SCIENCE STANDARDS FRAMEWORK
PRESCHOOL THROUGH GRADE 12

STATE GOAL 11: Understand the processes of scientific inquiry and technological design to investigate questions, conduct experiments, and solve problems.

Why This Goal Is Important: The inquiry process prepares learners to engage in science and apply methods of technological design. Thus, the abilities needed to do scientific inquiry, and the understandings of scientific inquiry, enable students to understand the natural world. They learn to pose questions, use models to enhance understanding, make predictions, conduct observations and gather data, analyze data, draw logical conclusions based on evidence, critically evaluate inferences and alternative explanations, and communicate findings and interpretations. The abilities of technological design let students identify design problems, propose solutions, build and test models, gather and analyze data, and communicate results. Developing skills in these areas will help students understand scientific investigations and technological problem solving. The skills embodied in the abilities and understandings of scientific inquiry are closely linked across grade levels. Mathematics also plays an essential role in all aspects of scientific inquiry and technology. All of these abilities are valuable attributes to students and citizens in endeavors beyond the sciences.

A. Know and apply the concepts, principles, and processes of scientific inquiry

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Ask scientific questions				
Ask an engaging question about objects, organisms, and events in the environment and discuss how the question can be answered. L1	Formulate and ask questions on a specific science topic and outline ideas for steps to answer the questions. L1	Identify questions that can be answered through scientific investigations. L1	Formulate testable questions and hypotheses, referencing prior experiences and knowledge. L1	Formulate testable questions and hypotheses, referencing prior experiences and knowledge. L1
Design scientific investigations				
Plan a simple investigation of objects, organisms, or systems and predict what might happen in the investigation. L1	Plan a simple investigation, design a valid experiment (a "fair test") to answer the question, and predict what might happen in the investigation. L1	Design a scientific experiment that controls all but one variable and write a prediction for the experiment outcome. L1	Design investigations that test questions and hypotheses; critically revise questions based on the experimental design, methods, controls, and variables; write a prediction for the results. L1	Design investigations that test questions and hypotheses; critically revise questions based on the experimental design, methods, controls, and variables; write a prediction for the results. L1
Conduct scientific investigations				
Conduct the investigation using the senses, simple equipment, skills, and tools (e.g., rulers, thermometers, balances, magnifying glasses); collect data by observing, measuring, cutting, connecting, turning off/on, pouring, tying, taping, and gluing. L1	Collect data from investigations with plants, animals, rocks, or other materials using skills such as observing, estimating and measuring, and somewhat more sophisticated tools such as scales, microscopes, computers, and calculators. L1	Collect and record data accurately and analyze data using consistent measuring and recording tools and techniques (e.g., experimental control). L1	Use observation methods, technologies, and design techniques (e.g., experimental control) to measure, record, and organize accurately the data from observations of scientific investigations. L1	Use observation methods, technologies, and design techniques (e.g., experimental control) to measure, record, and organize accurately the data from observations of scientific investigations. L1

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Analyze data using appropriate methods and technologies				
Arrange data and observations into patterns and compare them with predictions. L1	Arrange data and observations into logical patterns, describe the patterns, and compare the data with predictions. L1	Use appropriate measurement methods and technologies to analyze data, then write logical inferences. L1	Use appropriate mathematics and technologies to represent measurements and observations (e.g., mean, spread, probability of event, graphical representation) and to analyze inferences. L1	Use appropriate mathematics and technologies to represent measurements and observations (e.g., mean, spread, probability of event, graphical representation) and to analyze inferences. L1
Construct reasonable explanations				
Use observations to develop reasonable scientific explanations for student investigations. L1	Use evidence, observations, and logic to develop scientific explanations for student investigations. L1	Develop descriptions, explanations, and models of investigations based on observations and evidence; revise and improve models and explanations using critical analysis and mathematical tools (e.g., mean, simple equations, graphs). L1	Use evidence, logic, and inference to formulate scientific explanations and models for a set of observations; use additional tests and analysis to revise and improve explanations and models. L1	Use evidence, logic, and inference to formulate scientific explanations and models for a set of observations; use additional tests and analysis to revise and improve explanations and models. L1
Compare and contrast one's explanation with the explanations of other students or other teams. L1	Use evidence, observations, and logic to evaluate respectfully the explanations of other students and other teams. L1	Recognize, describe, and critically evaluate in a respectful manner alternative explanations or predictions. L1	Recognize and analyze in a respectful dialogue any alternative explanations and models that use scientific criteria and evidence. L1	Recognize and analyze in a respectful dialogue any alternative explanations and models that use scientific criteria and evidence. L1
Communicate explanations and results				
Describe and explain individual and group observations and results. L1	Report and display the results of individual and group investigations. L1	Communicate results and use evidence and logic to defend scientific explanations. L1	Communicate results and use evidence and logic to defend scientific explanations. L1	Communicate results and use evidence and logic to defend scientific explanations. L1
Demonstrate understandings of scientific inquiry				
Describe how scientists use their observations and measurements of the natural world to build upon and test what they already know. L2	Give examples of how scientists make the results of their investigations public and how they describe their work so that any other scientist can repeat the investigation. L2	Explain reasons and examples for why scientists inquire about how physical and living systems function and why new knowledge benefits society. L2	Describe that scientific explanations for the natural world must adhere to certain criteria, such that the explanations are logically consistent, rely on evidence, are revised by analysis and constructive review, and are based on current knowledge and technologies. L2	Describe that scientific explanations for the natural world must adhere to certain criteria, such that the explanations are logically consistent, rely on evidence, are revised by analysis and constructive review, and are based on current knowledge and technologies. L2

