INTRODUCTION TO PERFORMANCE EXPECTATIONS

“The NGSS are standards or goals, that reflect what a student should know and be able to do; they do not dictate the manner or methods by which the standards are taught. . . . Curriculum and assessment must be developed in a way that builds students’ knowledge and ability toward the PEs [performance expectations]” (Next Generation Science Standards, 2013, page xiv).

This chapter shows how the NGSS Performance Expectations were bundled in the Earth and Sun Module to provide a coherent set of instructional materials for teaching and learning.

This chapter also provides details about how this FOSS module fits into the matrix of the FOSS Program (page 43). Each FOSS module K–5 and middle school course 6–8 has a functional role in the FOSS conceptual frameworks that were developed based on a decade of research on science education and the influence of A Framework for K–12 Science Education (2012) and Next Generation Science Standards (NGSS, 2013).

The FOSS curriculum provides a coherent vision of science teaching and learning in the three ways described by the NRC Framework. First, FOSS is designed around learning as a developmental progression, providing experiences that allow students to continually build on their initial notions and develop more complex science and engineering knowledge. Students develop functional understanding over time by building on foundational elements (intermediate knowledge). That progression is detailed in the conceptual frameworks.

Second, FOSS limits the number of core ideas, choosing depth of knowledge over broad shallow coverage. Those core ideas are addressed at multiple grade levels in ever greater complexity. FOSS investigations at each grade level focus on elements of core ideas that are teachable and learnable at that grade level.

Third, FOSS investigations integrate engagement with scientific ideas (content) and the practices of science and engineering by providing firsthand experiences.

Teach the module with the confidence that the developers have carefully considered the latest research and have integrated into each investigation the three dimensions of the Framework and NGSS, and have designed powerful connections to the Common Core State Standards for English Language Arts.
Disciplinary Core Ideas Addressed

The Earth and Sun Module connects with the NRC Framework for the grades 3–5 grade band and the NGSS performance expectations for grade 5. The module focuses on core ideas for Earth and space sciences and physical sciences.

Earth and Space Sciences

Framework 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? [The Sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their size and distance from Earth.]

• ESS1.B: Earth and the solar system
  What are the predictable patterns caused by Earth’s movement in the solar system? [The orbits of Earth around the Sun and of the Moon around Earth, together with the rotation of Earth about an axis between its North and South Poles, cause observable patterns. These include day and night; daily and seasonal changes in the length and direction of shadows; phases of the Moon; and different positions of the Sun, Moon, and stars at different times of the day, month, and year.]

Some objects in the solar system can be seen with the naked eye. Planets in the night sky change positions and are not always visible from Earth as they orbit the Sun. Stars appear in patterns called constellations, which can be used for navigation and appear to move together across the sky because of Earth’s rotation.

The following NGSS grade 5 performance expectations for ESS1 are derived from the Framework disciplinary core ideas above.

• 5-ESS1-1. Support an argument that the apparent brightness of the Sun and stars is due to their relative distances from Earth. [Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).]

• 5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]
**Framework core idea ESS2: Earth’s systems—How and why is Earth constantly changing?**

- **ESS2.A: Earth materials and systems**
  *How do the Earth’s major systems interact?* [Earth’s major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth’s surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. Rainfall helps shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. Human activities affect Earth’s systems and their interactions at its surface.]

- **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?* [Water is found almost everywhere on Earth: as vapor; as fog or clouds in the atmosphere; as rain or snow falling from clouds; as ice, snow, and running water on land and in the ocean; and as ground water beneath the surface. The downhill movement of water as it flows to the ocean shapes the appearance of the land. Nearly all of Earth’s available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.]

The following NGSS grade 5 performance expectations for ESS2 are derived from the Framework disciplinary core ideas above.

- **5-ESS2-1.** Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. [Clarification Statement: Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system.] [Assessment Boundary: Assessment is limited to the interactions of two systems at a time.]

- **5-ESS2-2.** Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. [Assessment Boundary: Assessment is limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere.]
**Framework core idea ESS3: Earth and human activity—How do Earth’s surface processes and human activities affect each other?**

- **ESS3.C: Human impacts on Earth systems**
  *How do humans change the planet?*  
  [Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth’s resources and environments.]

The following NGSS grade 5 performance expectation for ESS3 is derived from the Framework disciplinary core idea above.

- **5-ESS3-1.** Obtain and combine information about ways individual communities use science ideas to protect Earth’s resources and environment.

**Physical Sciences**

**Framework 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 matter one observes?*  
  [Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means (e.g., by weighing or by its effects on other objects). For example, a model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon; the effects of air on larger particles or objects (e.g., leaves in wind, dust suspended in air); and the appearance of visible scale water droplets in condensation, fog, and, by extension, also in clouds or the contrails of a jet. The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish (e.g., sugar in solution, evaporation in a closed container). Measurement of a variety of properties (e.g., hardness, reflectivity) can be used to identify particular materials.]

The following NGSS grade 5 performance expectation for PS1 is derived from the Framework disciplinary core idea above.

- **5-PS1-1.** Develop a model to describe that matter is made of particles too small to be seen.  
  [Clarification Statement: Examples of evidence could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.  
  [Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.]
Framework core idea PS2: Motion and stability: Forces and interactions—How can one explain and predict interactions between objects and within systems of objects?

- PS2.B: Types of interactions
  What underlying forces explain the variety of interactions observed? (Objects in contact exert forces on each other (friction, elastic pushes and pulls). Electric, magnetic, and gravitational forces between a pair of objects do not require that the objects be in contact—for example, magnets push or pull at a distance. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. The gravitational force of Earth acting on an object near Earth’s surface pulls that object toward the planet’s center.)

The following NGSS grade 5 performance expectation for PS2 is derived from the Framework disciplinary core idea above.

- 5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down. [Clarification Statement: Down is a local description that points toward the center of the spherical Earth.] [Assessment Boundary: Assessment does not include mathematical representation of gravitational force.]
Engineering, Technology, and Applications of Science

Framework 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? [Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.]

