Implementation Guidance for the 2018 Arizona Science Standards

Complete Set of K-12 Progression Matrix Elements for the 3-Dimensions of the Arizona Science Standards- Core Ideas, Science & Engineering Practices, & Crosscutting Concepts

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Introduction

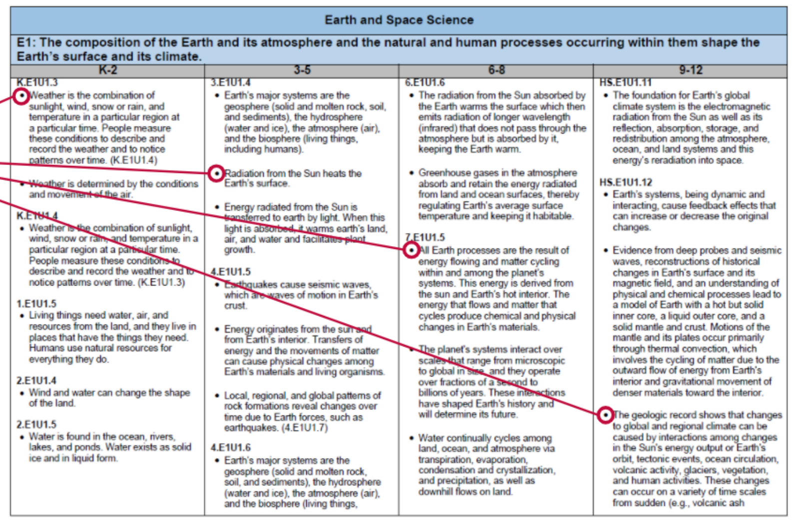
This document provides a full picture of how the 3-dimensional Arizona Science Standards progress from grade-to-grade. These vertical progression matrixes have been created to support educators in determining:

- what is the essential knowledge and skills embedded within the science standards
- what are the specific details of the core ideas of knowing and using science, the science and engineering practices, and the crosscutting concepts
- what should be emphasized in the science curriculum and instruction to support the grade-level standards

Purpose

These vertical progressions will help you understand how and what students are expected to know and do in each grade-band, builds on what they have learned in earlier grades and prepares them for what they are expected to learn in later grades. The expectations for each grade-band are called "elements," which are illustrated as bullets in each of the matrixes. Here is a sample of elements from the Core Idea of Knowing Science Matrix:

Elements: Specific pieces of knowledge and skill that make up the Core Idea, Crosscutting Concepts, or the Science & Engineering Practice at that grade-band.



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.			
K-2	**3-5**	**6-8**	**9-12**
K.E1U1.3 • 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. (K.E1U1.4) • Weather is determined by the conditions and movement of the air. K.E1U1.4 • 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. (K.E1U1.3) 1.E1U1.5 • Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. 2.E1U1.4 • Wind and water can change the shape of the land. 2.E1U1.5 • Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.	3.E1U1.4 • 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). • Radiation from the Sun heats the Earth's surface. • Energy radiated from the Sun is transferred to earth by light. When this light is absorbed, it warms earth's land, air, and water and facilitates plant growth. 4.E1U1.5 • Earthquakes cause seismic waves, which are waves of motion in Earth's crust. • Energy originates from the sun and from Earth's interior. Transfers of energy and the movements of matter can cause physical changes among Earth's materials and living organisms. • Local, regional, and global patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. (4.E1U1.7) 4.E1U1.6 • 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,	6.E1U1.6 • 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. • Greenhouse gases in the atmosphere absorb and retain the energy radiated from land and ocean surfaces, thereby regulating Earth's average surface temperature and keeping it habitable. 7.E1U1.5 • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials. • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. • Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.	HS.E1U1.11 • The foundation for Earth's global climate system is the electromagnetic radiation from the Sun as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems and this energy's reradiation into space. HS.E1U1.12 • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. • Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, and a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. • The geologic record shows that changes to global and regional climate can be caused by interactions among changes in the Sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash

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How to use and read this document:

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band. The elements support educators to ensure that the 3-dimensional science instruction that is being taught is grade level appropriate for all three dimensions. These matrixes provide insight into the learning progressions for the three dimensions along the K-12 continuum.

