Standard 4—Science
Elementary

Physical Setting

1. The Earth and celestial phenomena can be described by principles of relative motion and perspective.

Students:
- **describe patterns of daily, monthly, and seasonal changes in their environment.**

This is evident, for example, when students:

▲ conduct a long-term weather investigation, such as running a weather station or collecting weather data.

▲ keep a journal of the phases of the moon over a one-month period. This information is collected for several different one-month periods and compared.

2. Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

Students:
- **describe the relationships among air, water, and land on Earth.**

This is evident, for example, when students:

▲ observe a puddle of water outdoors after a rainstorm. On a return visit after the puddle has disappeared, students describe where the water came from and possible locations for it now.

▲ assemble rock and mineral collections based on characteristics such as erosional features or crystal size features.

3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Students:
- **observe and describe properties of materials using appropriate tools.**
- **describe chemical and physical changes, including changes in states of matter.**

This is evident, for example, when students:

▲ compare the appearance of materials when seen with and without the aid of a magnifying glass.

▲ investigate simple physical and chemical reactions and the chemistry of household products, e.g., freezing, melting, and evaporating; a comparison of new and rusty nails; the role of baking soda in cooking.

4. Energy exists in many forms, and when these forms change energy is conserved.

Students:
- **describe a variety of forms of energy (e.g., heat, chemical, light) and the changes that occur in objects when they interact with those forms of energy.**
- **observe the way one form of energy can be transformed into another form of energy present in common situations (e.g., mechanical to heat energy, mechanical to electrical energy, chemical to heat energy).**

This is evident, for example, when students:

▲ investigate the interactions of liquids and powders that result in chemical reactions (e.g., vinegar and baking soda) compared to interactions that do not (e.g., water and sugar).

▲ in order to demonstrate the transformation of chemical to electrical energy, construct electrical cells from objects, such as lemons or potatoes, using pennies and aluminum foil inserted in slits at each end of fruits or vegetables; the penny and aluminum are attached by wires to a milliammeter. Students can compare the success of a variety of these electrical cells.

5. Energy and matter interact through forces that result in changes in motion.

Students:
- **describe the effects of common forces (pushes and pulls) on objects, such as those caused by gravity, magnetism, and mechanical forces.**
- **describe how forces can operate across distances.**

This is evident, for example, when students:

▲ investigate simple machines and use them to perform tasks.

Key ideas are identified by numbers (1).
Performance indicators are identified by bullets (•).
Sample tasks are identified by triangles (▲).

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

The Living Environment

1. Living things are both similar to and different from each other and nonliving things.

Students:
- **describe the characteristics of and variations between living and nonliving things.**
- **describe the life processes common to all living things.**

This is evident, for example, when students:

▲ grow a plant or observe a pet, investigating what it requires to stay alive, including evaluating the relative importance and necessity of each item.

▲ investigate differences in personal body characteristics, such as temperature, pulse, heart rate, blood pressure, and reaction time.

2. Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

Students:
- **recognize that traits of living things are both inherited and acquired or learned.**
- **recognize that for humans and other living things there is genetic continuity between generations.**

This is evident, for example, when students:

▲ interact with a classroom pet, observe its behaviors, and record what they are able to teach the animal, such as navigation of a maze or performance of tricks, compared to that which remains constant, such as eye color, or number of digits on an appendage.

▲ use breeding records and photographs of racing horses or pedigreed animals to recognize that variations exist from generation to generation but "like begets like."

3. Individual organisms and species change over time.

Students:
- **describe how the structures of plants and animals complement the environment of the plant or animal.**
- **observe that differences within a species may give individuals an advantage in surviving and reproducing.**

This is evident, for example, when students:

▲ relate physical characteristics of organisms to habitat characteristics (e.g., long hair and fur color change for mammals living in cold climates).

▲ visit a farm or a zoo and make a written or pictorial comparison of members of a litter and identify characteristics that may provide an advantage.

4. The continuity of life is sustained through reproduction and development.

Students:
- **describe the major stages in the life cycles of selected plants and animals.**
- **describe evidence of growth, repair, and maintenance, such as nails, hair, and bone, and the healing of cuts and bruises.**

This is evident, for example, when students:

▲ grow bean plants or butterflies; record and describe stages of development.