- **ETS1.B: Developing possible solutions**
  What is the process for developing potential design solutions? [Research on a problem should be carried out before beginning to design a solution. An often productive way to generate ideas is for people to work together to brainstorm, test, and refine possible solutions. Testing a solution involves investigating how well it performs under a range of likely conditions. Tests are often designed to identify failure points or difficulties, which suggest the elements of a design that need to be improved. At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.]

- **ETS1.C: Optimizing the design solution**
  How can the various proposed design solutions be compared and improved? [Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.]
The following NGSS grades 3–5 performance expectations for ETS1 are derived from the Framework disciplinary core ideas on the previous page.

- **3-5-ETS1-2.** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

- **3-5-ETS1-3.** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
Science and Engineering Practices Addressed

1. Asking questions and defining problems
   - Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause-and-effect relationships.
   - Define a simple design problem that can be solved through the development of an object, tool, process, or system.

2. Developing and using models
   - Identify limitations of models.
   - Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regularly occurring events.
   - Develop and/or use models to describe and/or predict phenomena.
   - Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.
   - Use a model to test cause-and-effect relationships or interactions concerning the functioning of a natural or designed system.

3. Planning and carrying out investigations
   - Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
   - Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.
   - Make predictions about what would happen if a variable changes.

4. Analyzing and interpreting data
   - Represent data in tables and/or various graphical displays to reveal patterns that indicate relationships.
   - Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.
   - Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.
   - Use data to evaluate and refine design solutions.
5. **Using mathematics and computational thinking**
   - Organize simple data sets to reveal patterns that suggest relationships.
   - Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems.

6. **Constructing explanations and designing solutions**
   - Construct an explanation of observed relationships.
   - Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
   - Identify the evidence that supports particular points in an explanation.
   - Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

7. **Engaging in argument from evidence**
   - Compare and refine arguments based on an evaluation of the evidence presented.
   - Construct and/or support an argument with evidence, data, and/or a model.
   - Use data to evaluate claims about cause and effect.

8. **Obtaining, evaluating, and communicating information**
   - Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.
   - Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.
Crosscutting Concepts Addressed

Patterns

- Similarities and differences in patterns can be used to sort and classify natural phenomena. Patterns of change can be used to make predictions and as evidence to support an explanation.

Cause and effect

- Cause-and-effect relationships are routinely identified and used to explain change.

Scale, proportion, and quantity

- Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods.
- Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.

Systems and system models

- A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. A system can be described in terms of its components and their interactions.

Energy and matter

- Matter is made of particles.
- Energy can be transferred in various ways and between objects. Energy is transported into, out of, and within systems.
Connections: Understandings about the Nature of Science

Scientific investigations use a variety of methods.
- Scientific methods are determined by questions. Scientific investigations use a variety of methods, tools, and techniques.

Scientific knowledge is based on empirical evidence.
- Science findings are based on recognizing patterns. Scientists use tools and technologies to make accurate measurements and observations.

Scientific knowledge is open to revision in light of new evidence.
- Scientific explanations can change based on new evidence.

Science knowledge assumes an order and consistency in natural systems.
- Science assumes consistent patterns in natural systems. Basic laws of nature are the same everywhere in the universe.

Science is a human endeavor.
- Men and women from all cultures and backgrounds choose careers as scientists and engineers. Most scientists and engineers work in teams. Science affects everyday life. Creativity and imagination are important to science.

Connections to Engineering, Technology, and Applications of Science

- Interdependence of science, engineering, and technology. Science and technology support each other. Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies.

CONNECTIONS
See volume 2, appendix H and appendix J, in the NGSS for more on these connections.
For details on learning connections to Common Core State Standards for English Language Arts and Math, see the chapters FOSS and Common Core ELA—Grade 5 and FOSS and Common Core Math—Grade 5 in Teacher Resources.
FOSS CONCEPTUAL FRAMEWORK

In the last half decade, teaching and learning research has focused on learning progressions. The idea behind a learning progression is that core ideas in science are complex and wide-reaching, requiring years to develop fully—ideas such as the structure of matter or the relationship between the structure and function of organisms. From the age of awareness throughout life, matter and organisms are important to us. There are things students can and should understand about these core ideas in primary school years, and progressively more complex and sophisticated things they should know as they gain experience and develop cognitive abilities. When we as educators can determine those logical progressions, we can develop meaningful and effective curricula for students.

FOSS has elaborated learning progressions for core ideas in science for kindergarten through grade 8. Developing a learning progression involves identifying successively more sophisticated ways of thinking about a core idea over multiple years.

If mastery of a core idea in a science discipline is the ultimate educational destination, then well-designed learning progressions provide a map of the routes that can be taken to reach that destination. . . . Because learning progressions extend over multiple years, they can prompt educators to consider how topics are presented at each grade level so that they build on prior understanding and can support increasingly sophisticated learning. (National Research Council, A Framework for K–12 Science Education, 2012, page 26)

The FOSS modules are organized into three domains: physical science, earth science, and life science. Each domain is divided into two strands, as shown in the table “FOSS Next Generation—K–8 Sequence.” Each strand represents a core idea in science and has a conceptual framework

- Physical Science: matter; energy and change
- Earth and Space Science: dynamic atmosphere; rocks and landforms
- Life Science: structure and function; complex systems

The sequence in each strand relates to the core ideas described in the NRC Framework. Modules at the bottom of the table form the foundation in the primary grades. The core ideas develop in complexity as you proceed up the columns.
Information about the FOSS learning progression appears in the **conceptual framework** (pages 46-47), which shows the structure of scientific knowledge taught and assessed in this module, and the **content sequence** (pages 54-57), a graphic and narrative description that puts this single module into a K–8 strand progression.

FOSS is a research-based curriculum designed around the core ideas described in the NRC Framework. The FOSS module sequence provides opportunities for students to develop understanding over time by building on foundational elements or intermediate knowledge leading to the understanding of core ideas. Students develop this understanding by engaging in appropriate science and engineering practices and exposure to crosscutting concepts. The FOSS conceptual frameworks therefore are **more detailed and finer grained** than the set of goals described by the NGSS performance expectations (PEs). The following statement reinforces the difference between the standards as a blueprint for assessment and a curriculum, such as FOSS.

