate tools and units of measurement.

S 4.1.4 By the end of fourth grade, students will develop an understanding of form and function.

Student demonstration:

- Construct a device to perform a simple task and explain how it works.

S 4.2 Science As Inquiry

Science as inquiry requires students to combine processes and scientific knowledge with scientific reasoning and critical thinking to develop their understanding of science.

S 4.2.1 By the end of fourth grade, students will develop the abilities needed to do scientific inquiry.

Student demonstrations:

- Ask a question about objects, organisms, and events in their surroundings.
- Plan and conduct a simple investigation.
- Employ simple equipment and tools to gather data and extend the senses.
- Use data to support explanations.
- Communicate procedures, results, and explanations of an investigation.

S 4.3 Physical Science

Physical science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

S 4.3.1 By the end of fourth grade, students will develop an understanding of the characteristics of objects and materials.

Student demonstrations:

- Classify objects by observable characteristics, such as shape, size, and color.
- Investigate characteristics of common materials using tools, such as rulers, balances, thermometers, microscopes, and hand lenses.
- Observe that materials can change from solid to liquid to gas by heating and from gas to liquid to solid by cooling.

S 4.3.2 By the end of fourth grade, students will develop an understanding of the position and motion of objects.

Student demonstrations:

- Use reference points to describe the position of an object.
- Indicate an object's motion by tracing its position over time.
- Observe that the position and motion of objects can be changed by pushing or pulling.
- Demonstrate how sound is produced when objects vibrate.
- Change the pitch of sound by changing the rate of vibration.

S 4.3.3 By the end of fourth grade, students will develop an understanding of light, heat, electricity, and magnetism.

Student demonstrations:

- Distinguish between reflection and refraction of light.
- Recognize heat can be produced in many ways, such as burning, rubbing, or mixing one substance with another.
- Demonstrate heat can flow from one object to another by conduction.
- Use electricity to produce heat, sound, and magnetic effects.
- Demonstrate electrical circuits require a complete loop through which an electrical current can pass.
- Describe the physical properties of magnets.

S 4.4 Life Science

Life science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

S 4.4.1 By the end of fourth grade, students will develop an understanding of the characteristics of living things.

Student demonstrations:

- Describe the differences between plants and animals.
- Describe the various structures of plants and animals necessary for growth, survival, and reproduction.
- Describe internal causes of behavior, such as hunger, and external causes of behavior, such as change in the environment, in living things.

S 4.4.2 By the end of fourth grade, students will develop an understanding of the life cycles of living things.

Student demonstrations:

- Describe the life cycle of an organism.
- Recognize inherited characteristics of living things, such as color and number of eyes.
- Recognize learned characteristics of living things, such as language or hunting for food.

S 4.4.3 By the end of fourth grade, students will develop an understanding of living things and environments.

Student demonstrations:
- Diagram a food chain.
- Explain how environmental changes affect behavior and survival of living things.
- Describe how humans and other living things cause positive and negative changes in their environment.

S 4.5 Earth and Space Science

Earth and space science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

S 4.5.1 By the end of fourth grade, students will develop an understanding of the characteristics of earth materials.

Student demonstrations:
- Identify characteristics of soils, rocks, water, and the atmosphere.
- List earth materials that are used by humans.
- Select the best earth material for a specific human use.
- Describe an ancient environment based on fossil evidence.

S 4.5.2 By the end of fourth grade, students will develop an understanding of objects in the sky.

Student demonstration:
- Describe and observe how objects move in patterns, such as sun, moon, stars, and clouds.

S 4.5.3 By the end of fourth grade, students will develop an understanding of the changes in the earth and sky.

Student demonstrations:
- Describe how slow processes, such as erosion, and rapid processes, such as earthquakes, change the earth's surface.
- Describe changes in weather using measurable quantities, such as temperature, precipitation, and wind direction and speed.

S 4.6 Science and Technology

An understanding of science and technology establishes connections between the natural and designed world, by linking science with technology.