B. Know and apply the concepts, principles, and processes of technological design

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Identify a design problem				
Explain a simple design problem directly related to students' experiences (e.g., coat hooks, dirty shoes, storing books) and formulate ways to solve the problem. L1	Identify a design problem and propose possible solutions to the problem with words and design sketches. L1	Identify a design need in a familiar object or process and establish steps for a solution. L1	Identify improvements to a current technological design and propose design revisions in writing and with diagrams. L1	Identify improvements to a current technological design and propose design revisions in writing and with diagrams. L1
Propose a design solution				
Design a device that will be useful in solving the problem. L1	Develop a plan, design a procedure to address the problem, and identify constraints (e.g., cost, time, materials, space, technology, safety). L1	Sketch, propose, and compare solutions to the problem or challenge. L1	Select criteria for a successful design solution to an identified problem given available materials, tools, efficiency, cost effectiveness, and safety. L1	Select criteria for a successful design solution to an identified problem given available materials, tools, efficiency, cost effectiveness, and safety. L1
Build and test a model, prototype, or simulation				
Build the device (individually or collaboratively) using the materials and tools provided (e.g., hammers, scissors, screwdrivers, rulers). L1	Build a prototype of the design using available tools and materials. L1	Select and implement the most appropriate design and build a prototype, simulation, or model of that design. L1	Develop and construct a proposed solution using blueprints, schematics, flowcharts, CAD-CAM software, or animations. L1	Develop and construct a proposed solution using blueprints, schematics, flowcharts, CAD-CAM software, or animations. L1
Test the device and record results using given instruments, techniques, and measurement methods. L1	Test the prototype using suitable instruments, techniques, and quantitative measurements to record data. L1	Test and evaluate the prototype or model using available materials, instruments, and technology; record all data and observations. L1	Test model and complete the simulation, making sure to record data and observations. L1	Test model and complete the simulation, making sure to record data and observations. L1
Analyze test data and evaluate results				
Decide if the solution worked based on test results. L1	Assess test results and the effectiveness of the design using the given criteria and noting possible sources of error. L1	Evaluate the test results based on established criteria, note sources of error, and recommend improvements. L1	Use design criteria to evaluate a technological solution by listing advantages, disadvantages, and sources of error; list revisions and justification. L1	Use design criteria to evaluate a technological solution by listing advantages, disadvantages, and sources of error; list revisions and justification. L1

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Record design process and communicate design solution				
Report the design of the device, the test process, and the results in solving a given problem. L1	Report the test design, the test process, and the test results, as would a team of scientists and engineers. L1	Complete a write-up with simple diagrams of the proposed design solution and the test results. L1	Report to an audience the level of success of the design (strengths, weaknesses) based on the test results and the performance criteria. Use available technology to write a report of findings for the design solution to an audience that may include professional and technical experts. L1	Report to an audience the level of success of the design (strengths, weaknesses) based on the test results and the performance criteria. Use available technology to write a report of findings for the design solution to an audience that may include professional and technical experts. L1

C. Use skills and abilities in math, writing, and dialogue (e.g., speaking, listening) to convey findings and understandings in the sciences

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Use numbers to represent objects or events in science and technology				
Use numbers to characterize and then to group objects or events in the sciences. L2	Use numbers to describe and compare scientific objects and events. L1	Use numbers over orders of magnitude and in different forms (e.g., integers, decimals, fractions, percentages, rounded off) to characterize objects or events in science. L1	Use both large and small numbers showing decimals or exponents and significant figures to describe and relate objects or events in science. L1	Use both large and small numbers showing decimals or exponents and significant figures to describe and relate objects or events in science. L1
Apply skills of mathematics to gather measurements, then organize and manipulate data				
Apply simple tools of mathematics to measure data (e.g., counting, reading values from instruments) and simple operations to relate data (e.g., grouping in sets, addition, subtraction). L1	Apply math skills to measure, record, and organize scientific data; apply several types of operations to compare the data and observations (e.g., multiplication, division). L1	Apply math skills and techniques in measuring, recording, and organizing scientific data with instruments (e.g., balances, microscopes) and in manipulating data with operations and simple functions. L1	Develop sophisticated skills of observing, measuring, replicating (e.g., scales, microscopes), organizing data tables, and applying computer (calculator) or algebraic functions to manipulate and analyze data. L1	Develop sophisticated skills of observing, measuring, replicating (e.g., scales, microscopes), organizing data tables, and applying computer (calculator) or algebraic functions to manipulate and analyze data. L1

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Use the language of mathematics to represent and communicate results from scientific investigations				
Identify shapes and patterns that are found in nature and in things that people make (e.g., circles, rectangles, triangles, cubes); identify how measurements can be displayed with simple graphs. L2	Identify shapes and patterns that are found in nature and in things that people make (e.g., circles, rectangles, triangles, cubes); identify how measurements can be displayed with simple graphs. L1	Use the language and skills of mathematics to express scientific patterns and ideas (e.g., plots, symbolic and numeric representation, simple functions, statistics and probability) and to make predictions. L1	Show how the language and skills of math can be used to represent objects or events in the sciences (e.g., mathematical models and formulas, equations, variables, symbols, graphs, statistics, precision and accuracy, significant figures). L1	Show how the language and skills of math can be used to represent objects or events in the sciences (e.g., mathematical models and formulas, equations, variables, symbols, graphs, statistics, precision and accuracy, significant figures). L1
Use writing and dialogue to express findings and understandings in science				
Use the skills needed for oral and written communication, such as describing and writing about findings, and asking questions of other students. L1	Use communication and dialogue (e.g., reading, writing, speaking, listening) to conduct investigations, report results, and learn others' discoveries. L1	Use both oral and written communication to convey effectively and logically the findings about scientific investigations. L1	Use both oral and written communication with evidence, logic, and argument to convey effectively findings from scientific investigations. L1	Use scientific evidence, logic, and respectful analysis in writing or dialogue to evaluate the scientific findings and inferences of others. L1
Use models, diagrams, and visualizations to represent concepts in science				
Develop skills to communicate ideas and findings in science with accurate representations, such as models, diagrams, flowcharts, and sketches. L2	Communicate ideas and findings in science to others using accurate representations, such as models, diagrams, numerics, flowcharts, and schematics. L2	Communicate ideas and findings in the sciences with accurate representations (2-D, 3-D) such as models, diagrams, dynamic settings, and sketches. L1	Communicate ideas and findings in the sciences with accurate representations (2-D, 3-D) such as models, diagrams, dynamic settings, and sketches. L1	Communicate ideas and findings in the sciences with accurate representations (2-D, 3-D) such as models, diagrams, dynamic settings, and sketches. L1