*Some reviewers of both public drafts [of NGSS] requested that the standards specify the intermediate knowledge necessary for scaffolding toward eventual student outcomes. However, the NGSS are a set of goals. They are PEs for the end of instruction—not a curriculum. Many different methods and examples could be used to help support student understanding of the DCIs and science and engineering practices, and the writers did not want to prescribe any curriculum or constrain any instruction. It is therefore outside the scope of the standards to specify intermediate knowledge and instructional steps.* (Next Generation Science Standards, 2013, volume 2, page 342)
BACKGROUND FOR THE CONCEPTUAL FRAMEWORK in Earth and Sun

Earth—The Big Picture

This module embraces huge concepts, huge in scope of the content and in physical dimensions of the study subjects. The module includes a survey of the solar system in order to place Earth in a larger context. The solar system is defined by the star Sol, our Sun. Sol is attended by the myriad planets and other bodies orbiting it. The generic name for a system of planets orbiting a star (or stars) is planetary system. The specific name of our planetary system is solar system. There is only one solar system.

Earth is the third planet from the Sun. It travels around the Sun in a nearly circular orbit at a distance of about 150 million kilometers. Earth is water rich, with 71% of the planet’s surface covered with water. It is surrounded by a shallow atmosphere of nitrogen (78%) and oxygen (21%), and small amounts of a lot of other gases. The atmosphere extends about 500 kilometers (km) above Earth’s surface, but most of the mass of the atmosphere is concentrated in the closest 9–20 km, the troposphere.

The module settles on Earth’s surface and focuses on subjects with global impact: atmosphere, water, and climate. Because Earth is situated at a fortuitous distance from the Sun, water is abundant in liquid form. Because Earth’s atmosphere is dynamic and restless, water is transported in the form of vapor over the entire globe. The constant renewal of water on land surfaces (hydrosphere and geosphere) by the activities in the atmosphere, called weather, is one of the defining characteristics of Earth, the water planet.

The atmosphere plays a major role in determining conditions on Earth’s surface. It acts as both a shield against certain solar radiation and an insulating blanket, slowing energy exchange between Earth’s surface and space. And, of critical importance, the atmosphere acts as a medium of transportation for both energy and matter around the planet. Students will be introduced to this important role of the atmosphere when they study the causes and effects of weather.
**Planetary Systems**

The best scientific estimates place the origin of the solar system about 4.65 billion years ago. Because the solar system is replete with so many fundamental substances, called elements, it is quite certain that there was a star in our neighborhood before our star came into being. The matter that streamed into the nascent universe at the time of the big bang was mostly hydrogen. The hydrogen condensed into stars in billions of locations in space and began their thermonuclear activity. A by-product of “burning” hydrogen in star furnaces is the production of larger atoms, specifically helium atoms. That’s what the Sun has been doing since its birth, and will continue to do for maybe another 5 billion years.

Interesting things happen at the end of stars’ lives. Large stars degenerate into novas or supernovas. During these incomprehensibly dramatic death throes, thermonuclear reactions synthesize larger and larger atoms—carbon, oxygen, nitrogen, iron, gold, uranium, and all the rest of the elements. The final act is annihilation of the star as it casts the products of its creative demise into space. It was probably such a cloud of hydrogen and heavy elements that coalesced into a gigantic rotating mass of star dust. Over time it differentiated into a huge central mass, with smaller masses forming at intervals away from the central mass. The central mass condensed into the Sun, the small accumulations condensed into planets, and the solar system was born. The origin as a rotating cloud explains why the planets all orbit the Sun in the same direction and why the Sun and all the planets rotate on their axes in the same direction. They all emerged from a single process.
CONCEPTUAL FRAMEWORK
Earth Science
Dynamic Atmosphere and Earth’s Place in the Universe:
Earth and Sun

Structure of Earth

Concept A  The hydrosphere has properties that can be observed and quantified.
  • Water is found almost everywhere on Earth: in fog, clouds, rain, snow, ice, rivers, lakes, ground water, and the ocean. Most of Earth’s water is in the ocean. Most fresh water is in glaciers and underground.

Concept B  The atmosphere has properties that can be observed and quantified.
  • Air is a mixture of gases, has mass, takes up space, and is compressible.
  • Most of Earth’s air resides in the troposphere, where weather happens.

Concept C  Humans depend on Earth’s land, ocean, atmosphere, and biosphere for many different resources.
  • The quality of the air and fresh water are critical for life on Earth.

Concept D  Earth is part of a planetary system in the universe.
  • The solar system includes the Sun and other objects that orbit it (Earth, the Moon, other planets and their moons, asteroids, comets).
  • The Moon is much smaller than Earth and orbits at a distance equal to about 30 Earth diameters. The Sun is 12,000 Earth diameters away from Earth and is more than 100 times larger than Earth.
  • The Sun is a star that appears larger and brighter than other stars because it is closer to Earth.
  • The Moon looks different every day, but looks the same again about every 4 weeks. The Moon phase is the portion of the illuminated half of the Moon that is visible from Earth.
  • Stars are different distances from Earth. The position of stars relative to one another creates patterns (constellations).
CONCEPTUAL FRAMEWORK
Earth Science
Dynamic Atmosphere and Earth’s Place in the Universe:
Earth and Sun

Earth Interactions

Concept A  Weather and climate are influenced by interactions of the Sun, the ocean, the atmosphere, ice, landforms, and living things.

- Weather is the condition of Earth’s atmosphere at a given time in a given place and is described by weather variables.
- The water cycle is driven by the Sun and involves evaporation, condensation, precipitation, and runoff.
- Energy is transferred to earth materials by radiation, conduction, and convection. The Sun is the major source of energy that heats Earth. Convection currents (wind) are driven by uneven heating of Earth’s surface.
- Climate is the average or typical weather expected to occur in a region based on long-term data. World climate is changing.

Concept B  Earth’s climate and human activities affect each other.

