

# National Science Framework for K-2

Eight practices to be essential elements of the K-12 science and engineering curriculum:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

## SEVEN CROSSCUTTING CONCEPTS OF THE FRAMEWORK

The committee identified seven crosscutting scientific and engineering concepts:

1. *Patterns.* Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.
2. *Cause and effect: Mechanism and explanation.* Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
3. *Scale, proportion, and quantity.* In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
4. *Systems and system models.* Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
5. *Energy and matter: Flows, cycles, and conservation.* Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. *Structure and function.* The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
7. *Stability and change.* For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of the system are critical elements of study.

# PHYSICAL SCIENCE

## Core and Component Ideas in the Physical Sciences

### Core Idea PS1: Matter and Its Interactions

- PS1.A: Structure and Properties of Matter
- PS1.B: Chemical Reactions
- PS1.C: Nuclear Processes

### Core Idea PS2: Motion and Stability: Forces and Interactions

- PS2.A: Forces and Motion
- PS2.B: Types of Interactions
- PS2.C: Stability and Instability in Physical Systems

### Core Idea PS3: Energy

- PS3.A: Definitions of Energy
- PS3.B: Conservation of Energy and Energy Transfer
- PS3.C: Relationship Between Energy and Forces
- PS3.D: Energy in Chemical Processes and Everyday Life

### Core Idea PS4: Waves and Their Applications in Technologies for Information Transfer

- PS4.A: Wave Properties
- PS4.B: Electromagnetic Radiation
- PS4.C: Information Technologies and Instrumentation.

## CORE IDEA PS1: MATTER AND ITS INTERACTIONS

*How can one explain the structure, properties, and interactions of matter?*

### PS1.A: Structure and Properties of Matter

*How do particles combine to form the variety of substances one observes?*

- **By the end of grade 2.** Matter exists as different substances (e.g., wood, metal, water), and many of them can be either solid or liquid, depending on temperature. Substances can be described and classified by their observable properties (e.g., visual, aural, textural), by their uses, and by whether they occur naturally or are manufactured. Different properties are suited to different purposes. A great variety of objects can be built up from a small set of pieces. Objects or samples of a substance can be weighed and their size can be described and measured.
- (Boundary: volume is introduced only for liquid measure.)

### **PS1.B: Chemical Reactions**

*How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?*

- **By the end of grade 2.** Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible (e.g., melting and freezing) and sometimes they are not (e.g., baking a cake, burning fuel).

### **PS1.C: Nuclear Processes**

*What forces hold nuclei together and mediate nuclear processes?*

- **By the end of grade 2.** Intentionally left blank.

## **CORE IDEA PS2: MOTION AND STABILITY: FORCES AND INTERACTIONS**

*How can one explain and predict interactions between objects and within systems?*

### **PS2.A: Forces and Motion**

*How can one predict an object's continued motion, changes in motion, or stability?*

- **By the end of grade 2.** Objects pull or push each other when they collide or are connected. Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. An object sliding on a surface or sitting on a slope experiences a pull due to friction between the object and the surface that opposes its motion.

### **PS2.B: Types of Interactions**

*What underlying forces explain the variety of interactions observed?*

- **By the end of grade 2.** When objects touch or collide, they push on one another and can change motion or shape.

### **PS2.C: Stability and Instability in Physical Systems**

*Why are some physical systems more stable than others?*

- **By the end of grade 2.** Whether an object stays still or moves often depends on the effects of multiple pushes and pulls on it (e.g., multiple players trying to pull an object in different directions). It is useful to investigating what pushes and pulls keep something in place (e.g., a ball on a slope, a ladder leaning on a wall) as well as what makes something change or move.

## **CORE IDEA PS3: ENERGY**

*How is energy transferred and conserved?*

### **PS3.A: Definitions of Energy**

*What is energy?*

- **By the end of grade 2.** Intentionally left blank.

### **PS3.B: Conservation of Energy and Energy Transfer**

*What is meant by conservation of energy?*

*How is energy transferred between objects or systems?*

- **By the end of grade 2.** Sunlight warms Earth's surface.

### **PS3.C Relationship Between Energy and Forces**

*How are forces related to energy?*

- **By the end of grade 2.** A bigger push or pull makes things go faster, and faster motion can cause a bigger change in shape when things collide.