Note: *Each benchmark shows one of three levels of significance in the grade-level alignment: critical to understand and master (L1, level 1); significant to develop (L2, level 2); useful to work on (L3, level 3).*

STATE GOAL 12: Understand fundamental concepts, principles, and interconnections of the life, physical, and earth and space sciences.

Why This Goal Is Important: State goal 12 consists of key concepts and principles in the life, physical, and earth and space sciences that have considerable explanatory and predictive power for all citizens. These ideas have been studied extensively, and are foundational for much of what we know, investigate, and use in science. Knowing concepts, principles, and processes helps students understand what they observe through scientific experimentation. Students can then apply their knowledge to construct and build deeper and more meaningful understandings, both within a scientific field and across the sciences. The grouping of key fields in this science goal also helps emphasize the multidisciplinary nature of modern science and technology.

A. Know and apply concepts that explain how living things function, adapt, and change over time

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Structure and function of organisms				
Give examples of the basic needs for animals and plants, such as air, protection, water, food, light, nutrients, and an appropriate environment (e.g., deserts, oceans, mountains). L1	Describe different structures of organisms that serve specific functions in growth and survival (e.g., birds have feathers; fish have fins; mammals have bones, blood, hair, and skin; humans have structures for walking, thinking, seeing, and talking). L1	Describe levels of organization for living systems, starting with cells, then moving to tissues, organs, organ systems, whole organisms, populations, and ecosystems. L1	Explain the levels of organization of living systems, from molecules to cells, tissues, organ systems, whole organisms, populations, communities, and ecosystems. L1	Describe the organelles in cells that underlie their basic cellular functions (e.g., energy production by cellular respiration and photosynthesis, cellular transport). L1
Explain structures in organisms (e.g., plants, animals) that serve specific functions in growth and survival (e.g., birds have feathers; fish have fins; trees have leaves). L1	Identify similar structures in organisms that have different purposes for different animals (e.g., arms, wings, fins; hair, feathers, scales). L1	Explain that all living things are composed of cells (i.e., "the building blocks of life") and that cells carry out the functions needed to sustain life (e.g., photosynthesis in plants). L1	Use examples to show that in a cell, thousands of distinct molecules carry out vital functions such as energy production, cellular transport, waste disposal, biosynthesis, and storage of genetic material. L1	Describe the process by which cells multiply (mitosis) and that cell differentiation leads from a single cell to organized arrangements of differentiated cells in the tissues of multicellular organisms. L1
Describe some structures and their functions for parts of human bodies (i.e., humans have bones, blood, hair, skin, legs, eyes, mouths, noses, and arms). L1	Describe several human body systems and their functions. L2	Describe human systems for digestion, respiration, reproduction, blood circulation, excretion, movement and coordination, and protection from disease and ways that these systems interact. L1	Describe key characteristics of plant cells that underlie their morphology and functions (e.g., cell walls; chloroplasts for photosynthesis). L1	Explain examples of cell functions that are regulated by proteins. L1
Discuss some differences between living and nonliving things. L1	Group and classify plants and animals (e.g., mammals, reptiles) based on their similarities and differences. L1	Describe how disease results from a breakdown in function, such as by invasion from outside the body (i.e., pathogens). L2		Describe cell differentiation as a process regulated through the expression of different genes. L2

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Behavior of organisms				
Give examples of behavior or responses of organisms, including humans, that ensure survival. L1	Describe that organisms' behaviors develop for adaptation to their environments. L1	Describe behavior as an organism's response to internal or external stimuli and that all organisms must obtain and use resources, grow, reproduce, and maintain internal conditions. L1	Describe examples of behavior in organisms that is innate or learned. L1	Explain that organisms use sensory organs with specialized cells to detect stimuli, such as light, sound, or chemicals, to monitor their surroundings. L1
	Classify traits and behaviors of living things as inherited or learned (e.g., flower or eye color as inherited traits; language or riding a bike as learned) and state how they relate to the organisms' environments. L1	Describe that regulation for organisms involves sensing their surroundings (external environment) and then using physiological activities at the cell or organism level to survive. L1	Diagram basic parts of neural networks consisting of specialized cells that generate responses to internal or external stimuli. L1	Describe and diagram the flow of information through an organism by electrical impulses. L2
			Explain behaviors of organisms that promote survival and reproduction and can evolve by natural selection. L2	Identify features of human behavioral biology that link to fields such as psychology, sociology, and anthropology. L3
Reproduction and heredity				
Give examples of ways that offspring resemble their parents. L1	Diagram life cycles of plants and animals and the similarities and differences between parents and their offspring. L1	Explain how reproduction is a characteristic of all living systems, with some organisms reproducing asexually and others reproducing sexually (through egg and sperm). L1	Explain how instructions for characteristics of organisms such as physiology, morphology, and reproduction are carried in the organic molecule DNA. L1	Describe the role of DNA replication in the production of new cells (e.g., mitosis for growth, differentiation, and asexual reproduction; meiosis for germ cells in sexual reproduction). L1
Describe changes in living things during life, from being born, to being young, then to being adult. L1	Characterize specific structures of organisms as being inherited from parent organisms. L2	Describe heredity as the passage of genetic information from one generation to the next. L1	Describe how genetic information is transmitted from one generation to the next through gametes (egg and sperm) produced in meiosis. L1	Explain that most human cells contain 46 chromosomes (2 copies of each of 22 chromosomes, plus another pair for the gender of an individual). L2
		Describe that genetic information is contained in genes and that traits are determined by one or more genes. L2		Describe that mutations occur regularly (but spontaneously) at low rates and that mutation may be affected by agents in the environment. L3

