Sixth Grade: Focus on Patterns; Scale, Proportion, and Quantity; Systems and System Models; Energy and Matter

By the end of sixth grade, students apply their understanding of how matter and energy relate to atoms, the solar system, and ecosystems. Students will develop an understanding of the nature of matter and the role of energy transformation. Students will also deepen their understanding of scales, patterns, and properties of matter, the solar system, and ecosystems. Student investigations focus on collecting and making sense of observational data and measurements using the science and engineering practices: ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematics and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate, and communicate information. While individual lessons may include connections to any of the crosscutting concepts, the standards in sixth grade focus on helping students understand phenomena through patterns; scale, proportion, and quantity; systems and system models; and energy and matter.

Core Ideas for Knowing Science*		Core Ideas for Using Science*
Physical Science P1: All matter in the Universe is made of very small particles. P2: Objects can affect other objects at a distance. P3: Changing the movement of an object requires a net force to be acting on it. P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event. **Earth and Space Science** E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate. E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe. **Life Science** L1: Organisms are organized on a cellular basis and have a finite life span. L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms. L3: Genetic information is passed down from one generation of organisms to another. L4: The unity and diversity of organisms, living and extinct, is the result of evolution.		U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised. U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products. U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

***Adapted from *Working with Big Ideas in Science Education*[2]**

Physical Sciences: Students develop an understanding of forces and energy and how energy can transfer from one object to another or be converted from one form to another. They also develop an understanding of the nature of matter.

Physical Science Standards	Learning Progressions, Key Terms, and Crosscutting Concepts
6.P1U1.1	
Analyze and interpret data to show that changes in states of matter are caused by different rates of movement of atoms in solids, liquids, and gases (Kinetic Theory).	If a **substance** could be divided into smaller and smaller pieces it would be found to be made of very, very small **particles**, smaller than can be seen even with a **microscope**. These particles are not in a substance; they are the substance. All the particles of a particular substance are the same and different from those of other substances. The particles are not static but move in random directions. The **speed** at which they move is experienced as the temperature of the material. The differences between substances in the **solid**, **liquid** or **gas** state can be explained in terms of the speed and range of the movement of particles and the separation and strength of the attraction between neighboring particles. All materials, anywhere in the universe, living and non-living, are made of a very large number of basic 'building blocks' called **atoms**, of which there are about 100 different kinds. The properties of different materials can be explained in terms of the behavior of the atoms and groups of atoms of which they are made. [2 (p. 20)]
6.P1U1.2	
Plan and carry out an investigation to demonstrate that variations in temperature and/or pressure affect changes in state of matter.	
6.P1U1.3	
Develop and use models to represent that matter is made up of smaller particles called atoms.	Crosscutting Concepts: **patterns**; cause and effect; **scale, proportion, and quantity; systems and system models; energy and matter;** structure and function; stability and change[4]
6.P2U1.4	
Develop and use a model to predict how forces act on objects at a distance.	**Gravity** is the universal attraction between all objects, however large or small, although it is only apparent when one of the objects is very large. This gravitational attraction keeps the planets in **orbit** around the **Sun**, the **Moon** round the **Earth** and their moons round other planets. The effect of gravity on an object on the Moon is less than that on Earth because the Moon has less mass than the Earth, so a person on the Moon **weighs** less than on Earth even though their mass is the same. The pull of the Earth on the Moon keeps it orbiting the Earth while the pull of the Moon on the Earth gives rise to **tides**. [2 (p. 21)] Crosscutting Concepts: cause and effect; **scale, proportion, and quantity; systems and system models**[4]

6.P4U2.5	
Analyze how humans use technology to store (potential) and/or use (kinetic) energy.	The **chemicals** in the cells of a battery store energy which is released when the battery is connected so that an electric current flows, **transferring energy** to other components in the circuit and on to the environment. [2] (p. 23) **Motion energy** is properly called **kinetic energy**; it is proportional to the mass of the moving object and grows with the square of its speed. A system of objects may also contain **stored (potential) energy**, depending on their relative positions. [4] (p. 123) Crosscutting Concepts: cause and effect; **energy and matter**[4]

Earth and Space Sciences: Students develop an understanding of the scale and properties of objects in the solar system and how forces (gravity) and energy cause observable patterns in the Sun-Earth-Moon system.