### **PS3.D: Energy in Chemical Processes and Everyday Life**

*How do food and fuel provide energy?*

*If energy is conserved, why do people say it is produced or used?*

- **By the end of grade 2.** When two objects are rubbed together heat is produced; this is called friction. There are ways to reduce the friction between two objects.

## **CORE IDEA PS4: WAVES AND THEIR APPLICATIONS IN TECHNOLOGIES FOR INFORMATION TRANSFER**

*How are waves used to transfer energy and information?*

### **PS4.A: Wave Properties**

*What are the characteristic properties and behaviors of waves?*

- **By the end of grade 2.** Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; it doesn't move in the direction of the wave—observe, for example, a bobbing cork or seabird—except when the water meets the beach. Sound can make matter vibrate, and vibrating matter can make sound.

### **PS4.B: Electromagnetic Radiation**

*What is light?*

*How can one explain the varied effects that involve light?*

*What other forms of electromagnetic radiation are there?*

- **By the end of grade 2.** Objects can be seen only when light is available to illuminate them. Very hot objects give off light (e.g., a fire, the sun).

### **PS4.C: Information Technologies and Instrumentation**

*How are instruments that transmit and detect waves used to extend human senses?*

- **By the end of grade 2.** People use their senses to learn about the world around them. Their eyes detect light, their ears detect sound, and they can feel vibrations by touch. People also use a variety of devices to communicate (send and receive information) over long distances.

# LIFE SCIENCE

## Core and Component Ideas in Life Sciences

### Core Idea LS1: From Molecules to Organisms: Structures and Processes

- LS1.A: Structure and Function
- LS1.B: Growth and Development of Organisms
- LS1.C: Organization for Matter and Energy Flow in Organisms
- LS1.D: Information Processing

### Core Idea LS2: Ecosystems: Interactions, Energy, and Dynamics

- LS2.A: Interdependent Relationships in Ecosystems
- LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- LS2.D: Social Interactions and Group Behavior

### Core Idea LS3: Heredity: Inheritance and Variation of Traits

- LS3.A: Inheritance of Traits
- LS3.B: Variation of Traits

### Core Idea LS4: Biological Evolution: Unity and Diversity

- LS4.A: Evidence of Common Ancestry and Diversity
- LS4.B: Natural Selection
- LS4.C: Adaptation
- LS4.D: Biodiversity and Humans

## CORE IDEA LS1: FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES

*How do organisms live, grow, respond to their environment, and reproduce?*

### LS1.A: Structure and Function

*How do the structures of organisms enable life's functions?*

- **By the end of grade 2.** All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive, grow, and produce more plants.

## **LS1.B: Growth and Development of Organisms**

*How do organisms grow and develop?*

- **By the end of grade 2.** Plants and animals have predictable characteristics at different stages of development. Plants and animals grow and change. Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive.

## **LS1.C: Organization for Matter and Energy Flow in Organisms**

*How do organisms obtain and use the matter and energy they need to live and grow?*

- **By the end of grade 2.** All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow.

## **LS1.D: Information Processing**

*How do organisms detect, process, and use information about the environment?*

- **By the end of grade 2.** Animals have body parts that capture and convey different kinds of information needed for growth and survival—for example, eyes for light, ears for sounds, and skin for temperature or touch. Animals respond to these inputs with behaviors that help them survive (e.g., find food, run from a predator). Plants also respond to some external inputs (e.g., turn leaves toward the sun).

## **CORE IDEA LS2: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS**

*How and why do organisms interact with their environment, and what are the effects of these interactions?*

### **LS2.A: Interdependent Relationships in Ecosystems**

*How do organisms interact with the living and nonliving environment to obtain matter and energy?*

- **By the end of grade 2.** Animals depend on their surroundings to get what they need, including food, water, shelter, and a favorable temperature. Animals depend on plants or other animals for food. They use their senses to find food and water, and they use their body parts to gather, catch, eat, and chew the food. Plants depend on air, water, minerals (in the soil), and light to grow. Animals can move around, but plants cannot, and they often depend on animals for pollination or to move their seeds around. Different plants survive better in different settings because they have varied needs for water, minerals, and sunlight.

## **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems**

*How do matter and energy move through an ecosystem?*

- **By the end of grade 2.** Organisms obtain the materials they need to grow and survive from the environment. Many of these materials come from organisms and are used again by other organisms.

## **LS2.C: Ecosystem Dynamics, Functioning, and Resilience**

*What happens to ecosystems when the environment changes?*

- **By the end of grade 2.** The places where plants and animals live often change, sometimes slowly and sometimes rapidly. When animals and plants get too hot or too cold, they may die. If they can't find enough food, water, or air, they may die.