S 4.6.1 By the end of fourth grade, students will develop an understanding of technological design.

Student demonstrations:
- Identify a simple problem.
- Propose a solution to a simple problem.
- Implement the proposed solution.
- Evaluate the implementation.
- Communicate the problem, design, and solution.

S 4.6.2 By the end of fourth grade, students will develop an understanding of science and technology.

Student demonstrations:
- Recognize science as one way of answering questions and explaining the natural world.
- Recognize that technology, such as tools and techniques, uses scientific knowledge to solve
- problems.

S 4.6.3 By the end of fourth grade, students will develop an understanding of the abilities to distinguish between natural objects and objects made by humans.

Student demonstration:
- Classify an object as either natural or manufactured.

S 4.7 Science in Personal and Social Perspectives

A personal and social perspective of science helps a student understand and act on personal and social issues. This perspective builds a foundation for future decision making.

S 4.7.1 By the end of fourth grade, students will develop an understanding of personal health.

Student demonstrations:
- Explain how the body uses food and how various foods contribute to health.
- Describe how different substances, such as tobacco, alcohol, and drugs, can damage the body and alter how it functions.

S 4.7.2 By the end of fourth grade, students will develop an understanding of the types of resources.

Student demonstrations:
- List examples of resources which are basic materials, such as air, water, and soil.
- List examples of resources produced from basic materials, such as food, fuel, and building materials.
- List examples of resources which are intangible materials, such as beauty, security, and quiet places.
- Research and report on the supply of various resources.

S 4.7.3 By the end of fourth grade, students will develop an understanding of environmental changes.

Student demonstration:
- Distinguish between natural environmental changes and human influenced environmental changes.

S 4.7.4 By the end of fourth grade, students will develop an understanding of how science and technology helps communities resolve problems.

Student demonstration:
- Research and explain how science and technology affect the quality of life.

S 4.8 History and Nature of Science

The history and nature of science illustrates different aspects of scientific inquiry, the human aspects of science, and the role of science in the development of various cultures.

S 4.8.1 By the end of fourth grade, students will develop an understanding of science as a human endeavor.

Student demonstrations:
- Research and report on the contributions to science and technology throughout history by men and women scientists of diverse cultures.
- Research and report on how science is used in different careers.
- Research and report on how current scientific discoveries illustrate that science is never finished.

At the middle school level, students expand their scientific inquiry skills through knowledge, observations, ideas, and questions. Middle school students will begin to recognize the relationships between explanation and evidence. They understand that background knowledge and theories guide the design of investigations, the types of observations made, and the interpretation of data. Student investigations will shape and modify students' background knowledge.

S 8.1 Unifying Concepts and Processes

Unifying concepts and processes help students think about and integrate a range of basic ideas which builds an understanding of the natural world.

S 8.1.1 By the end of eighth grade, students will develop an understanding of systems, order, and organization.

Student demonstrations:

- Recognize and describe integral parts and functions of any system.
- Analyze and predict the interactions within a system and between systems.
- Create and use classification schemes.
- Interpret cause and effect relationships within and between systems.

S 8.1.2 By the end of eighth grade, students will develop an understanding of evidence, models, and explanation.

Student demonstrations:

- Collect, manipulate, and analyze data from an experiment.
- Observe and develop models, such as physical, mathematical, mental, and computer simulations.
- Interpret and explain products of experimentation.
- Review investigative procedures and conclusions for reasonableness.

S 8.1.3 By the end of eighth grade, students will develop an understanding of change, constancy, and measurement.

Student demonstrations:

- Select and use appropriate measurement units.
- Quantify changes in systems.
- Use English and metric systems of measurements.
- Investigate and describe changes in terms of scale, rate, and pattern.

S 8.1.4 By the end of eighth grade, students will develop an understanding of form and function.

Student demonstration:

- Demonstrate how the design of an object makes it possible for that object to perform a specialized task, such as a bicycle or airplane.

S 8.2 Science as Inquiry

Science as inquiry requires students to combine processes and scientific knowledge with scientific reasoning and critical thinking to develop their understanding of science.