- Meteorologists record patterns of weather in order to predict what kind of weather might happen next.
- If Earth’s mean temperature continues to rise, organisms, including humans, will be affected in many ways.
- Individual communities use science ideas to protect the Earth’s resources and its environment.

Concept C  The orbits of Earth around the Sun and of the Moon around Earth, together with the rotation of Earth about its axis between its North and South Poles, cause observable patterns.

- Patterns of change and apparent motion can be observed, described, and explained with models.
- Shadows change during the day because the position of the Sun changes in the sky.
- The cyclical change between day and night is the result of a rotating Earth in association with a stationary Sun.
- The pulling force of gravity keeps the planets and other objects in orbit.
- We see different stars during each season because Earth revolves around the Sun; we can see stars only when we face away from the Sun.
Up in the Sky

The natural objects in the heavens that we can observe directly include the Sun, Moon, and stars. The Sun is the most reliable and predictable of the bunch, and easiest to find. Upper-elementary students know that it “comes up” in the morning, is high overhead at midday, and “goes down” at night. They know where to look for it during the day, and might be able to predict when and where it will rise the next day. They might not realize, however, that the height to which it rises above the southern horizon changes with the season. Because of the tilt of Earth’s axis, North America gains a position where the Sun is more directly overhead as the summer solstice approaches. And the converse is true—the Sun dips lower and lower in the noon sky as the winter solstice approaches. Perhaps one of the most concrete ways to demonstrate this is to log the noon shadow of a convenient fixture, such as a tree or flagpole. The short shadow of summer betrays a more overhead position of the Sun.

The Moon is a trickier companion. It is visible sometimes at night and sometimes during the day. In fact, the Moon splits each month evenly between day and night. The Moon’s shape also appears to change with its time of arrival and departure in the sky. The changes in shape are known as phases, and one complete pass through the phases, the lunar cycle, takes 4 weeks. Students can observe the Moon in three of its four key phases—first quarter, full Moon, and third quarter, each occurring 1 week apart. The new Moon, the fourth key phase, is invisible and is an important part of the lunar cycle. The cycle of phases is a product of the Moon’s 4-week orbit around Earth.

The Moon before the first quarter and after the third quarter is in the crescent phase, and the rounding Moon before and after the full Moon is in the gibbous phase. The Moon is said to be waxing as the visible portion increases from new to full, and waning from full to new. Understanding why we see phases of the Moon is hard because it involves the relative positions and motions of the Sun, Earth, and the Moon. The mechanism of Moon phases is conceptually difficult for elementary students, but they can successfully observe and record the changing shapes, learn their names, and learn the overall pattern of the changes in the Moon’s appearance.

Earth is a planet orbiting the Sun once every year. Earth is one of eight planets. Two of the others are in orbits between Earth and the Sun (Mercury and Venus), and five are in orbits outside Earth’s orbit (Mars, Jupiter, Saturn, Uranus, and Neptune). These eight planets and the Sun are the major players in the solar system.
The Sun is a star. In a dark location on a clear night, scores of other stars can be seen shining in the sky. They are distributed in patterns called constellations and asterisms, with names like Ursa Major, Scorpius, Capricornus, Perseus, Draco, and so on. The patterns we see today are pretty much the same as they were thousands of years ago when the first stargazers described and named the constellations. The stars appear to move across the sky during the night, but the geometric relationships between the stars don’t change much. Because Earth orbits the Sun, the visible night stars change with the seasons. But the same familiar patterns do return, exactly as they were a year ago.

On a dark night, a human can typically see 1000–2000 stars. This is but a minute fraction of the several hundred billion stars in our galaxy. The intensity of light reaching Earth from most of them is so low that it simply cannot stimulate a photoreceptor in the human eye. When a telescope, a powerful light-capturing instrument, is positioned between the sky and the eye, stars in the deepest reaches of the galaxy snap into view, and details appear on closer objects, like the Moon, planets, and Sun.

Water

Water is exceptional stuff. Liquid water is the basis of life. The chemistry of life occurs in solution, so without liquid water, there is no life. Water transitions through the three common states of matter within a modest 100°C change of temperature. Most of the water on Earth is liquid. That means the average temperature of Earth’s surface is somewhere between 0°C and 100°C. Sometimes referred to as the Goldilocks effect, the temperature on Earth isn’t too hot, it isn’t too cold, it’s just right, for liquid water and life.

Earth is a water planet—actually a saltwater planet. The ocean and seas hold 97% of Earth’s water. And countless thousands of different kinds of organisms are adapted to live robust lives in the salty water. The remaining 3% of Earth’s water is distributed in myriad ways around the planet. About 69% of Earth’s fresh water is inaccessible, frozen in glaciers and ice caps. Some 30% of the fresh water is underground in aquifers. It is accessible, but sometimes difficult to use. The remaining 1% is in rivers, lakes, organisms, the atmosphere, soil moisture, and ground ice. This is mobile water, and it is constantly being refreshed and recycled.
Water Cycle

One of the marvels of Earth’s hydrosphere (the mass and activities of water on Earth) is the water cycle. Because water readily evaporates (changes phase from liquid to gas), water enters Earth’s atmosphere all the time as water vapor. As an invisible gas, water is free to move with and through the atmosphere. When a mass of humid air cools, the water condenses into liquid. Then we can see the water again as clouds and fog. When the droplets of water coalesce into large drops or crystals of ice, they fall to Earth’s surface. And usually the water returns to Earth’s surface far from where it evaporated.

The big idea of the water cycle is that liquid water evaporates from Earth’s surface in the form of water vapor and enters the atmosphere. Water moves to a new location in the atmosphere, condenses into liquid (or solid), and falls to Earth’s surface. This redistribution of water has made it possible for life to thrive on virtually every square meter of Earth’s solid surface.

Where Did the Water Come From?

How did water come to Earth? Modern theories consider volcanoes to be the source of most of Earth’s water. It is thought that a very large amount of water existed in the assemblage of dust that was compressed by gravitational forces billions of years ago to form the Sun and its planets. Water trapped inside Earth was released to the atmosphere through volcanic eruptions. (Today, volcanic emissions are about 80% water vapor by volume.) Because Earth was very hot during its formative years, the water remained as water vapor in the atmosphere.