Earth and Space Standards	Learning Progressions, Key Terms, and Crosscutting Concepts
6.E1U1.6	
Investigate and construct an explanation demonstrating that radiation from the Sun provides energy and is absorbed to warm the Earth's surface and atmosphere.	The layer of air at the **Earth's** surface is **transparent** to most of the **radiation** coming from the **Sun**, which passes through. The radiation that is absorbed at its surface is the Earth's external source of energy. The radiation from the Sun absorbed by the Earth warms the surface which then emits radiation of longer **wavelength** (**infrared**) that does not pass through the atmosphere but is absorbed by it, keeping the Earth warm. This is called the **greenhouse effect** because it is similar to the way the inside of a greenhouse is heated by the Sun. [2] (p. 24) Crosscutting Concepts: **patterns**; cause and effect; **systems and system models; energy and matter;** structure and function[4]
6.E2U1.7	
Use ratios and proportions to analyze and interpret data related to scale, properties, and relationships among objects in our solar system.	The **Earth** rotates about an **axis** lying north to south and this motion makes it appear that the **Sun**, **Moon** and **stars** are moving round the Earth. This **rotation** causes day and night as parts of the Earth's surface turn to face towards or away from the Sun. It takes a year for the Earth to pass round the Sun. The Earth's axis is tilted relative to the plane of its orbit around the Sun so that the length of day

	varies with position on the Earth's surface and time of the year, giving rise to the **seasons**. The Earth is one of eight (so far known) planets in our solar system which, along with many other smaller bodies, **orbit** the Sun, in roughly circular paths, at different distances from the Sun and taking different times to complete an orbit. The distances between these bodies are huge – Neptune is 4.5 billion **km** from the Sun, 30 times further than Earth. As seen from Earth, planets move in relation to the positions of the stars which appear fixed relative to each other. [2] (p. 25) The **solar system** consists of the sun and a collection of objects, including planets, their moons, and **asteroids** that are held in orbit around the sun by its **gravitational pull** on them. This model of the solar system can explain **tides**, **eclipses** of the sun and the moon, and the motion of the planets in the sky relative to the **stars**. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. [4] (p. 176)
6.E2U1.8	
Develop and use models to explain how constellations and other night sky patterns appear to move due to Earth's rotation and revolution.	
6.E2U1.9	
Develop and use models **to construct an explanation** of how eclipses, moon phases, and tides occur within the Sun-Earth-Moon system.	
6.E2U1.10	
Use a model to show how the tilt of Earth's axis causes variations in the length of the day and gives rise to seasons.	Crosscutting Concepts: **patterns**; cause and effect; **scale, proportion and quantity; systems and system models;** stability and change[4]

Life Sciences: Students develop an understanding of how energy from the Sun is transferred through ecosystems.

Life Science Standards	Learning Progressions, Key Terms, and Crosscutting Concepts
6.L2U3.11	
Use evidence to **construct an argument** regarding the impact of human activities on the environment and how they positively and negatively affect the competition for energy and resources in ecosystems.	**Interdependent organisms** living together in particular environmental conditions form an **ecosystem**. In a stable ecosystem there are **producers** of food (plants), **consumers** (animals) and **decomposers**, (bacteria and fungi which feed on waste products and dead organisms). The decomposers produce materials that help plants to grow, so the molecules in the organisms are constantly re-used. At the same time, **energy** resources pass through the ecosystem. When **food** is used by organisms for **life processes** some energy is **dissipated** as **heat** but is replaced

6.L2U3.12 **Engage in argument from evidence** to support a claim about the factors that cause species to change and how humans can impact those factors. **6.L2U1.13** **Develop and use models** to demonstrate the interdependence of organisms and their environment including biotic and abiotic factors. **6.L2U1.14** **Construct a model** that shows the cycling of matter and flow of energy in ecosystems.	in the ecosystem by **radiation** from the **Sun** being used to produce plant food. In any given ecosystem there is **competition** among species for the energy resources and the materials they need to live. The persistence of an ecosystem depends on the continued availability in the environment of these energy resources and materials. Plant species have **adaptations** to obtain the water, light, minerals and space they need to grow and reproduce in particular locations characterized by climatic, geological and hydrological conditions. [2 (p. 27)] **Organisms** and populations of organisms are dependent on their environmental interactions both with other **living** things and with **nonliving** factors. Growth of organisms and population increases are limited by access to resources. In any ecosystem, organisms and **populations** with similar requirements for food, water, oxygen, or other **resources** may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. Similarly, **predatory** interactions may reduce the number of organisms or eliminate whole populations of organisms. **Mutually beneficial** interactions, in contrast, may become so interdependent that each organism requires the other for survival.[4] A healthy ecosystem is one in which multiple **species** of different types are each able to meet their needs in a relatively stable web of life. Newly **introduced species** can damage the balance of an ecosystem. [4 (p. 152)] Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of many other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. [4 (p. 196)] Crosscutting Concepts: **patterns; cause and effect; systems and system models; energy and matter; stability and change** [4]