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Biologic evolution and change over time				
Show how organisms can be grouped or classified based on how similar or different their features are. L1	Identify differences in individuals of a species that can provide an advantage in survival and reproduction. L1	Compare features of organisms for their adaptive, competitive, and survival potential (e.g., appendages, reproductive rates, camouflage, defensive structures). L1	Identify examples of organisms classified into groups and subgroups based on evolutionary relations, with species on Earth today related by descent from common ancestors. L1	Describe processes where biologic evolution can account for species extinctions, as well as diversity in species that can develop over many, many generations. L1
Describe the external features of animals and plants that help them survive in different environments. L2		Describe the unity of organisms by studying their similar internal structures, chemical processes, and evidence of common ancestry. L1	Explain how natural selection and evolutionary changes account for the fossil record of ancient life-forms, plus the molecular and morphological similarities among living organisms. L1	Explain that genetic mutations (e.g., inserting, deleting, or substituting DNA segments in genes) may be beneficial, harmful, or have no effect in natural selection and biologic evolution. L2
		Describe how natural selection in the environment (e.g., by predators, climate change) leaves individuals more apt to survive and to pass on their genes to offspring. L1	Describe the great diversity of organisms on Earth that have evolved from at least 3.5 million years of evolution in every ecological niche. L1	Identify disciplines in science that contribute to understanding biologic evolution and how species change over time, including comparative anatomy, physiology, nuclear chemistry, embryology, molecular biology, and paleontology (the fossil record). L2

B. Know and apply concepts that describe how living things interact with each other and with their environments

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Populations, interdependence, and ecosystems				
Describe living things that depend on one another for survival in food chains (e.g., some animals eating plants, other animals eating animals). L1	Describe how organisms interact in ecosystems by food chains and other interdependencies (e.g., predator-prey, parasite-host, pollination, food chains, food webs). L1	Use examples to show that populations of plants or animals consist of all individuals that occur together in a region. L1	Analyze factors that influence the size and stability of populations of organisms in ecosystems (e.g., birthrate, death rate, predation, migration patterns, changing ecosystems). L1	Describe how energy flows through ecosystems from photosynthesizing organisms to consumers to decomposers, as these organisms build organic molecules (e.g., proteins, DNA, sugars, fats) and use the molecules for energy. L2
Compare living and nonliving things in several of the many types of environments and habitats in the world (e.g., rain forest, desert, tundra, coral reef). L1	Describe factors that cause populations of organisms in an area to increase or decrease (e.g., disease, famine, larger ecosystems). L2	Explain how when an environment becomes overpopulated, the ecosystem may become degraded due to increased use of resources, yet such effects may vary from region to region. L2	Compare physical, ecological and behavioral factors that influence interactions and interdependencies (e.g., cooperation and competition) of organisms in ecosystems. L1	Explain that populations reach limits to growth, with carrying capacity being the maximum number of individuals that can be supported in an environment. L1
Give examples of changes in the environment that affect plants and animals (e.g., seasons, human influence). L2		Identify and classify key biotic and abiotic interactions in an ecosystem and factors that affect population density. L2		
Matter and energy in ecosystems				
Describe how plants need sunlight, soil, and water to grow. L1	Show how food chains rely on plants, which in turn rely on energy from the sun. L1	Develop a diagram showing sunlight (the major source of energy in ecosystems) entering ecosystems through producers by photosynthesis, then passing to consumers and decomposers through food webs. L1	Describe the energy for life as being derived from the sun, as primary producers (plants) absorb sunlight to make covalent bonds between the atoms of carbon-containing (organic) molecules, which provide a source of energy when eaten as food. L1	Explain that chemical elements (nutrients) are combined and cycled in different ways as matter and energy flow through living systems (e.g., cells, organs, organisms, communities) and the environment. L1
Diversity and adaptation of organisms				
Describe and compare living things relative to nonliving things in their environments. L1	Identify physical features of plants and animals that help them live in different environments and habitats (e.g., specialized teeth, thorns for protection, insulation for cold). L1	Compare examples of ecosystems with vast numbers of species of animals, plants, and microorganisms in many kinds of habitats. L1	List several examples of species extinction that occur as the environment changes, or because the species cannot adapt quickly enough to external pressures for survival (e.g., the fossil record shows a history of extinctions). L1	Describe organisms and their distinctive features that are specially adapted to their environment through biologic evolution (e.g., the shapes of bird beaks). L1

C. Know and apply concepts that describe properties of matter and energy and the kinds of interactions between matter and energy