When Earth cooled to below 100°C, the massive accumulation of vapor began to condense and fall as rain. Scientists think that it rained hard and continuously for many millions of years as Earth continued to cool. In time, the low places on Earth’s surface were covered with water to a great depth, and the ocean formed. The salt came from minerals weathered from Earth’s crust and dissolved from volcanic outgassing. It was probably in the primitive ocean that life began.

Over the billions of years of Earth history, water from the ocean evaporated into the atmosphere, cooled, condensed into a liquid or solid, and fell back to Earth as precipitation. As water flowed back to the ocean, this continually recycling water eroded Earth’s surface. If it weren’t for the ongoing mountain-building forces, Earth’s surface would have been leveled and covered by one vast ocean long ago.
The water cycle has been operating ever since the first water vapor condensed and fell to Earth. A significant amount of water doesn’t find its way directly back to the ocean. It gets waylaid in lakes and underground aquifers. It can take many different routes between the atmosphere, Earth’s surface, and the ocean. Evaporation and condensation can happen at any point along the way.

Most scientists agree that Earth’s total water supply doesn’t change much. They have calculated the total supply to be about 1,386,000,000 cubic kilometers. Only a tiny part of that amount is in motion; the rest is stored in the ocean, ice caps and glaciers, and underground.

**Weather**

Weather is the activity taking place in the atmosphere at any given time and place. It’s determined by the amount of heat, movement, and moisture in the atmosphere. If the amount of heat is modest, the movement slight, and the moisture negligible, we judge the weather to be good and don’t think about it. If one of the variables is excessive, however, we fret about it and plan around it. Thunderstorms, hurricanes, tornadoes, blizzards, and droughts can dominate our lives. What causes those radical swings in weather?

The Sun. All that movement, heat, and thrashing about is driven by energy. Energy from the Sun, either directly or indirectly, produces effects in the atmosphere. Some effects are obvious. Direct intense insolation (exposure to solar radiation) transfers energy to land and water and then to the air itself. Warming of water enhances evaporation. Other less obvious effects are equally influential on weather. Differential heating of Earth’s surface produces associated air masses of different temperatures. Warm air is less dense than cool air. Dense cool air flows to areas of less-dense air. This produces convection currents in the atmosphere, which results in wind. Another cryptic energy interaction that intensifies thunderstorms, hurricanes, and tornadoes is the release of heat when water condenses from water vapor. This process is not discussed in depth with students, but the foundation is laid for this concept.
Climate and Change

Weather and climate? What’s the difference? Climate is what you expect; weather is what you get. Weather is the day-to-day experience, the condition of the atmosphere over a short period of time in a specific location. Climate is the aggregate of all the weather recorded over a long period of time; it is the trends, patterns, and averages.

Climate affects every part of our lives, from when and where we want to take our vacations to how our food is produced. Knowing about the climate can tell us the right time and place to plant crops, can help us design comfortable, cost-effective houses, and allows us to plan efficient delivery of goods and services.

Weather varies from day to day and year to year. Climate varies on a much larger scale—centuries or more. Complete interaction among the geosphere, atmosphere, hydrosphere, and biosphere have created climate changes in the past and will continue to do so.

The atmosphere is a mixture of nitrogen, oxygen, and trace gases, including water vapor and carbon dioxide. The trace gases play pivotal roles in climate and climate change. Energy from the Sun is absorbed by Earth’s surface, both land and sea. Earth reradiates energy back into the atmosphere as infrared radiation. Atmospheric gases, known as greenhouse gases (primarily water vapor, carbon dioxide, and methane), absorb some of the outgoing energy, retaining heat. Without this natural heat trapping, the average temperature on Earth would be much lower, and life as we know it would not be possible.

But there is another side to the effects of greenhouse gases. The greenhouse gas we hear about the most is carbon dioxide. The concentration of CO₂ can be measured accurately, so we have a long-term record of the change in concentration of this important greenhouse gas. CO₂ has been steadily increasing for the past 100 years. As of May 2015, CO₂ constitutes 403.70 parts per million (ppm) in the atmosphere. In other words, about 404 molecules out of each million air molecules are CO₂. In May 2014, it was 401.88 ppm and the year before that it was 399.90 ppm. In the early 1950s, it was 315 ppm. The amount of CO₂ in Earth’s atmosphere is steadily increasing. As the concentration of greenhouse gases increases, the atmosphere absorbs and “holds” more energy. The system warms up. And once CO₂ is in the atmosphere, there are few ways to remove it.
Over the last 100 years, Earth’s average surface temperature rose by about 0.6°C. And since 2000, warming of more than 0.14°C has been measured. Though this might seem like a small increase, it represents an extraordinarily rapid rate of change compared to those changes that took place in the previous 10,000 years.

The overwhelming consensus of scientific studies on climate indicates that most of the observed increase in global average temperatures since the latter part of the 20th century is very likely due to human activities, primarily from increases in greenhouse-gas concentrations resulting from burning fossil fuels. Two anticipated results are rising global sea level and increased frequency and changes in severe weather, including floods, droughts, and heat waves. These changes will affect every aspect of human society as well as the lives of most living things on Earth.

It is imperative that students study and understand the variables that contribute to our weather and climate and how human activities influence natural systems. Climate change will continue to be a significant part of our lives and those of our students, and we must be prepared to engage in the discourse on climate as informed citizens.

NOTE
## Dynamic Atmosphere Content Sequence

This table shows the five FOSS modules and courses that address the content sequence “dynamic atmosphere” for grades K–8. Running through the sequence are the two progressions—structure of Earth and Earth interactions. The supporting elements in each module (somewhat abbreviated) are listed. The elements for the Earth and Sun Module are expanded to show how they fit into the sequence.