5. Organisms maintain a dynamic equilibrium that sustains life.

Students:
- **describe basic life functions of common living specimens (guppy, mealworm, gerbil).**
- **describe some survival behaviors of common living specimens.**
- **describe the factors that help promote good health and growth in humans.**

This is evident, for example, when students:

▲ observe a single organism over a period of weeks and describe such life functions as moving, eating, resting, and eliminating.

▲ observe and demonstrate reflexes such as pupil dilation and contraction and relate such reflexes to improved survival.

▲ analyze the extent to which diet and exercise habits meet cardiovascular, energy, and nutrient requirements.

6. Plants and animals depend on each other and their physical environment.

Students:
- **describe how plants and animals, including humans, depend upon each other and the nonliving environment.**
- **describe the relationship of the sun as an energy source for living and nonliving cycles.**

This is evident, for example, when students:

▲ investigate how humans depend on their environment (neighborhood), by observing, recording, and discussing the interactions that occur in carrying out their everyday lives.

▲ observe the effects of sunlight on growth for a garden vegetable.

7. Human decisions and activities have had a profound impact on the physical and living environment.

Students:
- **identify ways in which humans have changed their environment and the effects of those changes.**

This is evident, for example, when students:

▲ give examples of how inventions and innovations have changed the environment; describe benefits and burdens of those changes.

Standard 4—Science
Intermediate

Physical Setting

1. The Earth and celestial phenomena can be described by principles of relative motion and perspective.

Students:
- **explain daily, monthly, and seasonal changes on earth.**

This is evident, for example, when students:

▲ create models, drawings, or demonstrations describing the arrangement, interaction, and movement of the Earth, moon, and sun.

▲ plan and conduct an investigation of the night sky to describe the arrangement, interaction, and movement of celestial bodies.

2. Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

Students:
- **explain how the atmosphere (air), hydrosphere (water), and lithosphere (land) interact, evolve, and change.**
- **describe volcano and earthquake patterns, the rock cycle, and weather and climate changes.**

This is evident, for example, when students:

▲ add heat to and subtract heat from water and graph the temperature changes, including the resulting phase changes.

▲ make a record of reported earthquakes and volcanoes and interpret the patterns formed worldwide.

3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Students:
- **observe and describe properties of materials, such as density, conductivity, and solubility.**
- **distinguish between chemical and physical changes.**
- **develop their own mental models to explain common chemical reactions and changes in states of matter.**

This is evident, for example, when students:

▲ test and compare the properties (hardness, shape, color, etc.) of an array of materials.

▲ observe an ice cube as it begins to melt at temperature and construct an explanation for what happens, including sketches and written descriptions of their ideas.

4. Energy exists in many forms, and when these forms change energy is conserved.

Students:
- **describe the sources and identify the transformations of energy observed in everyday life.**
- **observe and describe heating and cooling events.**
- **observe and describe energy changes as related to chemical reactions.**
- **observe and describe the properties of sound, light, magnetism, and electricity.**
- **describe situations that support the principle of conservation of energy.**

This is evident, for example, when students:

▲ design and construct devices to transform/transfer energy.

▲ conduct supervised explorations of chemical reactions (not including ammonia and bleach products) for selected household products, such as hot and cold packs used to treat sport injuries.

▲ build an electromagnet and investigate the effects of using different types of core materials, varying thicknesses of wire, and different circuit types.

5. Energy and matter interact through forces that result in changes in motion.

Students:
- **describe different patterns of motion of objects.**
- **observe, describe, and compare effects of forces (gravity, electric current, and magnetism) on the motion of objects.**

This is evident, for example, when students:

▲ investigate physics in everyday life, such as at an amusement park or a playground.

▲ use simple machines made of pulleys and levers to lift objects and describe how each machine transforms the force applied to it.

▲ build "Rube Goldberg" type devices and describe the energy transformations evident in them.

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Performance indicators are identified by bullets (•).
Sample tasks are identified by triangles (▲).