## **LS2.D: Social Interactions and Group Behavior**

*How do organisms interact in groups so as to benefit individuals?*

- **By the end of grade 2.** Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size.

## **CORE IDEA LS3: HEREDITY: INHERITANCE AND VARIATION OF TRAITS**

*How are characteristics of one generation passed to the next?*

*How can individuals of the same species and even siblings have different characteristics?*

### **LS3.A: Inheritance of Traits**

*How are the characteristics of one generation related to the previous generation?*

- **By the end of grade 2.** Organisms have characteristics that can be similar or different. Young animals are very much, but not exactly, like their parents and also resemble other animals of the same kind. Plants also are very much, but not exactly, like their parents and resemble other plants of the same kind.

### **LS3.B: Variation of Traits**

*Why do individuals of the same species vary in how they look, function, and behave?*

- **By the end of grade 2.** Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.

## **IDEA LS4: BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY**

*How can there be so many similarities among organisms yet so many different kinds of plants, animals, and microorganisms?*

*How does biodiversity affect humans?*

### **LS4.A: Evidence of Common Ancestry and Diversity**

*What evidence shows that different species are related?*

- **By the end of grade 2.** Some kinds of plants and animals that once lived on Earth (e.g., dinosaurs) are no longer found anywhere, although others now living (e.g., lizards) resemble them in some ways.

### **LS4.B: Natural Selection**

*How does genetic variation among organisms affect survival and reproduction?*

- **By the end of grade 2.** Intentionally left blank.

### **LS4.C: Adaptation**

*How does the environment influence populations of organisms over multiple generations?*

- **By the end of grade 2.** Living things can survive only where their needs are met. If some places are too hot or too cold or have too little water or food, plants and animals may not be able to live there.

### **LS4.D: Biodiversity and Humans**

*What is biodiversity, how do humans affect it, and how does it affect humans?*

- **By the end of grade 2.** There are many different kinds of living things in any area, and they exist in different places on land and in water.

# EARTH SCIENCE

## Core and Component Ideas in Earth and Space Sciences

### Core Idea ESS1: Earth's Place in the Universe

- ESS1.A: The Universe and Its Stars
- ESS1.B: Earth and the Solar System
- ESS1.C: The History of Planet Earth

### Core Idea ESS2: Earth's Systems

- ESS2.A: Earth Materials and Systems
- ESS2.B: Plate Tectonics and Large-Scale System Interactions
- ESS2.C: The Roles of Water in Earth's Surface Processes
- ESS2.D: Weather and Climate
- ESS2.E: Biogeology

### Core Idea ESS3: Earth and Human Activity

- ESS3.A: Natural Resources
- ESS3.B: Natural Hazards
- ESS3.C: Human Impacts on Earth Systems
- ESS3.D: Global Climate Change

## CORE IDEA ESS1: EARTH'S PLACE IN THE UNIVERSE

*What is the universe, and what is Earth's place in it?*

### ESS1.A: The Universe and Its Stars

*What is the universe, and what goes on in stars?*

- **By the end of grade 2.** Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. At night one can see the light coming from many stars with the naked eye, but telescopes make it possible to see many more and to observe them and the moon and planets in greater detail.

### ESS1.B: Earth and the Solar System

*What are the predictable patterns caused by Earth's movement in the solar system?*

- **By the end of grade 2.** Seasonal patterns of sunrise and sunset can be observed, described, and predicted.

### **ESS1.C: The History of Planet Earth**

*How do people reconstruct and date events in Earth's planetary history?*

- **By the end of grade 2.** Some events on Earth occur in cycles, like day and night, and others have a beginning and an end, like a volcanic eruption. Some events, like an earthquake, happen very quickly; others, such as the formation of the Grand Canyon, occur very slowly, over a time much longer than one can observe them.

### **CORE IDEA ESS2: EARTH'S SYSTEMS**

*How and why is the earth constantly changing?*

#### **ESS2.A: Earth Materials and Systems**

*How do the major earth systems interact?*

- **By the end of grade 2.** Wind and water can change the shape of the land. The resulting landforms, together with the materials on the land, provide homes for living things.