<table>
<thead>
<tr>
<th>Module or course</th>
<th>Structure of Earth</th>
<th>Earth interactions</th>
</tr>
</thead>
</table>
| **Weather and Water** (middle school) | - Weather is the condition of Earth's atmosphere at a given time in a given place; climate is the range of an area's weather conditions over years.  
- Weather happens in the troposphere.  
- Density is a ratio of a mass and its volume.  
- The angle at which light from the Sun strikes the surface of Earth is the solar angle. | - Complex patterns of interactions determine local weather patterns.  
- Energy transfers from one place to another by radiation and conduction.  
- Convection is the circulation of a fluid that results from energy transfer in a fluid.  
- When air masses of different densities meet, weather changes.  
- The Sun's energy drives the water cycle and weather. |
| **Earth and Sun** (grade 5)       |                                                                                      |                                                                                     |
| **Water and Climate** (grade 3)   | - Water is found almost everywhere on Earth, (e.g., vapor, clouds, rain, snow, ice). Most of Earth's water is in the ocean.  
- Water expands when heated, contracts when cooled, and expands when frozen.  
- Cold water is more dense than warmer water; liquid water is more dense than ice.  
- Scientists observe, measure, and record patterns of weather to make predictions.  
- Soils retain more water than rock particles alone. | - Water moves downhill; the steeper the slope, the faster water moves.  
- Ice melts when heated; liquid water freezes when cooled.  
- Evaporation is the process by which liquid (water) changes into gas (water vapor).  
- Condensation is the process by which gas (water vapor) changes into liquid (water).  
- Climate is the range of an area's typical weather.  
- A variety of natural hazards result from weather-related phenomena. |
| **Air and Weather** (grade 1)     | - Air is matter (gas) and takes up space.  
- Weather describes conditions in the air outdoors.  
- Weather conditions can be measured using tools such as thermometers, wind vanes, anemometers, and rain gauges.  
- Clouds are made of liquid water drops.  
- Natural sources of water include streams, rivers, lakes, and the ocean. | - The Sun heats Earth during the day.  
- Wind is moving air.  
- Daily changes in temperature, precipitation, and weather type can be observed, compared, and predicted.  
- Each season has typical weather conditions that can be observed, compared, and predicted.  
- Weather affects animals and plants. |
| **Trees and Weather** (grade K)   | - Weather is the condition of the air outdoors; weather changes.  
- Temperature is how hot or cold it is, and can be measured with a thermometer.  
- Wind is moving air; wind socks indicate wind direction and speed. | - Each season has typical weather conditions that can be observed, compared, and predicted.  
- Trees change through the seasons. |
Earth and Sun Module—FOSS Next Generation

FOSS Conceptual Framework

Structure of Earth

• Most of Earth’s air resides in the troposphere, where weather happens.
• Most of Earth’s water is in the ocean; most of Earth’s fresh water is in glaciers and underground.
• Weather is described in terms of variables including temperature, humidity, precipitation, wind, and air pressure.
• Scientists observe, measure, and record patterns of weather to make predictions.
• The Sun is the major source of energy that heats Earth.

Earth interactions

• The different energy-transferring properties of earth materials lead to uneven heating of Earth’s surface and convection currents.
• The water cycle is driven by the Sun and involves evaporation and condensation.
• Energy transfers to Earth materials by radiation, conduction, and convection.
• Climate—the range of an area’s typical weather conditions—is changing globally; this change will affect all life.

NOTE

See the Assessment chapter at the end of Investigations Guide for more details on how the FOSS embedded and benchmark assessment opportunities align with the conceptual frameworks and the learning progressions. In addition, the Assessment chapter describes specific connections between the FOSS assessments and the NGSS performance expectations.

The NGSS performance expectations addressed in this module include

Earth Sciences
5-ESS1-1
5-ESS1-2
5-ESS2-1
5-ESS2-2
5-ESS3-1

Physical Sciences
5-PS1-1
5-PS2-1

Engineering, Technology, and Applications of Science
3–5 ETS1-2
3–5 ETS1-3

See pages 32–37 in this chapter for more details on the Grade 5 NGSS Performance Expectations.
Earth’s Place in the Universe Content Sequence

This table shows the four FOSS modules and courses that address the content sequence “Earth’s place in the universe” for grades K–8. Running through the sequence are the two progressions—structure and Earth interactions. The supporting elements in each module (somewhat abbreviated) are listed. The elements for the Earth and Sun Module are expanded to show how they fit into the sequence.

<table>
<thead>
<tr>
<th>Module or course</th>
<th>Structure of Earth</th>
<th>Earth interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planetary Science</strong></td>
<td>• Earth and Sun are part of the Milky Way galaxy; many such systems exist in the universe. Gravity holds objects in orbit.</td>
<td>• Patterns of apparent motion of the Sun, the Moon, and stars can be observed, described, predicted, and explained with models.</td>
</tr>
<tr>
<td>(middle school)</td>
<td>• Earth’s axis tilts at an angle of 23.5° and points toward the North Star.</td>
<td>• Models of the solar system can explain tides, eclipses of the Sun and Moon, and motion of the planets relative to the stars.</td>
</tr>
<tr>
<td></td>
<td>• The Moon has surface features that can be identified in telescope images.</td>
<td>• Earth’s spin axis is fixed in direction but tilted relative to its orbit around the Sun; seasons are a result of that tilt, as is differential intensity of light in different areas of Earth during the year.</td>
</tr>
<tr>
<td></td>
<td>• Location or position can be described in terms of a frame of reference.</td>
<td>• Earth and the Moon have been and continue to be bombarded by meteoroids at the same rate.</td>
</tr>
<tr>
<td></td>
<td>• Scale can be expressed as a ratio when an object and its representation are measured in related units.</td>
<td>• The solar system formed during a sequence of events that started with a nebula.</td>
</tr>
<tr>
<td></td>
<td>• The temperature on planets in the solar system depends on two major variables—the distance from the Sun and the nature of the planet’s atmosphere.</td>
<td></td>
</tr>
<tr>
<td><strong>Earth and Sun</strong></td>
<td>• The Moon can be seen sometimes at night and sometimes during the day. It looks different every day, but looks the same again about every 4 weeks.</td>
<td>• The Sun and Moon can be observed moving across the sky; we see them at different locations in the sky, depending on the time of day or night.</td>
</tr>
<tr>
<td>(grade 5)</td>
<td>• There are more stars in the sky than anyone can easily see or count.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The Sun can be seen only in the daytime.</td>
<td></td>
</tr>
<tr>
<td><strong>Air and Weather</strong></td>
<td>• Objects can be seen in the sky.</td>
<td>• Trees change through the seasons.</td>
</tr>
<tr>
<td>(grade 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trees and Weather</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(grade K)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Earth and Sun**