S 8.2.1 By the end of eighth grade, students will develop the abilities needed to do scientific inquiry.

Student demonstrations:
- Identify questions and form hypotheses that can be examined through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationship between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

S 8.3 Physical Science

Physical science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

S 8.3.1 By the end of eighth grade, students will develop an understanding of properties and changes of properties in matter.

Student demonstrations:
- Investigate and demonstrate that characteristic properties, such as density, boiling point, and solubility of substances, are not dependent on the quantity of the substance.
- Observe, describe, and measure physical and chemical properties of matter.
- Relate that all matter is composed of elements which may combine in a variety of ways to form compounds.
- Investigate and relate that in chemical reactions, total mass is conserved.

S 8.3.2 By the end of eighth grade, students will develop an understanding of motion and forces.

Student demonstrations:
- Investigate, describe, and represent the motion of an object by its position, direction of motion, and speed.
- Investigate and demonstrate that the speed and/or direction of an object changes when a force is applied to that object.

S 8.3.3 By the end of eighth grade, students will develop an understanding of the transfer of energy.

Student demonstrations:
- Investigate, explain, and give examples of the forms of energy, such as heat, light, chemical, sound, electrical, and how energy is transferred.
- Investigate and describe energy transfer using simple machines.
- Investigate and describe how heat is transferred from a warmer object to a cooler object until both reach the same temperature.
- Investigate and describe the properties of sound.
- Investigate and describe the basic principles of electricity and magnetism.

S 8.4 Life Science

Life science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

S 8.4.1 By the end of eighth grade, students will develop an understanding of the structure and function in living systems.

Student demonstrations:
- Investigate and describe the levels of organizations: cells, tissues, organs, organ systems, whole organisms, and ecosystems.

- Investigate and describe how all living things are composed of cells.
- Investigate and describe how cells sustain life through functions, such as growth and nutrition.
- Investigate and describe the specialized function performed by specialized cells, such as muscular and skeletal, in multi cellular organisms.
- Investigate and describe the internal human body systems.
- Investigate and explain how disease affects the structure and/or function of an organism.

S 8.4.2 By the end of eighth grade, students will develop an understanding of reproduction and heredity.

Student demonstrations:
- Investigate and describe how all organisms reproduce through sexual or asexual reproduction.
- Investigate and relate that females produce eggs and males produce sperm in many species.
- Investigate and state that chromosomes contain genes which influence heredity.
- Investigate and describe the effects of inherited traits on an organism's characteristics.

S 8.4.3 By the end of eighth grade, students will develop an understanding of regulation and behavior.

Student demonstrations:
- Investigate and explain how all organisms obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment.
- Investigate and relate how an organism senses change in its internal or external environment and attempts to respond to keep conditions within a required range.
- Investigate and explain how behavior is a response to internal and external stimuli.
- Investigate and explain how an organism's behavior evolves through environmental adaptation.

S 8.4.4 By the end of eighth grade, students will develop an understanding of populations and ecosystems.

Student demonstrations:
- Investigate and describe that a population consists of all individuals of a species at a given place and time.
- Investigate and describe the living and nonliving factors, such as air, water, and light that determine the number of organisms an ecosystem can support.
- Describe an organism by the function it serves in an ecosystem, such as producer, consumer, and decomposer.
- Investigate and explain how energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis, and that energy then passes from organism to organism in food webs.

S 8.4.5 By the end of eighth grade, students will develop an understanding of diversity and adaptations of organisms.

Student demonstrations:
- Analyze internal structures, similarity of chemical processes, and evidence of common ancestry to explain the unity among organisms.
- Investigate and explain how organisms adapt to living and nonliving factors in a biome.
- Investigate and explain how environmental changes created by nature and by humans may cause species extinction.

S 8.5 Earth and Space Science

Earth and space science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

S 8.5.1 By the end of eighth grade, students will develop an understanding of the structure of the earth.