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Structure and properties of matter				
Identify with the senses or simple tools several observable properties of objects (e.g., size, weight, shape, color, odor, temperature). L1	List some observable properties of objects that can be measured and described (e.g., size, weight, mass, shape, color, temperature, odor). L1	Describe some characteristic physical properties of substances that are independent of the mass of the substance (e.g., density, boiling point, solubility). L1	Describe how matter consists of atoms, which are composed of even smaller particles that have measurable properties such as mass and charge. L1	Explain with sketches and words that characteristic properties of matter (solids, liquids, gases) result from the microscopic structure and interactions of atoms and molecules. L1
Make comparisons between materials (e.g., heavier, hotter, shinier, color). L1	Demonstrate that tools can be used to extend the senses, such as in measuring the properties of objects with simple tools (e.g., rulers, timers, balances, thermometers). L1	Show that properties of objects can be measured and recorded with simple tools (e.g., rulers, timers, balances, thermometers). L1	Show with a simple diagram that atoms consist of a nucleus of protons and neutrons surrounded by electrons. L1	Explain the relationship between pressure, volume, temperature, and amount in the ideal gas law (PV = nRT). L1
Measure and record properties of objects with simple tools such as rulers, timers, balances, and thermometers. L1	Explore and describe how chemical and physical properties of natural and human-made materials can change (e.g., dissolving doesn't mean disappearing). L1	Describe simple patterns in the periodic table of elements that relate to the physical properties of matter (e.g., solids, gases; metals, non-metals). L2	Give examples of how carbon is a unique element that makes chains, rings, and branching networks to form an array of carbon-based molecules in living and nonliving systems. L2	Describe how some processes and interactions of matter occur at the level of the nucleus (e.g., fission in nuclear reactors, fusion in stars, radioactive decay of elements). L2
Chemical reactions of matter				
Compare objects that are made of one substance with objects that consist of more than one substance (e.g., wood, paper, metal, plastic, cloth, rock). L1	Describe what happens when some substances are mixed with other substances. L1	Explain that substances react chemically in characteristic ways with other substances to form new substances with different characteristic properties. L1	Describe how in chemical reactions, atoms interact with one another by sharing or transferring outer electrons in different types of electron bonds (e.g., polar, covalent, ionic). L1	Use enthalpy diagrams to show that the overall energy change in a chemical reaction equals the sum of the steps (e.g., Hess's law; catalysts in biological or industrial reactions). L1
Describe how mixing materials together can change their properties (e.g., color, appearance). L1	Identify the properties of 2 separate substances before and after they are mixed to create a new substance. L1	Give examples of how total mass is conserved in chemical reactions (e.g., combustion, rusting, antacid tablet reaction). L1	Use electronic structure (valence, electronegativity) of groups in the periodic table to predict chemical behavior and properties of elements. L1	Use balanced equations for common chemical reactions to show the conservation of mass (e.g., stoichiometry). L1

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Chemical reactions of matter (continued)				
		Describe evidence that in most chemical reactions, energy is transferred either into or out of the system (evidence in heat or temperature, light, mechanical motion, electricity). L2	Describe that many replacement reactions show a competition for electrons (oxidation/reduction) or hydrogen ions (acid/base) among reacting ions, molecules, or atoms. L1	Describe factors that speed up or slow down a chemical reaction (e.g., chemical kinetics by catalysis). L1
Interactions of energy and matter				
Experiment with sources of energy (e.g., light, heat, electricity, magnetism, sound) and make observations and measurements of these physical phenomena. L1	Describe that materials occur in different states (solid, liquid, gas) that change by heating or cooling. L1	Describe how energy is a property of substances that is associated with heat, light, solar radiation, electricity, mechanical motion, sound, and chemical substances. L1	Explain that chemical reactions may increase or decrease the temperature of the reaction environment by forming and breaking chemical bonds (i.e., change in enthalpy). L1	Describe with examples that factors (e.g., concentration, pressure, volume, temperature) can influence the position of a chemical equilibrium (Le Chatelier's principle). L1
Show how light travels in a straight line until it strikes an object; light can be reflected by a mirror, absorbed by an object, or be divided into colors (e.g., rainbow, laser). L3	Diagram how electricity must form a closed circuit (loop) to produce light, heat, sound, or magnetic effects. L2	Explain how electrical circuits are converting energy when light, heat, sound, or chemical changes occur. L3	Identify examples of changes in heat for a material and explain what this tells you about its properties (calorimetry). L1	Describe how to distinguish waves that gain or lose specific amounts of energy based on electron transitions at the atomic level (e.g., spectral lines for chemical identification). L1
	Describe how sound and pitch relate to the perception of vibrating objects (e.g., strings, bells, blades of grass). L3	Diagram examples of how waves carry energy and transfer energy when they interact with matter (e.g., seismic, light, electromagnetic, sound). L2	Describe how all waves transfer energy when they interact with matter (e.g., seismic, electromagnetic, sound waves, tsunamis). L1	
Explain how people burn fuels such as wood, oil, coal, or natural gas or use electricity to cook their food and warm their houses. L3	Explore and describe how heat can be transferred between objects. L2	Show that heat can be transferred between objects in predictable ways (flows from hot to cold). L2	Describe how energy can be stored in fossil fuels and released for human consumption when fuels are burned. L2	