A **boundary** is a statement that provides guidance about the scope of the standard at a particular grade level.

A **clarification statement** is a statement that provides examples or additional clarification for the standard.

A **note** is a statement that describes additional resources and/or instructional guidance.

What do the codings in the parentheses mean?
There are codings in parentheses throughout the document. These codings indicate that there is a connected standard(s) which uses the same element. See example below:

> **6.E2U1.9**
> - Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, and explained with models. (6.E2U1.8) (6.E2U1.10)

What is engineering, technology, and application of science in the Core Ideas of Using Science?
Science, engineering and technology are often lumped together. According to the *Framework for K-12 Science Education*, engineering and technology are included as they relate to the applications of science, and in doing so they offer students a path to strengthen their understanding of the roles of sciences (pg 11).

Technology is any modification of the natural world made to fulfill human needs or desires (pg xi NAEP.TEL Framework and *Framework for K-12 Science Education*, pg 202).

Engineering is a systematic and often iterative approach to designing objects, processes, and systems to meet human needs and wants (pg xi NAEP.TEL Framework , and *Framework for K-12 Science Education*, pg 202).

An application of science is any use of scientific knowledge for a specific purpose, whether to do more science, to design a product, process, or medical treatment; to develop a new technology; or to predict the impacts of human actions. (*Framework for K-12 Science Education*, pg 202).

To learn more about how the elements are used, please click here to watch this short video: Click for Video

Credits:

K-12 Core Ideas of Knowing and Using Science Progression Matrix of Elements	Christine Allred *(Using Science & Earth & Space Science reviewer)* Sanlyn Buxner *(Earth & Space Science reviewer)* Rebecca Garelli *(Lead Writer)* Melissa Girmscheid *(Physical Science reviewer)* Ron Gray *(Life Science reviewer)* Anna Heyer *(Life Science reviewer)* DaNel Hogan *(Using Science reviewer)* Jennifer Manlick *(Physical Science reviewer)* Steven Semken *(Earth & Space Science reviewer)* Sarah Sleasman *(Lead Writer)* Vicente Talanquer *(Physical Science reviewer)* Sara Torres *(Lead Writer)* Margaret Wilch *(Life Science reviewer)*
K-12 Science and Engineering Practices (SEPs) Progression Matrix of Elements	Adapted by Achieve from National Research Council (2011)
K-12 Crosscutting Concepts(CCCs) Progression Matrix of Elements	Adapted by Achieve from National Research Council (2011)

Physical Science

P1: All matter in the Universe is made of very small particles.

K-2	3-5	6-8	9-12
2.P1U1.1 • All the 'stuff' encountered in everyday life, including air, water, and different kinds of solid substances, is called matter because it has mass and takes up space. • Different materials are recognizable by their properties, some of which are used to classify them as being solid or liquid, depending on temperature**.** Matter can be described by its observable properties. (2.P1U1.2) ***Note:*** *According to the text, Disciplinary Core Ideas: Teaching & Learning, the study of states of matter are limited to studying solids and liquids, gases are not included. Since gases cannot be observed and are therefore much more difficult to study, students should not be asked to study gases till they are able to use equipment to make observations of gases. (Disciplinary Core Ideas: Teaching & Learning pg. 17)* **2.P1U1.2** • Different materials are recognizable by their properties, some of which are used to classify them as being solid or liquid, depending on temperature. (2.P1U1.1) • Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not. • Heating can cause change, as in cooking, melting solids or changing water to vapor.	**5.P1U1.1** • 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. • The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. • No matter what reaction or change in properties occurs, the amount of matter does not change. (5.P1U1.2) ***Boundary:*** *At this grade level, mass and weight are not distinguished and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.* **5.P1U1.2** • When two or more different substances are mixed, a new substance with different properties may be formed. Other substances simply mix without changing permanently and can often be separated again. ***Boundary:*** *At this grade level, mass and weight are not distinguished and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.*	**6.P1U1.1** • The particles are not static but move in random directions. The speed at which they move is experienced as the temperature of the material. • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with each other; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and vibrate in position but do not change relative locations. **6.P1U1.2** • The changes of state that occur with variations in temperature or pressure can be described and predicted using models of matter. ***Boundary:*** *Predictions here are qualitative, not quantitative.* **6.P1U1.3** • All materials, anywhere in the universe, living and nonliving, are made of a very large numbers of basic "building blocks" called atoms, of which there are about 100 different kinds. • The behavior and arrangement of the atoms explains the properties of different materials.	**HS.P1U1.1** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. **HS.P1U1.2** • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. • The opposite electric charges of protons and electrons attract each other, keeping atoms together and accounting for the formation of some compounds. **HS.P1U1.3** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, that are matched by changes in kinetic energy. **HS.P1U3.4** • There are disadvantages as well as advantages to some technological products. Although the use of some artificial materials may mean less