Student demonstrations:
- Investigate and diagram the crust, mantle, and core of the earth.
- Investigate and describe how a combination of constructive and destructive weathering and erosion forces create land forms.
- Investigate and describe the composition of soils.
- Investigate and describe the water cycle.
- Investigate and describe the composition of the atmosphere at different altitudes.
- Investigate and describe the major impact of topography, location, and oceans on climate.
- Investigate and describe the effect of living organisms on weathering, the composition of rocks, and the atmosphere.

S 8.5.2 By the end of eighth grade, students will develop an understanding of the earth's history.

Student demonstrations:
- Investigate and understand how earth processes that occur today, such as weather and natural catastrophes, are similar to those that occurred in the past.
- Investigate and use the fossil record to provide evidence and explain how environmental conditions have changed.

S 8.5.3 By the end of eighth grade, students will develop an understanding of the earth in the solar system.

Student demonstrations:
- Investigate and list the components of the solar system, galaxies, and universe.
- Investigate and describe the motion of solar system objects in terms of the concepts of day, year, seasons, eclipses, and phases of the moon.
- Investigate and describe gravity's relationship to the solar system.
- Investigate and understand that the sun is a major source of energy for phenomena in the atmosphere and on the earth's surface.
- Investigate and describe the effect of the tilt of the earth's axis on seasons.

S 8.6 Science and Technology

An understanding of science and technology establishes connections between the natural and designed world, linking science and technology.

S 8.6.1 By the end of eighth grade, students will develop an understanding of technological design.

Student demonstrations:
- Identify appropriate problems for technological design.
- Design a solution or product.
- Implement a proposed design.
- Evaluate completed technological designs or products.
- Communicate the process of technological design.

S 8.6.2 By the end of eighth grade, students will develop an understanding of science and technology.

Student demonstrations:
- Distinguish between scientific inquiry (asking questions about the natural world) and technological design (using science to solve practical problems).
- Describe how science and technology are reciprocal.

- List the avoidable and unavoidable limits of a technological design.
- Recognize that solutions have intended and unintended consequences.

S 8.7 Science in Personal and Social Perspectives

A personal and social perspective of science helps a student understand and act on personal and social issues. This perspective builds a foundation for future decision making.

S 8.7.1 By the end of eighth grade, students will develop an understanding of personal health.

Student demonstrations:
- Research and identify substances harmful to human beings in the natural environment, such as radon, lead, and nitrates.
- Investigate and explain how personal choices can directly affect a person's health, such as exercise, nutrition, and use of drugs.

S 8.7.2 By the end of eighth grade, students will develop an understanding of populations, resources, and environments.

Student demonstrations:
- Investigate and describe how population levels affect resources and the environment.
- Investigate and understand that the causes of environmental degradation and resource depletion vary locally and globally.

S 8.7.3 By the end of eighth grade, students will develop an understanding of natural hazards.

Student demonstrations:
- Investigate and describe the effect of natural hazards on the environment, such as earthquakes, landslides, wildfires, floods, and storms.
- Investigate and describe human activities, such as urban growth, land use, and waste disposal, which can accelerate many natural changes.

S 8.7.4 By the end of eighth grade, students will develop an understanding of risks and benefits.

Student demonstrations:
- Analyze a type of hazard, such as natural, chemical, or biological, estimating the number of people that might be exposed and the number likely to suffer consequences.
- Describe how perceptions of risks and benefits influence personal and social decisions, such as seat belt usage and waste disposal procedures.

S 8.7.5 By the end of eighth grade, students will develop an understanding of science and technology in society.

Student demonstrations:
- Understand the effect of science on society is neither entirely beneficial nor entirely detrimental.
- Understand that societal challenges often inspire questions for scientific research, but that science cannot answer all questions and technology cannot solve all human problems or meet all human needs.
- State an example of when societal priorities influenced research priorities.
- Practice the ethical codes followed by scientists, such as informing research subjects about risks and benefits, humane treatment of animals, and truth in reporting.