D. Know and apply concepts of force and motion and the principles that explain them

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Force and motion				
Identify forces in nature that can be observed (e.g., pushes, pulls, gravity, magnetism, sound) and explain ways to change or modify the forces. L1	Demonstrate and explain ways that forces cause actions and reactions (e.g., magnets attracting and repelling; objects falling, rolling and bouncing, changing direction). L1	Describe ways that forces can affect motion (e.g., action/reaction, equilibrium conditions, free-falling objects, rockets). L1	Describe examples of how work is done when a force is applied over a distance ($W = F \times d$) and how power indicates the expenditure of work per unit time ($P = W/t$). L1	Show that between charged particles or masses, electromagnetic forces are much greater than gravitational forces, with the electromagnetic forces proportional to charge and inversely proportional to distance squared. L2
Explain how the position and motion of objects can be changed by pushing or pulling by different amounts, directions, or by varying the strength of the push or pull. L1	Demonstrate and record that motion can be characterized as constant, variable, or periodic. L1	Describe and use graphs to show the motion of an object with position, direction, and speed. L1	Demonstrate how objects change their motion only when a net force is applied, with the magnitude of force related to mass and acceleration ($F = ma$), or to the rate of change of momentum ($F = \Delta p/\Delta t$). L1	Analyze and diagram with vectors the factors that influence the relative motion of an object in different settings (e.g., friction, wind shear, crosscurrents, potential differences). L1
Describe the position of an object by locating it relative to another object, a background, or a numbered position (distance). L2	Measure how the position of an object (e.g., distance) can change with time to give speed. L1	Explain the factors that affect the gravitational forces on objects (e.g., changes in mass, distance) and use classic experiments to demonstrate gravitational or electromagnetic forces (e.g., pendulum). L2	Show that gravitation is a universal force between any masses and that gravitation depends on the masses and distances between the masses. L2	Demonstrate factors that govern types of motion (e.g., projectile, harmonic, circular, free fall), such as distance, velocity, time, and acceleration in projectile motion (e.g., $d = V_o t + 1/2\, at^2$). L1
Identify moving objects with different kinds of motion (fast, slow, straight, back and forth, circular, zigzag). L3			Describe with an example how electricity and magnetism are 2 aspects of a single electromagnetic force. L3	Describe that acceleration results from a change in velocity of a moving object ($a = \Delta V/\Delta t$). L2
Conservation of energy				
Explore and describe experiments with heat, temperature, and energy. L1	Explore and describe different ways to produce heat, such as burning substances, rubbing (friction), or mixing substances. L1	Describe some of the physical and chemical processes that are used to produce energy and how society uses this natural resource. L1	Distinguish between energy described as kinetic energy (motion), potential energy (position), and field energy (electromagnetic waves). L1	Show that temperature is a measure of random motions and vibrations of atoms, molecules, and ions (i.e., average kinetic energy). L1
			Describe the conversions or transfer of energy between physical processes in a closed system (harmonic motion). L1	Describe how waves such as electromagnetic waves (radio, microwave, visible, ultraviolet, X-ray, gamma ray) have a wavelength that is inversely proportional to frequency. L2

E. Know and apply concepts that describe the changing features and processes of Earth and its resources

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Properties and structure of Earth				
Identify various Earth materials (e.g., minerals, rocks, soil, water, atmosphere) and their distinctive properties. L1	Identify several rocks and minerals based on their properties. L2	Diagram how the structure of Earth includes a crust, mantle, liquid metal outer core, and solid metal inner core. L1		
Explore and describe the properties of soils (e.g., color and texture, water retention, plant support) and soils as vital parts of ecosystems. L1	Describe some locations on Earth where earthquakes and volcanoes occur and how those events relate to processes and people on Earth. L2	Describe how tectonic plates (crust plus upper mantle) move over Earth atop a slowly convecting mantle, affecting processes on Earth's land, oceans, and atmosphere. L1		
Describe parts of Earth made of rock, water, and air. L1	Show how the atmosphere and weather have properties that are measurable and sometimes predictable (e.g., temperature, air pressure, wind direction, wind speed). L2	Use maps to show that geologic features of Earth's surface are often related to plate tectonic boundaries (e.g., mountain ranges, ocean basins, continents). L1		
		Identify key parts of the atmosphere (e.g., layers, composition) and hydrosphere (e.g., oceans, ice caps, waters on land). L1		
History of processes on Earth				
Describe the light and heat from the sun that warms the Earth. L2	Give examples of how fossils are evidence of the plants and animals that lived long ago and the nature of their environment. L2	Give examples of how fossils are evidence of life and environments that have changed on Earth. L1	Describe how rock sequences and their fossils and environments are used to interpret and reconstruct changes that have occurred on Earth and its environments. L1	Use half-lives to describe radiometric dating for the ages of geologic and biologic processes on Earth and in our solar system (e.g., age of the solar system at about 4.5 billion years; evidence for first life at about 3.5 billion years; first humans at about 200,000 years). L2
		Describe examples of how natural and regular Earth events can become natural disasters for humans and describe the causes of those natural events (e.g., earthquakes, floods, tornadoes, hurricanes). L1	Describe how some Earth processes occur quickly, while others require much more geologic time (e.g., earthquakes and volcanic eruptions versus ices ages, mountain building, or biologic evolution). L1	Explain evidence that the early Earth was very different from the Earth today. L3

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Cycles and energy in Earth systems				
Describe how weather changes are daily and seasonal and how they relate to energy from the sun. L1	Describe and explain slow and fast processes that occur on Earth's surface (e.g., weathering, mountain formation, landslides, earthquakes, volcanism). L1	Describe processes that show interactions in cycles between the geosphere, hydrosphere, atmosphere and biosphere (e.g., rock cycle, water cycle, rock weathering and formation of soil, formation of limestone or coal). L1	Explain how external and internal energy sources drive Earth processes (e.g., solar energy drives climate patterns in oceans and the atmosphere; internal heat and density of materials link to forces that drive plate tectonics). L2	Explain that Earth is a system with elements and matter (e.g., carbon, nitrogen, oxygen) distributed and moving among the living and nonliving parts of the planet (e.g., hydrosphere, atmosphere, geosphere, biosphere) in geochemical cycles. L2
Identify how weather can be measured by quantities such as rainfall, temperature, or wind speed. L1	Describe how processes interacting at the surface of Earth are related in cycles (e.g., water cycle, rock cycle, weather patterns) and have different forces driving the cycles (e.g., gravitation, energy). L2	Describe geologic evidence that many Earth processes occurring today (e.g., erosion, sedimentation, volcanism) are similar to those that occurred in the geologic past. L2	Describe how some Earth processes are cyclical (e.g., rock cycle, water cycle), whereas other Earth processes evolve continuously with time (e.g., chemistry of oceans, chemistry of atmosphere, size and shape of continents, diversity of life). L2	
Resources from Earth				
Identify products that are made from natural resources from Earth and whether those products can be classified as recyclable or nonrecyclable after they are used. L2	Describe the physical and chemical properties used to classify Earth materials used in communities (e.g., building materials, fuel and energy, agriculture). L1	Summarize how Earth processes relate to resources and products that are needed and used by society. L1	Describe how natural resources help humans maintain and improve their quality of life, and describe Earth processes the result in resources used by humans. L1	Study and identify different sources of energy for society and how all forms of energy relate to resources of Earth (e.g., coal, oil, natural gas, nuclear energy). L1