		8.P1U1.1 • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. • The total number of each type of atom is conserved, and thus the mass does not change. **8.P1U1.2** • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.	demand on scarce natural ones, many new materials do not degrade as do natural materials, presenting a waste disposal problem when discarded.

P2: Objects can affect other objects at a distance.

K-2	3-5	6-8	9-12
K.P2U1.1 • 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. (K.P2U2.2) **K.P2U2.2** • 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. (K.P2U1.1) • People also use a variety of devices to communicate (send and receive information) over long distances. **1.P2U1.1** • Some materials allow light to pass through them, others allow only some light through, and others block all the light and create a dark shadow on any surface beyond them where the light cannot reach. Mirrors can be used to redirect a light beam. ***Boundary:*** *The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.* **1.P2U1.2** • Sound can make matter vibrate, and vibrating matter can make sound. • Sound comes from things that vibrate and can be detected at a distance from the source because the air or other material around is made to vibrate. Sounds are heard when the vibrations in the air enter our ears.	**3.P2U1.1** • An object can be seen when light reflected from its surface enters the eyes; the color people see depends on the color of the available light sources as well as the properties of the surface. ***Clarification Statement:*** *This phenomenon is observed, but no attempt is made to discuss what confers the color reflection and absorption properties on a surface. The stress is on understanding that light traveling from the object to the eye determines what is seen.* **3.P2U1.2** • Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). • Sound comes from things that vibrate and can be detected at a distance from the source because the air or other material around is made to vibrate. Sounds are heard when the vibrations in the air enter our ears. **4.P2U1.3** • Magnetic forces between a pair of objects do not require that the objects be in contact. The size 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. **5.P2U1.3** • All objects have an effect on other objects without being in contact with them. In some cases the effect travels	**6.P2U1.4** • Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass. • Forces that act at a distance (gravitational, electric, and magnetic) can be explained by force fields that extend through space and can be mapped by their effect on a test object (a ball, a charged object, or a magnet, respectively). (7.P2U1.2) ***Note:*** *Gravitational force is a suggested focus for 6th grade; It is suggested that all 3 forces be focused on in 7th grade.* **7.P2U1.1** • Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. **7.P2U1.2** • Forces that act at a distance (gravitational, electric, and magnetic) can be explained by force fields that extend through space and can be mapped by their effect on a test object (a ball, a charged object, or a magnet, respectively). (6.P2U1.4) ***Note:*** *Gravitational force is a suggested focus for 6th grade; It is suggested that all 3 forces be focused on in 7th grade.*	**HS.P2U1.5** • Gravity, electric and magnetic interactions can be described in terms of fields. • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.

	out from the source to the receiver in the form of radiation (e.g. visible light). • Electric, magnetic, and gravitational forces between a pair of objects do not require that the objects be in contact. • The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5.E2U1.8)		

P3: Changing the movement of an object requires a net force to be acting on it.