S 8.8 History and Nature of Science

An understanding of the history and nature of science illustrates different aspects of scientific inquiry, the human aspects of science, and the role of science in the development of various cultures.

S 8.8.1 By the end of eighth grade, students will develop an understanding of science as a human endeavor.

Student demonstrations:

- Investigate and understand that women and men of various social and ethnic backgrounds, working alone or in teams, engage in the activities of science, engineering, and related fields.
- Investigate and understand that scientists have different abilities, basic human qualities, and scientific habits of mind.

S 8.8.2 By the end of eighth grade, students will develop an understanding of the nature of science.

Student demonstrations:

- Formulate and test a hypothesis using observations, experiments, and theoretical and mathematical models.
- Use questioning, response to criticism, and open communication when defending a conclusion.
- Evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists.
- Distinguish between scientific fact and scientific theory.

S 8.8.3 By the end of eighth grade, students will develop an understanding of the history of science.

Student demonstration:

- Research and report on the difficulties experienced by a scientific innovator who had to overcome flawed, commonly held beliefs of his/her time to reach conclusions that we now take for granted.

Senior high students should be able to understand scientific inquiry at increasingly higher levels of sophistication. Questions and issues relevant to students should form the basis of investigations. An adequate knowledge base and an understanding of the concepts that guide inquiry are needed to assure success. Students should learn how to analyze evidence and evaluate their own explanations and those of scientists.

S 12.1 Unifying Concepts and Processes

Unifying concepts and processes help students think about and integrate a range of basic ideas which builds an understanding of the natural world.

S 12.1.1 By the end of twelfth grade, students will develop an understanding of systems, order, and organization.

Student demonstrations:

- Predict and evaluate how change within a system affects that system.
- Use system analysis to understand how things work and to design solutions to problems.

S 12.1.2 By the end of twelfth grade, students will develop an understanding of evidence, models, and explanation.

Student demonstrations:

- Create a physical, mental, or mathematical model to show how objects and processes are connected.
- Test the usefulness of a model by comparing its predictions to actual observations.
- Understand that the way data are displayed affects interpretation.
- Evaluate the reasonableness of answers to problems by reviewing the process used to find answers and checking against typical values.
- Understand that larger well-chosen population samples produce better estimates of population summary statistics.
- Use some random process to avoid sample bias.
- Understand that a believable correlation between two variables doesn't mean that either one causes the other.

S 12.1.3 By the end of twelfth grade, students will develop an understanding of change, constancy, and measurement.

Student demonstrations:

- Use powers of ten to represent large numbers and to compare things that are greatly different.
- Compare data for two groups by representing averages and ranges of values.
- Understand that measurement errors may affect calculations.
- Use estimates of magnitude of error to analyze disparities between estimates and calculated answers when making measurements.
- Describe rate of change by comparing one measured quantity to another measured quantity.
- Investigate and describe how different characteristics, properties, or relationships within a system change as their dimensions increase or decrease.
- Investigate and understand that as the number of parts within a system change, the number of possible internal interactions varies with the square of the number of parts.

S 12.1.4 By the end of twelfth grade, students will develop an understanding of form and function.

Student demonstration:

- Demonstrate the reciprocal aspect of form and function, explaining function by referring to form and explaining form by referring to function.

S 12.1.5 By the end of twelfth grade, students will develop an understanding of change over a period of time.

Student demonstrations:
- Identify the series of changes that occur in objects, organisms, and natural and human designed systems.
- Explain equilibrium in terms of changes in opposite and off-setting directions.

S 12.2 Science as Inquiry

Science as inquiry requires students to combine processes and scientific knowledge with scientific reasoning and critical thinking to develop their understanding of science.

S 12.2.1 By the end of twelfth grade, students will develop the abilities needed to do scientific inquiry.

Student demonstrations:
- Identify questions and concepts that guide scientific investigations.
- Design and conduct scientific investigations.
- Use technology and mathematics to improve investigations and communications.
- Formulate and revise scientific explanations and models using logic and evidence.
- Recognize and analyze alternative explanations and models.
- Communicate and defend a scientific argument.