<table>
<thead>
<tr>
<th>Structure of Earth</th>
<th>Earth interactions</th>
</tr>
</thead>
</table>
| • The Moon can be observed both day and night, but the Sun only during the day.  
• Moon phase is the portion of the illuminated half of the Moon that is visible from Earth.  
• The solar system includes the Sun and other objects that orbit it (Earth and the Moon, other planets, moons, asteroids).  
• Stars are at different distances from Earth. The position of stars relative to one another creates patterns (constellations). | • Shadows change (length and direction) during the day because the position of the Sun changes in the sky.  
• The cyclical change between day and night is the result of a rotating Earth in association with a stationary Sun.  
• The pulling force of gravity keeps the planets and other objects in orbit.  
• Moon phases have a monthly cycle.  
• We see different stars during each season because Earth revolves around the Sun. |
CONNECTIONS TO NGSS BY INVESTIGATION

**Science and Engineering Practices**
- Asking questions
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations
- Obtaining, evaluating, and communicating information

**Connections to Common Core State Standards for ELA**
- **RF 4:** Read with sufficient accuracy and fluency to support comprehension.
- **RI 1:** Quote accurately from a text when explaining what the text says explicitly and when drawing inferences.
- **RI 2:** Determine main ideas of a text; summarize the text.
- **RI 3:** Explain the relationships between two concepts.
- **RI 8:** Explain how an author uses reasons and evidence to support particular points in a text.
- **W 2:** Write informational/explanatory texts.
- **W 8:** Recall or gather relevant information; summarize information in notes.
- **W 9:** Draw evidence from informational texts.
- **SL 4:** Report on a topic, sequencing ideas logically.

**Inv. 1: The Sun**
- Asking questions
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

**Inv. 2: Planetary Systems**
- Asking questions
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

---

**ESS1.A: The universe and its stars**
- The Sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their size and distance from Earth.

**ESS1.B: Earth and the solar system**
- The orbits of Earth around the Sun and of the Moon around Earth, together with the rotation of Earth about an axis between its North and South Poles, cause observable patterns. These include day and night; daily and seasonal changes in the length and direction of shadows; phases of the Moon; and different positions of the Sun, Moon, and stars at different times of the day, month, and year.

---

**PS2.B: Types of Interactions**
- The gravitational force of Earth acting on an object near Earth’s surface pulls that object toward the planet’s center.
## Connections to NGSS by Investigation

### Disciplinary Core Ideas

**ESS1.B: Earth and the solar system**
- The orbits of Earth around the Sun and of the Moon around Earth, together with the rotation of Earth about an axis between its North and South Poles, cause observable patterns. These include day and night; daily and seasonal changes in the length and direction of shadows; phases of the Moon; and different positions of the Sun, Moon, and stars at different times of the day, month, and year. *(5-ESS1-2)*

**ESS1.A: The universe and its stars**
- The Sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their size and distance from Earth. *(5-ESS1-1)*

**ESS1.B: Earth and the solar system**
- The orbits of Earth around the Sun and of the Moon around Earth, together with the rotation of Earth about an axis between its North and South Poles, cause observable patterns. These include day and night; daily and seasonal changes in the length and direction of shadows; phases of the Moon; and different positions of the Sun, Moon, and stars at different times of the day, month, and year. *(5-ESS1-2)*

### Crosscutting Concepts

**Patterns**  
Cause and effect  
Systems and system models

**Patterns**  
Cause and effect  
Scale, proportion, and quantity  
Systems and system models

**PS2.B: Types of Interactions**
- The gravitational force of Earth acting on an object near Earth’s surface pulls that object toward the planet’s center. *(5-PS2-1)*
## Inv. 3: Earth's Atmosphere

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Connections to Common Core State Standards for ELA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking questions</td>
<td>RF 4: Read with accuracy and fluency to support comprehension.</td>
</tr>
<tr>
<td>Developing and using models</td>
<td>RI 1: Quote accurately from a text when explaining what the text says explicitly and when drawing inferences.</td>
</tr>
<tr>
<td>Planning and carrying out</td>
<td>RI 2: Determine main ideas of a text; summarize the text.</td>
</tr>
<tr>
<td>investigations</td>
<td>RI 3: Explain the relationships between two concepts.</td>
</tr>
<tr>
<td>Analyzing and interpreting data</td>
<td>RI 4: Determine the meaning of general academic and domain-specific words.</td>
</tr>
<tr>
<td>Using mathematics and computational thinking</td>
<td>RI 5: Compare the overall structure of events, ideas, concepts, or information in two or more texts.</td>
</tr>
<tr>
<td>Constructing explanations and</td>
<td>RI 6: Analyze multiple accounts of the same event or topic, noting important similarities and differences.</td>
</tr>
<tr>
<td>designing solutions</td>
<td>RI 7: Draw on information from multiple sources, to answer a question or solve a problem efficiently.</td>
</tr>
<tr>
<td>Engaging in argument from</td>
<td>RI 9: Integrate information from several texts on the same topic in order to write or speak about the subject.</td>
</tr>
<tr>
<td>evidence</td>
<td>RI 10: Read and comprehend informational science texts.</td>
</tr>
<tr>
<td>Obtaining, evaluating, and</td>
<td>W 5: Develop and strengthen writing.</td>
</tr>
<tr>
<td>communicating information</td>
<td>W 6: Conduct short research projects.</td>
</tr>
<tr>
<td></td>
<td>W 8: Recall or gather relevant information; summarize in notes.</td>
</tr>
<tr>
<td></td>
<td>W 9: Draw evidence from informational texts.</td>
</tr>
<tr>
<td></td>
<td>SL 1: Engage in collaborative discussions.</td>
</tr>
<tr>
<td></td>
<td>SL 2: Summarize a written text read aloud or information presented in diverse media.</td>
</tr>
<tr>
<td></td>
<td>L 4: Determine or clarify the meaning of unknown and multiple-meaning words and phrases.</td>
</tr>
<tr>
<td></td>
<td>L 5: Demonstrate understanding of word relationships.</td>
</tr>
</tbody>
</table>