F. Know and apply concepts that explain the composition and structure of solar systems, galaxies, the universe, and Earth's place in these

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Structure of solar systems and stars				
Describe and sketch common objects seen in the sky. L1	Identify and explain natural cycles and patterns in the solar system (e.g., order of the planets, moon phases, seasons, latitude, and Earth in its yearly orbit around the Sun). L1	Demonstrate that the Sun is a typical star and that Earth is the 3rd planet from the Sun in a solar system that includes the Moon, 8 other planets (some with moons), and smaller objects such as asteroids and comets. L1	Compare the processes involved in the life cycle of stars (e.g., gravitational collapses, thermonuclear fusion, novae) and evaluate the supporting evidence from scientific missions and astronomical observations. L1	Describe how nuclear fusion in stars (starting with 4 hydrogen fusing to form helium) begins the process to create all elements of the periodic table. L2
Observe and describe the properties, locations, and movement patterns of objects in the sky (sun, moon, stars, clouds, birds, airplanes). L1	Explain the apparent motion of the sun and stars or other objects in the sky. L1	Explain that objects in the solar system have regular and predictable motions due to the force of gravity between these objects, with motions relating to phenomena such as time of day, season, or phase of the Moon. L1		
Describe how the rotation and orbit of Earth are related to patterns that humans experience (day or night, seasons). L2	Diagram how Earth rotates on a tilted axis and orbits the Sun one time each year. L1			
Evolution of the solar system and universe				
Discuss that the night sky contains more stars than can be counted. L3	Identify easily recognizable star patterns in constellations (e.g., Orion, the Big Dipper, Cygnus, Cassiopeia). L3	Compare and contrast the Sun as a star with other objects in the Milky Way galaxy (e.g., nebulae, globular clusters, dust clouds, stars, black hole) and describe methods to view and study such features. L2	Explain that Earth, the Sun, and the rest of the solar system formed from a nebular cloud of gas and rock particles 4.6 billion years ago. L3	Describe and compare the chemical and physical characteristics of galaxies and objects within galaxies (e.g., stars, globular clusters, nebulae, pulsars, black holes, dark matter). L3
			Diagram several types of stars and their life cycles on H-R diagrams of star surface temperature (K) versus luminosity (L_{star}/L_{Sun}). L3	Describe evidence for the size of the universe and the age of the universe of about 13.7 billion years (e.g., redshifts of elemental spectra for galaxies, Hubble's constant). L2

Note: *Each benchmark shows one of three levels of significance in the grade-level alignment: critical to understand and master (L1, level 1); significant to develop (L2, level 2); useful to work on (L3, level 3).*

STATE GOAL 13: Understand the relationships among science, technology, and society in historical and contemporary contexts.

Why This Goal Is Important: Learners develop understandings of the scientific process by doing investigations and by comparing their enquiries with the history, nature, and practices of science in society. This process includes concepts of reproducing, confirming, and sharing results; building on prior findings; and evaluating costs and benefits for society. Some decisions using the findings of science and technology are clear, while other decisions require discussion by communities. Relationships among science, technology, and society let humans understand and research further changes in their surroundings. Such endeavors in scientific discovery by learners help them appreciate the efforts and effects of past and current scientific work and the ways that science and technology contribute to and affect society.

A. Know and apply the practices and understandings of science and technology, and how these relate to the history and nature of science

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Safety in science				
Demonstrate a knowledge of basic safety practices at home and when doing science at school (e.g., nothing in mouth without permission, "stop, drop, and roll"). L1	Demonstrate ways to perform science investigations safely at home and at school (e.g., wearing goggles, using fire extinguishers). L1	Identify and reduce potential hazards in science activities using common sense and technology (e.g., having ventilation, handling chemicals). L1	Estimate and suggest ways to reduce the degree of risk involved in science activities. L1	Design procedures and policies to eliminate or reduce risk in potentially hazardous science activities. L1
Understanding science and technology				
Compare objects that occur in nature with objects that have been designed and made by humans. L1	Describe some accepted tools and procedures (ways of doing something) used by scientists and engineers to solve problems in society and to explain the natural world. L1	Identify examples of scientific and technological solutions that have constraints and consequences and that harbor limitations in cost, materials, and practicality (e.g., influenza vaccination) or environmental implications (clear-cutting, overfishing). L2	Explain that questions of science drive technology, and technology provides new methods for scientific analysis that enhance measuring variables, such as quantity, distance, location, size, mass, or speed. L1	Describe with examples that scientists in different disciplines ask different types of questions, and new disciplines in science such as biochemistry or geophysics emerge at the interface of scientific fields. L2
Science as a human endeavor				
Give examples of scientists and engineers working in teams to do different tasks that contribute to the overall results (e.g., Mars missions). L1	Describe examples of women and men using science to learn about objects and the history of the natural world and recognize that much still remains to be understood. L1	Describe how science involves different types of abilities, such as logic, reasoning, intellectual honesty, openness, imagination, and creativity. L1	Identify procedures used by scientists to substantiate results, including peer review, citation of prior findings, accurate reporting of methods and measurements, and publishing results in journals. L1	Give examples that science is accomplished by teams working on projects (e.g., space missions), as well as by individual scientists doing work in settings ranging from the field to the laboratory. L1