K-2	3-5	6-8	9-12
1.P3U1.3 • Forces can push, pull or twist objects, making them change their motion or shape. • 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. • The movement of objects is changed if the forces acting on them are not in balance.	**5.P3U1.4** • Each force acts on one particular object and has both a strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (5.P3U2.5) ***Boundary:*** *Qualitative and conceptual, but not quantitative addition of forces are used at this level.* • Objects in contact exert forces on each other. • How quickly an object's motion is changed depends on the force acting and the object's mass. The greater the mass of an object, the longer it takes to speed it up or slow it down. (5.P3U2.5) ***Boundary:*** *At this grade level, mass and weight are not distinguished and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.* **5.P3U2.5** • Each force acts on one particular object and has both a strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (5.P3U1.4) ***Boundary:*** *Qualitative and conceptual, but not quantitative addition of forces are used at this level.*	**7.P3U1.3** • All objects on the Earth are affected by gravitational forces. An object which stays at rest on the surface of the Earth has one or more forces acting on it counter balancing the force of gravity. **7.P3U1.4** • For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first but in the opposite direction. • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to change the object's motion. For any given object, a larger force causes a larger change in motion. • All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.	**HS.P3U1.6** • Newton's second law accurately predicts changes in the motion of macroscopic objects. • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. • Within an isolated system of interacting objects, any change in momentum of one object is balanced by an equal and oppositely directed change in the total momentum of the other objects. Thus total momentum is a conserved quantity. • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. ***Clarification Statement:*** *Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, and object rolling down a ramp, or a moving object being pulled by a constant force. Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.* **HS.P3U2.7** • Interactions between any two objects can cause changes in one or both of them. An understanding of the forces between objects is important for describing how their motions change, as well as for predicting stability or instability in systems at any scale.

	• The patterns of an object's motion in various situations can be observed and measured; when past motion exhibits a regular pattern, future motion can be predicted from it. ***Boundary:*** *Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.* • How quickly an object's motion is changed depends on the force acting and the object's mass. The greater the mass of an object, the longer it takes to speed it up or slow it down. (5.P3U1.4)		

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.

K-2	3-5	6-8	9-12
1.P4U2.4 • When two objects rub against each other, this interaction is called friction. • Friction between two surfaces can warm both of them (e.g., rubbing hands together). • There are ways to reduce the friction between two objects. **2.P4U1.3** • Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.	**3.P4U1.3** • Energy can be moved from place to place by moving objects or through sound or light. ***Boundary:*** *At this grade level, no attempt is made to give a precise or complete definition of energy.* **4.P4U1.1** • Energy is transferred from one object, which is an energy source or resource, to another. • Energy is present whenever there are moving objects, sound, light, or heat. (4.P4U1.2) **4.P4U1.2** • Energy is present whenever there are moving objects, sound, light, or heat. (4.P4U1.1) • Energy can be moved from place to place by moving objects or through sound or light, or electric currents. ***Boundary:*** *At this grade level, no attempt is made to give a precise or complete definition of energy.* • Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. • Light also transfers energy from place to place.	**6.P4U2.5** • Objects can have stored energy (that is, the ability to make things change) either because of their chemical composition, their movement, their temperature, their position in a gravitational or other field. • 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. **8.P4U1.3** • Energy is transferred out of hotter regions or objects and into colder ones by the processes of conduction, convection, and radiation. **8.P4U1.4** • A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. • A sound wave needs a medium through which it is transmitted. • When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of light. • The path that light travels can be traced as straight lines, except at surfaces between different transparent materials where the light bends.	**HS.P4U1.8** • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • Energy cannot be created or destroyed. When energy is transferred from one object to others the total amount of energy in the universe remains the same; the amount that one object loses is the same as the other objects gain. **HS.P4U3.9** • The availability of energy limits what can occur in any system. • Although energy cannot be destroyed, it can be converted to less useful forms - for example, to thermal energy in the surrounding environment. • Across the world, the demand for energy increases as human populations grow and because modern lifestyles require more energy, particularly in the convenient form of electrical energy. Ways of generating electricity have to be sought, while reducing demand and improving the efficiency of the processes in which we use it. **HS.P4U1.10** • The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which

Developed in collaboration with Arizona Department of Education (ADE) and the Arizona Science Teachers Association (ASTA). This document was developed from the two research documents used to develop the 2018 Arizona Science Standards: National Research Council (2012): A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas and Working with Big Ideas of Science Education.