S 12.3 Physical Science

Physical science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

S 12.3.1 By the end of twelfth grade, students will develop an understanding of the structure of the atom.

Student demonstrations:
- Investigate and describe the components and properties of atoms. Investigate and explain the decay of radioactive isotopes.
- Investigate and describe the effect of electrical and nuclear forces which hold atoms together.

S 12.3.2 By the end of twelfth grade, students will develop an understanding of the structure and properties of matter.

Student demonstrations:
- Investigate and understand that an element is composed of a single type of atom.
- Investigate and explain the periodic table of elements in terms of repeating patterns.
- Investigate and describe how the structure of an atom determines the chemical properties of an element.
- Investigate and explain how the interactions among the molecules of a compound determine physical and chemical properties.
- Use differences in molecular energy to explain the differences among the states of matter.
- Investigate and describe how carbon atoms bond together in chains, rings, and other structures to produce large molecules essential to life.

S 12.3.3 By the end of twelfth grade, students will develop an understanding of chemical reactions.

Student demonstrations:
- Investigate and describe common chemical reactions.
- Investigate and explain how chemical reactions release or absorb energy.
- Investigate and discuss chemical reactions in terms of bond formation by electron transfers.
- Investigate and describe the factors influencing the rates of chemical reactions.
- Investigate and describe how the use of catalysts accelerates chemical reactions.

S 12.3.4 By the end of twelfth grade, students will develop an understanding of motions and forces.

Student demonstrations:
- Calculate the effect of forces on the motion of objects.
- Investigate and understand gravity as a universal force that each mass exerts on any other mass.
- Investigate and understand electrical force as a universal force that exists between any two charged objects.
- Describe an electric field and a magnetic field, and compare the interaction between them.

S 12.3.5 By the end of twelfth grade, students will develop an understanding of the conservation of energy and increase in disorder.

Student demonstrations:
- Investigate and understand that the total energy in the universe is constant and can never be destroyed.
- Investigate and distinguish among kinetic energy, potential energy, and energy contained in a field.
- Investigate and describe heat in terms of conduction, convection, and radiation.
- Investigate and demonstrate how systems tend to become less organized and more disorderly over time.

S 12.3.6 By the end of twelfth grade, students will develop an understanding of the interactions of energy and matter.

Student demonstrations:
- Investigate and understand all waves have energy and transfer energy.
- Investigate and demonstrate how electromagnetic waves result when a charged object accelerates.
- Investigate and illustrate how wavelength and frequency of waves are inversely related.
- Investigate and understand that the energy of waves can be changed into other forms of energy, just as other forms of energy can be transformed into wave energy.
- Investigate and identify atoms or molecules by spectral analysis.
- Investigate and describe how the composition and temperature of a material affects electron flow.

S 12.4 Life Science

Life science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

S 12.4.1 By the end of twelfth grade, students will develop an understanding of the cell.

Student demonstrations:
- Investigate and describe sub cellular structures that underlie cell functions.
- Investigate and describe how cell functions involve chemical reactions.
- Investigate and describe how DNA regulates cell functions.
- Investigate and understand that plant cells and many microorganisms use solar energy to combine molecules of carbon dioxide and water into organic compounds.
- Investigate and understand that complex multi cellular organisms are formed as highly organized arrangements of differentiated cells.

S 12.4.2 By the end of twelfth grade, students will develop an understanding of the molecular basis of heredity.

Student demonstrations:
- Investigate and understand that genetic variation occurs when genetic information is transmitted to an offspring through the union of an egg and a sperm cell which contain one representative of each chromosome pair.
- Investigate and explain how some mutations make no difference to organisms, whereas others can alter cells.
- Investigate and explain how only mutations in germ cells create the variations that change an organism's offspring.

S 12.4.3 By the end of twelfth grade, students will develop an understanding of the theory of biological evolution.