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Science as a human endeavor (continued)				
Demonstrate the use of creativity, curiosity, imagination, and new approaches in a scientific investigation. L2	Explain with examples scientists who have used creativity, curiosity, imagination, and new approaches. L2	Describe that science and technology give information about how the physical and biological worlds work, yet humans must make decisions about how to use science and new technologies. L1	Give examples of a scientific discovery that relies on creativity, imagination, solid skills, and a firm knowledge base. L1	Describe that understandings of science may be influenced by societal, cultural, and personal beliefs. L2
Nature of science				
Describe that scientists include women and men of all ages and from all cultures. L1	Use evidence to explain why similar results are expected when procedures are done the same way. L1	Describe that science seeks to test and explain nature by using observations, experiments, models, logic, evidence, analysis, and the revision of ideas. L2	Explain that science is one way of knowing, but not the only way of knowing, and that science may not be an appropriate means to investigate some matters of personal beliefs. L1	Detail how core ideas in science have been tested repeatedly (e.g., conservation of energy, laws of motion, biologic evolution, plate tectonics), while in other areas understandings may still be improving (e.g., human evolution, global warming, origin of life, virus transmission, origin of the universe). L1
	Explain what a scientist might do if the results of an investigation turn out differently than expected (e.g., replicate the experiment and measurements). L2	Describe an example showing that scientists participate in a public process of peer review of their work, publishing all evidence and results and continuing debate and discussion when results or interpretations do not agree. L2	Describe that science seeks to explain the natural world by using empirical standards, logic, analysis, skepticism, and revision. L2	Compare different experimental designs in the sciences (direct observation, controlled or random-assigned experiments, computer modeling, statistical comparison). L2
History of science				
Describe the diversity of women and men of all ages and cultures that have contributed to new scientific ideas and to new scientific and technological work. L1	Describe evidence showing that science and technology have been practiced for a long time by people in many cultures and that many people choose science as a professional career. L2	Give examples of individuals from many cultures who have contributed to science and technology and describe that studying the works of these individuals helps to understand the relationship between science and society. L1	Give examples of how historical perspectives of scientific explanations by an array of persons show that knowledge of the natural world changes over time and builds on prior knowledge (e.g., medical sciences, computer capabilities). L1	Give examples of how science typically occurs as small changes to existing knowledge in all fields, while at other times advances have a long-lasting impact on science and society (e.g., Copernican revolution, relativity, geologic and astronomical time, DNA, biologic evolution, plate tectonics, germ theory). L2

B. Know and apply concepts that describe the interaction among science, technology and society

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Science, technology, and society				
Identify and describe ways that science and technology affect people's everyday lives (e.g., transportation, medicine, agriculture, sanitation, communication occupations). L1	Describe from everyday experiences (e.g., the grocery store) how science and technology relate to things like improved food quality, transportation, health practices, sanitation, and communication (e.g., imported fruit in winter). L1	Describe challenges and issues for society that have inspired scientific research or new technologies for developing new processes and products. L1	Describe situations where science and technology only indicate what can happen (or what are the odds of it happening), while human decisions are needed to evaluate what should happen. L1	Give examples of policies regarding science and technology that are important at local, state, national, and global levels and require analysis of costs, benefits, and effects (e.g., genetic engineering, greenhouse gas production, agriculture and aquaculture). L2
Discuss and describe examples of several important careers in science. L1	Describe examples of how technology is used in many types of professions and how technology can change ecosystems (e.g., highways, dams, cities, power plants). L1	Explain with examples that society and communities must make decisions on whether, or how, to use modern scientific information (e.g., nuclear energy, biotechnology, genetic engineering). L1		
Personal health				
Give examples of good health habits for individuals and families (e.g., nutrition, dental care, personal hygiene, cleanliness, regular exercise). L1	Describe how nutrition is essential to health, including eating a variety of foods, less sugar, and less fat, and understanding how the body uses food. L1	Give evidence that regular exercise leads to the physiological benefits of physical fitness (healthy weight, good strength, strong heart-lung system). L1	List ways that families are an important support structure that serves many physical, mental, and social needs of individuals, particularly young children. L1	Describe examples of substances that modify an individual's physiology or behavior in detrimental or beneficial ways (e.g., cholesterol-lowering drugs), yet can also lead to physical dependency and increased health risks. L1
	Give examples of substances or medicines that can help the body and others that can damage the body and how it functions (e.g., medicine, tobacco products, alcohol, drugs). L2	Discuss ways that sexuality is a natural human function that requires physiological, cultural, and ethical understandings. L1	Write ways that sexuality is basic to the physical, personal, and social development of humans and involves understandings of physiological functions, cultural influences, and ethical values of families and communities. L1	Describe how diseases depend on many factors (e.g., influenza) and while many diseases can be prevented (HIV, STDs), controlled (asthma), or cured (tuberculosis), other diseases may result from body dysfunctions or personal habits and cannot be transmitted (cancer, heart disease). L1

Early elementary	Late elementary	Middle/junior high school	Early high school	Late high school
Natural resources and humans in the environment				
Examine and group how things humans use come from the living and nonliving parts of the environment. L1	Give examples of how the supply of many resources is limited (e.g., wood, fish), while many materials can be reused or recycled. L1	Explain different ways that humans interact with and rely on the environment. L1	Describe examples of factors that influence ecosystems and the environment, such as organism populations and distribution, resource use, consumption patterns, socioeconomic needs, and political or religious views. L1	
Natural hazards and level of risk				
Describe changes in the environment that are natural, and can become hazardous (e.g., floods, earthquakes, hurricanes, tornadoes). L1	Explain changes in the environment that humans can cause and when these can be hazardous (e.g., increased erosion, pollution). L1	Describe natural processes that result in hazards that rapidly change the environment, damage property, and harm and kill humans with different levels of risk (e.g., earthquakes, wildfires, tornadoes, volcanic eruptions, droughts, floods). L1	Describe with examples both natural and human-related hazards that present a need to assess potential danger and levels of risk. L1	Show how many types of hazards (natural or human-induced) can lead to injury, illness, or death, but that such hazards can often be reduced using science and technology. L2

Note: *Each benchmark shows one of three levels of significance in the grade-level alignment: critical to understand and master (L1, level 1); significant to develop (L2, level 2); useful to work on (L3, level 3).*