## Inv. 4: Heating Earth

| Developing and using models      | RF 4: Read with accuracy and fluency to support comprehension. |
| Planning and carrying out        | RI 1: Quote accurately from a text when explaining what the text says explicitly and when drawing inferences. |
| investigations                   | RI 2: Determine main ideas of a text; summarize the text. |
| Analyzing and interpreting data  | RI 3: Explain the relationships between two concepts. |
| Using mathematics and computational thinking | RI 4: Determine the meaning of general academic and domain-specific words. |
| Constructing explanations and    | RI 5: Compare the overall structure of events, ideas, concepts, or information in two or more texts. |
| designing solutions              | RI 6: Analyze multiple accounts of the same event or topic, noting important similarities and differences. |
| Engaging in argument from        | RI 7: Draw on information from multiple sources, to answer a question or solve a problem efficiently. |
| evidence                         | RI 9: Integrate information from several texts on the same topic in order to write or speak about the subject. |
| Obtaining, evaluating, and       | RI 10: Read and comprehend informational science texts. |
| communicating information        | W 5: Develop and strengthen writing. |
|                                  | W 6: Conduct short research projects. |
|                                  | W 8: Recall or gather relevant information; summarize in notes. |
|                                  | W 9: Draw evidence from informational texts. |
|                                  | SL 1: Engage in collaborative discussions. |
|                                  | SL 2: Summarize information presented in diverse media. |
|                                  | SL 3: Summarize the points a speaker makes. |
|                                  | SL 6: Adapt speech to a variety of contexts and tasks. |
### Disciplinary Core Ideas

**PS1.A: Structure and properties of matter**
- Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. (5-PS1-1)

**ESS2.A: Earth materials and systems**
- Earth's major systems are the geosphere, the hydrosphere, the atmosphere, and the biosphere. These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS1-1)

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**ESS3.C: Human impacts on Earth systems**
- Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)

**ETS1.B: Developing solutions**
- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3–5-ETS1-2)
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3–5-ETS1-2)

**ETS1.C: Optimizing design solutions**
- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3–5-ETS1-3)

### Crosscutting Concepts

- **Cause and effect**
- **Scale, proportion, and quantity**
- **Systems and system models**
- **Patterns**
- **Energy and matter**
EARTH AND SUN  

Framework and NGSS

Science and Engineering Practices

- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

Connections to Common Core State Standards for ELA

- RF 4: Read with sufficient accuracy and fluency to support comprehension.
- RI 1: Quote accurately from a text when explaining what the text says explicitly and when drawing inferences.
- RI 2: Determine main ideas of a text; summarize the text.
- RI 3: Explain the relationships between two concepts.
- RI 5: Compare the overall structure of events, ideas, concepts, or information in two or more texts.
- RI 6: Analyze multiple accounts of the same event or topic, noting important similarities and differences.
- RI 8: Explain how an author uses reasons and evidence to support particular points in a text.
- RI 9: Integrate information from several texts on the same topic in order to write or speak about the subject.
- RI 10: Read and comprehend informational science texts.
- W 8: Recall or gather relevant information; summarize information in notes.
- SL 1: Engage in collaborative discussions.
- SL 2: Summarize information presented in diverse media.
- SL 3: Summarize the points a speaker makes.
- L 1: Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
- L 5: Demonstrate understanding of word relationships.
### Disciplinary Core Ideas

**PS1.A: Structure and properties of matter**
- Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. (5-PS1-1)

**ESS2.A: Earth materials and systems**
- Earth’s major systems are the geosphere, the hydrosphere, the atmosphere, and the biosphere. These systems interact in multiple ways to affect Earth’s surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1)

**ESS2.C: The roles of water in Earth’s surface processes**
- Nearly all of Earth’s available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2)

**ESS3.C: Human impacts on Earth systems**
- Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth’s resources and environments. (5-ESS3-1)

### Crosscutting Concepts

- Cause and effect
- Scale, proportion, and quantity
- Systems and system models
- Energy and matter
## RECOMMENDED FOSS NEXT GENERATION K–8
### SCOPE AND SEQUENCE

<table>
<thead>
<tr>
<th>Grade</th>
<th>Physical Science</th>
<th>Earth Science</th>
<th>Life Science</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5</strong></td>
<td>Mixtures and Solutions</td>
<td>Earth and Sun</td>
<td>Living Systems</td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>Energy</td>
<td>Soils, Rocks, and Landforms</td>
<td>Environments</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>Motion and Matter</td>
<td>Water and Climate</td>
<td>Structures of Life</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>Solids and Liquids</td>
<td>Pebbles, Sand, and Silt</td>
<td>Insects and Plants</td>
</tr>
<tr>
<td><strong>1</strong></td>
<td>Sound and Light</td>
<td>Air and Weather</td>
<td>Plants and Animals</td>
</tr>
<tr>
<td><strong>K</strong></td>
<td>Materials and Motion</td>
<td>Trees and Weather</td>
<td>Animals Two by Two</td>
</tr>
</tbody>
</table>

### Half-length courses

- **Heredity and Adaptation**
- **Electromagnetic Force**
- **Gravity and Kinetic Energy**
- **Waves**
- **Planetary Science**
- **Chemical Interactions**
- **Earth History**
- **Populations and Ecosystems**
- **Weather and Water**
- **Diversity of Life**
- **Human Systems Interactions**

*Half-length courses

- Physical Science content
- Earth Science content
- Life Science content
- Engineering content

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**Full Option Science System**