Student demonstrations:

- Understand that the concept of biological evolution is a theory which explains the consequence of the interactions of: (1) the potential for a species to increase its numbers: (2) the genetic variability of offspring due to mutation and recombination of genes: (3) a finite supply of the resources of life; and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.
- Investigate and use the theory of biological evolution to explain diversity of life.
- Investigate whether natural selection provides a scientific explanation of the fossil record and the molecular similarities among the diverse species of living organisms.
- Investigate and use biological classifications based on similarities.

S 12.4.4 By the end of twelfth grade, students will develop an understanding of the interdependence of organisms.

Student demonstrations:

- Investigate and understand that atoms and molecules cycle among living and nonliving components of the biosphere.
- Investigate and describe the flow of energy through ecosystems, in one direction, from producers to herbivores to carnivores and decomposers.
- Investigate and cite examples of organisms cooperating and competing in ecosystems.
- Investigate and understand that interactions among organisms are affected by the conflict between an organism's capacity to produce infinite populations and the finite amount of resources.
- Investigate and describe how humans modify the ecosystem as a result of population growth, technology, and consumption.

S 12.4.5 By the end of twelfth grade, students will develop an understanding of matter, energy, and organization in living systems.

Student demonstrations:

- Investigate and understand that living systems require a constant input of energy.
- Investigate and explain how the energy for life is derived from the sun.
- Investigate and explain how distribution and abundance of organisms in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials.

S 12.4.6 By the end of twelfth grade, students will develop an understanding of the behavior of organisms.

Student demonstrations:

- Investigate and describe how nervous systems function in multi cellular animals.
- Investigate and describe how organisms respond to internal changes and external stimuli.
- Investigate and explain how the behavioral patterns of organisms have evolved through natural selection.
- Investigate and understand that behavioral biology relates to humans since it provides links to psychology, sociology, and anthropology, such as the population dynamics demonstrated by the increased aggressiveness of laboratory rats in overcrowded cages.

S 12.5 Earth and Space Science

Earth and space science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

S 12.5.1 By the end of twelfth grade, students will develop an understanding of energy in the earth system.

Student demonstrations:

- Investigate and distinguish between internal sources of energy, such as radioactive decay and gravitational energy, and external sources of energy, such as the sun, explaining that both create heat in earth systems.

- Investigate and explain how the outward transfer of earth's internal heat drives convection in the mantle that propels the plates comprising the earth's surface.
- Investigate and explain how global climate is determined by energy transfer from the sun and is influenced by dynamic processes, such as cloud formation and the earth's rotation and static conditions, such as the position of mountain ranges and oceans.

S 12.5.2 By the end of twelfth grade, students will develop an understanding of geochemical cycles.

Student demonstration:
- Investigate and diagram how elements and compounds on earth move among reservoirs in the solid earth, oceans, atmosphere, and organisms as part of geochemical cycles.

S 12.5.3 By the end of twelfth grade, students will develop a scientific understanding of the origin of the earth system.

Student demonstrations:
- Investigate and understand that the early earth was very different from the planet we live on today.
- Investigate and estimate geologic time by observing rock sequences and using fossils to correlate the sequences at various locations.
- Investigate and use known decay rates of radioactive isotopes in rocks to determine when the rock was formed.
- Investigate and relate the effects of interactions among the solid earth, oceans, atmosphere, and organisms to the ongoing evolution of the earth.

S 12.5.4 By the end of twelfth grade, students will develop a scientific understanding of the origin of the universe.

Student demonstrations:
- Investigate and analyze various theories on the origin of the universe.
- Investigate and understand the effects of gravity and nuclear reactions upon stars.
- Research and describe the life cycle of a star.

S 12.6 Science and Technology

An understanding of science and technology establishes connections between the natural and designed world, linking science to technology.

S 12.6.1 By the end of twelfth grade, students will develop an understanding of technological design.

Student demonstrations:
- Identify a problem.
- Propose designs and choose between alternative solutions.
- Implement a proposed solution.
- Evaluate the solution and its consequences.
- Communicate the problem, process, and solution.

S 12.6.2 By the end of twelfth grade, students will develop an understanding about science and technology.