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

The Living Environment

1. Living things are both similar to and different from each other and nonliving things.

Students:
- **compare and contrast the parts of plants, animals, and one-celled organisms.**
- **explain the functioning of the major human organ systems and their interactions.**

This is evident, for example, when students:

▲ conduct a survey of the school grounds and develop appropriate classification keys to group plants and animals by shared characteristics.

▲ use spring-type clothespins to investigate muscle fatigue or rulers to determine the effect of amount of sleep on hand-eye coordination.

2. Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

Students:
- **describe sexual and asexual mechanisms for passing genetic materials from generation to generation.**
- **describe simple mechanisms related to the inheritance of some physical traits in offspring.**

This is evident, for example, when students:

▲ contrast dominance and blending as models for explaining inheritance of traits.

▲ trace patterns of inheritance for selected human traits.

3. Individual organisms and species change over time.

Students:
- **describe sources of variation in organisms and their structures and relate the variations to survival.**
- **describe factors responsible for competition within species and the significance of that competition.**

This is evident, for example, when students:

▲ conduct a long-term investigation of plant or animal communities.

▲ investigate the acquired effects of industrialization on tree trunk color and those effects on different insect species.

4. The continuity of life is sustained through reproduction and development.

Students:
- **observe and describe the variations in reproductive patterns of organisms, including asexual and sexual reproduction.**
- **explain the role of sperm and egg cells in sexual reproduction.**
- **observe and describe developmental patterns in selected plants and animals (e.g., insects, frogs, humans, seed-bearing plants).**
- **observe and describe cell division at the microscopic level and its macroscopic effects.**

This is evident, for example, when students:

▲ apply a model of the genetic code as an analogue for the role of the genetic code in human populations.

5. Organisms maintain a dynamic equilibrium that sustains life.

Students:
- **compare the way a variety of living specimens carry out basic life functions and maintain dynamic equilibrium.**
- **describe the importance of major nutrients, vitamins, and minerals in maintaining health and promoting growth and explain the need for a constant input of energy for living organisms.**

This is evident, for example, when students:

▲ record and compare the behaviors of animals in their natural habitats and relate how these behaviors are important to the animals.

▲ design and conduct a survey of personal nutrition and exercise habits, and analyze and critique the results of that survey.

6. Plants and animals depend on each other and their physical environment.

Students:
- **describe the flow of energy and matter through food chains and food webs.**
- **provide evidence that green plants make food and explain the significance of this process to other organisms.**

This is evident, for example, when students:

▲ construct a food web for a community of organisms and explore how elimination of a particular part of a chain affects the rest of the chain and web.

7. Human decisions and activities have had a profound impact on the physical and living environment.

Students:
- **describe how living things, including humans, depend upon the living and nonliving environment for their survival.**
- **describe the effects of environmental changes on humans and other populations.**

This is evident, for example, when students:

▲ conduct an extended investigation of a local environment affected by human actions, (e.g., a pond, stream, forest, empty lot).

Standard 4—Science
Commencement

Physical Setting

1. The Earth and celestial phenomena can be described by principles of relative motion and perspective.

Students:
- **explain complex phenomena, such as tides, variations in day length, solar insolation, apparent motion of the planets, and annual traverse of the constellations.**
- **describe current theories about the origin of the universe and solar system.**

This is evident, for example, when students:

▲ create models, drawings, or demonstrations to explain changes in day length, solar insolation, and the apparent motion of planets.

2. Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

Students:
- **use the concepts of density and heat energy to explain observations of weather patterns, seasonal changes, and the movements of the Earth's plates.**
- **explain how incoming solar radiations, ocean currents, and land masses affect weather and climate.**

This is evident, for example, when students:

▲ use diagrams of ocean currents at different latitudes to develop explanations for the patterns present.

3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Students:
- **explain the properties of materials in terms of the arrangement and properties of the atoms that compose them.**
- **use atomic and molecular models to explain common chemical reactions.**
- **apply the principle of conservation of mass to chemical reactions.**
- **use kinetic molecular theory to explain rates of reactions and the relationships among temperature, pressure, and volume of a substance.**

This is evident, for example, when students:

▲ use the atomic theory of elements to justify their choice of an element for use as a lighter than air gas for a launch vehicle.