	4.P4U3.4 • The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. • Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. **5.P4U1.6** • The faster a given object is moving, the more energy it possesses. • Energy can be moved from place to place by moving objects. • When objects collide, the contact forces transfer energy so as to change the objects' motions. • Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.	• A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. • Since light can travel through space, it cannot be a matter wave, like sound or water waves. ***Clarification Statement:*** *Emphasis is on describing waves with both qualitative and quantitative thinking. Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.* **8.P4U2.5** • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. • Energy is spontaneously transferred out of hotter regions or objects and into colder ones.	depends on the type of wave and the medium through which it is passing. • Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.

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.

K-2	3-5	6-8	9-12
K.E1U1.3 • 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. (K.E1U1.4) • Weather is determined by the conditions and movement of the air. **K.E1U1.4** • 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. (K.E1U1.3) **1.E1U1.5** • Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. **2.E1U1.4** • Wind and water can change the shape of the land. **2.E1U1.5** • Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.	**3.E1U1.4** • 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). • Radiation from the Sun heats the Earth's surface. • Energy radiated from the Sun is transferred to earth by light. When this light is absorbed, it warms earth's land, air, and water and facilitates plant growth. **4.E1U1.5** • Earthquakes cause seismic waves, which are waves of motion in Earth's crust. • Energy originates from the sun and from Earth's interior. Transfers of energy and the movements of matter can cause physical changes among Earth's materials and living organisms. • Local, regional, and global patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. (4.E1U1.7) **4.E1U1.6** • 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,	**6.E1U1.6** • 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. • Greenhouse gases in the atmosphere absorb and retain the energy radiated from land and ocean surfaces, thereby regulating Earth's average surface temperature and keeping it habitable. **7.E1U1.5** • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials. • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. • Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.	**HS.E1U1.11** • The foundation for Earth's global climate system is the electromagnetic radiation from the Sun as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems and this energy's reradiation into space. **HS.E1U1.12** • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. • Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, and a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. • The geologic record shows that changes to global and regional climate can be caused by interactions among changes in the Sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash

2.E1U2.6 • Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events. • The temperature, pressure, direction, speed of movement and the amount of water vapor in the air combine to create the weather. Measuring these properties over time enables patterns to be found that can be used to predict the weather. **2.E1U3.7** • Plants and animals can change their environment. • 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.	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. • The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. • 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. (4.E1U1.7) **4.E1U1.7** • Local, regional, and global patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. (4.E1U1.5) • 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. (4.E1U1.6)	• The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. ***Clarification Statement:*** *Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials. This does not include the identification and naming of minerals. Emphasis is also on the ways that water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.* **7.E1U1.6** • Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geological history. • Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. • Tectonic processes continually generate new ocean seafloor at ridges and destroy old seafloor at trenches. **7.E1U2.7** • Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. Because these patterns are so	clouds) to intermediate (ice ages) to very long-term tectonic cycles. ***Clarification Statement:*** *Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and seafloor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion). This does not include memorization of the details of the formation of specific geographic features of Earth's surface. Emphasis is also on both a one dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.* **HS.E1U1.13** • Continental rocks, which can be older than 4 billion years, are generally much older than rocks on the ocean floor, which are less than 200 million years old. • The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mangle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. **HS.E1U3.14** • Resource availability has guided the development of human society. • Global climate models are often used to understand the process of climate change because these changes are

	• Earth has changed over time. Understanding how landforms develop, are weathered (broken down into smaller pieces), and erode (get transported elsewhere) can help infer the history of the current landscape. **4.E1U1.8** • Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. • Climate describes the ranges of an area's typical weather conditions and the extent to which those conditions vary over years. **4.E1U3.9** • Nearly all of Earth's available water is in the ocean. Most freshwater is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. • About two-thirds of the surface of the Earth is covered by liquid water, which is essential to life. **4.E1U2.10** • A variety of hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.	complex, weather can be predicted only probabilistically. **8.E1U1.6** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analysis of rock strata and the fossil record provide only relative dates, not an absolute scale. **8.E1U3.7** • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events. **8.E1U3.8** • Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing extinction of many other species. But changes to Earth's environment 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.	complex and can occur slowly over Earth's history. Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. • Natural hazards and other geologic events have shaped the course of human history; they have significantly altered the sizes of human populations and have driven human migrations. • The sustainability of human societies and biodiversity that supports them requires responsible management of natural resources.