Student demonstrations:
- State an example of how science advanced with the introduction of new technology.
- Understand creativity, imagination, and a good knowledge base are all needed to advance the work of science and engineering.
- Contrast the reasons for the pursuit of science and the pursuit of technology.
- Contrast the reporting of scientific knowledge and the reporting of technical knowledge.

S 12.7 Science in Personal and Social Perspectives

A personal and social perspective of science helps a student understand and act on personal and social issues. This perspective builds a foundation for future decision making.

S 12.7.1 By the end of twelfth grade, students will develop an understanding of personal and community health.

Student demonstrations:

- Investigate and describe the effect of nutritional balance on growth, development, and personal well-being.
- Investigate and explain how diseases are prevented, controlled, and cured.
- Investigate and explain how genetics affect a person's health.
- Investigate and analyze risk versus benefit assessments to facilitate personal and community health.

S 12.7.2 By the end of twelfth grade, students will develop an understanding of the effects of population change.

Student demonstrations:

- Investigate and state causes of population growth or decline.
- Investigate and explain how various factors influence birth rates and death rates.
- Investigate and describe how population change impacts resource use and environments.

S 12.7.3 By the end of twelfth grade, students will develop an understanding of natural resources.

Student demonstrations:

- Investigate and explain how human populations use environmental resources to maintain and improve their existence.
- Investigate and understand that the earth has renewable and finite resources.
- Investigate and understand the limitations of natural systems to renew and recycle resources.

S 12.7.4 By the end of twelfth grade, students will develop an understanding of environmental quality.

Student demonstrations:

- Investigate and describe how the positive and negative consequences of human intervention or nonintervention impacts the ecosystem.
- Investigate and discuss factors which may influence environmental quality. Factors to consider may include population distribution and consumption.

S 12.7.5 By the end of twelfth grade, students will develop an understanding of natural and human-induced hazards.

Student demonstrations:

- Investigate and describe how human activities increase or reduce the potential for hazards.
- Investigate and distinguish between slow occurring hazards, such as coastal erosion, and rapid occurring hazards, such as tornadoes, and discuss their impact on the environment.
- Investigate and assess potential dangers and risks of a hazard.

S 12.7.6 By the end of twelfth grade, students will develop an understanding of the role of science and technology in local, national, and global challenges.

Student demonstrations:

- Understand that knowledge of basic concepts about scientific and technological challenges should precede active debate.
- Investigate and understand that social issues and challenges may affect advancements in science and technology.
- Understand that science and technology are essential social enterprises that indicate what could happen, but not what should happen.

S 12.8 History and Nature of Science

The history and nature of science illustrates different aspects of scientific inquiry, the human aspects of science, and the role of science in the development of various cultures.

S 12.8.1 By the end of twelfth grade, students will develop an understanding of science as a human endeavor.

Student demonstrations:

- Practice the ethical traditions of scientists, such as peer review, truthful reporting, and public disclosure of work.
- Examine and understand the societal, cultural, and personal beliefs that influence scientists.

S 12.8.2 By the end of twelfth grade, students will develop an understanding of the nature of scientific knowledge.

Student demonstrations:

- Demonstrate the use of empirical standards, logical arguments, and skepticism in science.
- Create scientific explanations consistent with experimental and observational evidence; make accurate predictions; strive to be logical; respect the rules of evidence; accept criticism; report methods and procedures; and make knowledge public.
- Understand that all scientific knowledge is, in principle, subject to change as new evidence becomes available.

S 12.8.3 By the end of twelfth grade, students will develop an understanding of the history of science.

Student demonstrations:

- Investigate and describe the contributions to scientific knowledge and technological inventions by diverse cultures.
- Research and understand that changes in scientific knowledge evolve over time and almost always build on earlier knowledge.
- Research and relate the long-lasting societal effects of science and technology advancements.
- Examples of such advances include germ theory, protein synthesis, Newtonian mechanics, quantum theory, geologic time scale, and plate tectonics.

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