#### **ESS2.B: Plate Tectonics and Large-Scale System Interactions**

*Why do the continents move, and what causes earthquakes and volcanoes?*

- **By the end of grade 2.** Rocks, soils, and sand are present in most areas where plants and animals live. There may also be rivers, streams, lakes, and ponds. Maps show where things are located. One can map the shapes and kinds of land and water in any area.

#### **ESS2.C: The Roles of Water in Earth's Surface Processes**

*How do the properties and movements of water shape Earth's surface and affect its systems?*

- **By the end of grade 2.** Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form. It carries soil and rocks from one place to another and determines the variety of life forms that can live in a particular location.

#### **ESS2.D: Weather and Climate**

*What regulates weather and climate?*

- **By the end of grade 2.** Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time.

### **ESS2.E: Biogeology**

*How do living organisms alter Earth's processes and structures?*

- **By the end of grade 2.** Plants and animals (including humans) depend on the land, water, and air to live and grow. They in turn can change their environment (e.g., the shape of land, the flow of water.)

## **CORE IDEA ESS3: EARTH AND HUMAN ACTIVITY**

*How do Earth's surface processes and human activities affect each other?*

### **ESS3.A: Natural Resources**

*How do humans depend on Earth's resources?*

- **By the end of grade 2.** Living things need water, air, and resources from the land, and they try to live in places that have the things they need. Humans use natural resources for everything they do: for example, they use soil and water to grow food, wood to burn to provide heat or to build shelters, and materials such as iron or copper extracted from the earth to make cooking pans.

### **ESS3.B: Natural Hazards**

*How do natural hazards affect individuals and societies?*

- **By the end of grade 2.** Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that communities can prepare for and respond to these events.

### **ESS3.C: Human Impacts on Earth Systems**

*How do humans change the planet?*

- **By the end of grade 2.** Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things—for example, by reducing trash through reuse and recycling.

### **ESS3.D: Global Climate Change**

*How do people model and predict the effects of human activities on Earth's climate?*

- **By the end of grade 2.** Intentionally left blank.

## ENGINEERING, TECHNOLOGY, AND APPLICATION OF SCIENCE

### Core and Component Ideas in Engineering, Technology, and Application of Science

#### Core Idea ETS1: Engineering Design

- ETS1.A: Defining and Delimiting an Engineering Problem
- ETS1.B: Developing Possible Solutions
- ETS1.C: Optimizing the Design Solution

#### Core Idea ETS2: Links Among Engineering, Technology, Science, and Society

- ETS2.A: Interdependence of Science, Engineering, and Technology
- ETS2.B: Influence of Engineering, Technology and Science on Society and the Natural World

### CORE IDEA ETS1: ENGINEERING DESIGN

*How do engineers solve problems?*

#### ETS1.A: Defining and Delimiting an Engineering Problem

*What is a design for?*

*What are the criteria and constraints of a successful solution?*

- **By the end of grade 2.** A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. Asking questions, making observations, and gathering information are helpful in thinking about problems. Before beginning to design a solution, it is important to clearly understand the problem.

#### ETS1.B: Developing Possible Solutions

*What is the process for developing potential design solutions?*

- **By the end of grade 2.** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. To design something complicated, one may need to break the problem into parts and attend to each part separately but must then bring the parts together to test the overall plan.

#### ETS1.C: Optimizing the Design Solution

*How can the various proposed design solutions be compared and improved?*

- **By the end of grade 2.** Because there is always more than one possible solution to a problem, it is useful to compare designs, test them, and discuss their strengths and weaknesses.

## **CORE IDEA ETS2: LINKS AMONG ENGINEERING, TECHNOLOGY, SCIENCE, AND SOCIETY**

*How are engineering, technology, science, and society interconnected?*

### **ETS2.A: Interdependence of Science, Engineering, and Technology**

*What are the relationships among science, engineering, and technology?*

- ***By the end of grade 2.*** People encounter questions about the natural world every day. There are many types of tools produced by engineering that can be used in science to help answer these questions through observation or measurement. Observations and measurements are also used in engineering to help test and refine design ideas.

### **ETS2.B: Influence of Engineering, Technology and Science on Society and the Natural World**

*How do science, engineering, and the technologies that result from them affect the ways in which people live? How do they affect the natural world?*

- ***By the end of grade 2.*** People depend on various technologies in their lives; human life would be very different without technology. Every human-made product is designed by applying some knowledge of the natural world and is built by using materials derived from the natural world, even when the materials are not themselves natural—for example, spoons made from refined metals. Thus, developing and using technology has impacts on the natural world.