▲ represent common chemical reactions using three-dimensional models of the molecules involved.

▲ discuss and explain a variety of everyday phenomena involving rates of chemical reactions, in terms of the kinetic molecular theory (e.g., use of refrigeration to keep food from spoiling, ripening of fruit in a bowl, use of kindling wood to start a fire, different types of flames that come from a Bunsen burner).

4. Energy exists in many forms, and when these forms change energy is conserved.

Students:
- **observe and describe transmission of various forms of energy.**
- **explain heat in terms of kinetic molecular theory.**
- **explain variations in wavelength and frequency in terms of the source of the vibrations that produce them, e.g., molecules, electrons, and nuclear particles.**
- **explain the uses and hazards of radioactivity.**

This is evident, for example, when students:

▲ demonstrate through drawings, models, and diagrams how the potential energy that exists in the chemical bonds of fossil fuels can be converted to electrical energy in a power plant (potential energy ⇨ heat energy ⇨ mechanical energy ⇨ electrical energy).

▲ investigate the sources of radioactive emissions in their environment and the dangers and benefits they pose for humans.

5. Energy and matter interact through forces that result in changes in motion.

Students:
- **explain and predict different patterns of motion of objects (e.g., linear and angular motion, velocity and acceleration, momentum and inertia).**
- **explain chemical bonding in terms of the motion of electrons.**
- **compare energy relationships within an atom's nucleus to those outside the nucleus.**

This is evident, for example, when students:

▲ construct drawings, models, and diagrams representing several different types of chemical bonds to demonstrate the basis of the bond, the strength of the bond, and the type of electrical attraction that exists.

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Sample tasks are identified by triangles (▲).

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

The Living Environment

1. Living things are both similar to and different from each other and nonliving things.

Students:
- **explain how diversity of populations within ecosystems relates to the stability of ecosystems.**
- **describe and explain the structures and functions of the human body at different organizational levels (e.g., systems, tissues, cells, organelles).**
- **explain how a one-celled organism is able to function despite lacking the levels of organization present in more complex organisms.**

2. Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

Students:
- **explain how the structure and replication of genetic material result in offspring that resemble their parents.**
- **explain how the technology of genetic engineering allows humans to alter the genetic makeup of organisms.**

This is evident, for example, when students:

▲ record outward characteristics of fruit flies and then breed them to determine patterns of inheritance.

3. Individual organisms and species change over time.

Students:
- **explain the mechanisms and patterns of evolution.**

This is evident, for example, when students:

▲ determine characteristics of the environment that affect a hypothetical organism and explore how different characteristics of the species give it a selective advantage.

4. The continuity of life is sustained through reproduction and development.

Students:
- **explain how organisms, including humans, reproduce their own kind.**

This is evident, for example, when students:

▲ observe the development of fruit flies or rapidly maturing plants, from fertilized egg to mature adult, relating embryological development and structural adaptations to the propagation of the species.

5. Organisms maintain a dynamic equilibrium that sustains life.

Students:
- **explain the basic biochemical processes in living organisms and their importance in maintaining dynamic equilibrium.**
- **explain disease as a failure of homeostasis.**
- **relate processes at the system level to the cellular level in order to explain dynamic equilibrium in multicelled organisms.**

This is evident, for example, when students:

▲ investigate the biochemical processes of the immune system, and its relationship to maintaining mental and physical health.

6. Plants and animals depend on each other and their physical environment.

Students:
- **explain factors that limit growth of individuals and populations.**
- **explain the importance of preserving diversity of species and habitats.**
- **explain how the living and nonliving environments change over time and respond to disturbances.**

This is evident, for example, when students:

▲ conduct a long-term investigation of a local ecosystem.

7. Human decisions and activities have had a profound impact on the physical and living environment.

Students:
- **describe the range of interrelationships of humans with the living and nonliving environment.**
- **explain the impact of technological development and growth in the human population on the living and non-living environment.**
- **explain how individual choices and societal actions can contribute to improving the environment.**

This is evident, for example, when students:

▲ compile a case study of a technological development that has had a significant impact on the environment.