E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe.			
K-2	**3-5**	**6-8**	**9-12**
K.E2U1.5 • Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. **2.E2U1.8** • There are patterns in the position of the Sun seen at different times of the day and in the shape of the Moon from one night to another.	**5.E2U1.7** • 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 changes in the length and direction of shadows; and different positions of the Sun and Moon at different times of the day, month, and year. **5.E2U1.8** • 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. • The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5.P2U1.3)	**6.E2U1.7** • 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. ***Note:*** *Utilize the Crosscutting Concept Scale, Proportion, and Quantity 6-8 elements when teaching this standard. (link to CCC progression on ADE website)* **6.E2U1.8** • Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, and explained with models. (6.E2U1.9) (6.E2U1.10) **6.E2U1.9** • Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, and explained with models. (6.E2U1.8) (6.E2U1.10) • A model of the solar system can explain tides and eclipses of the sun and the moon. **6.E2U1.10** • Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, and explained with models.(6.E2U1.8) (6.E2U1.9) • 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.	**HS.E2U1.15** • Our Sun is one of many stars that make up the Universe, essentially made of hydrogen. The source of energy that the Sun and all stars radiate comes from nuclear reactions in their central cores. • Nuclear fusion processes in the center of the Sun release the energy that ultimately reaches Earth as radiation. • Other than hydrogen and helium formed at the time of the big bang, nuclear fusion within stars produce all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. **HS.E2U1.16** • Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the Sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. • Cyclical changes in the shape of Earth's orbit around the Sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the Earth. These phenomena cause a cycle of ice ages and other gradual climate changes.

			Clarification Statement: *Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and Moons.* ***Boundary:*** *Mathematical representations for the gravitational attraction of bodies and Kepler's laws of orbital motions should not deal with more than two bodies, nor involve calculus.* **HS.E2U1.17** • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. • The big bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. ***Clarification Statement:*** *Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the big bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the big bang theory (3/4 hydrogen and 1/4 helium).*

Life Science

L1: Organisms are organized on a cellular basis and have a finite life span.

K-2	3-5	6-8	9-12
K.L1U1.6 • 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. (K.L1U1.7) **K.L1U1.7** • 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. (K.L1U1.6) • 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). **1.L1U1.6** • Adult plants and animals can have young. • Plants and animals grow and change. Plants and animals have predictable	**3.L1U1.5** • Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. **3.L1U1.6** • Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions.	**7.L1U1.8** • All living things are made up of cells, which is the smallest unit that can be said to be alive. All the basic processes of life are the results of what happens inside cells. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). • Cells divide to replace aging cells and to make more cells in growth and in reproduction. **7.L1U1.9** • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. ***Boundary:*** *At this grade level, only a few major cell structures should be introduced.* **7.L1U1.10** • In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions, such as respiration, digestion, elimination of waste and temperature control. **7.L1U1.11** • Organisms respond to stimuli from their environment and actively maintain their internal environment.	**HS.L1U1.20** • Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. **HS.L1U1.22** • In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a simple cell (fertilized egg) that divides successfully to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. • Most cells are programmed for a limited number of cell divisions. Organisms die if their cells are incapable of further division. **HS.L1U3.23** • Diseases, which may be caused by invading microorganisms, environmental conditions or defective cell programming, generally result in disturbed cell function.

characteristics at different stages of development.			• Given a suitable medium, cells from a variety of organisms can be grown in situ, that is, outside the organism. These cell cultures are used by scientists to investigate cell functions and have medical implications such as the production of vaccines, screening of drugs, and in vitro fertilization.

L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.

K-2	3-5	6-8	9-12
K.L2U1.8 • There is a wide variety of living things, including plants and animals. They are distinguished from non-living things by their ability to move, reproduce, and react to certain stimuli. **1.L2U2.7** • All animals need food in order to live and grow. They obtain their food from plants or from other animals. (1.L2U1.8) • Plants depend on air, water, minerals (in the soil), and light to grow. (1.L2U1.8) • Animals can move around, but plants cannot, and they often depend on animals for pollination or to move their seeds around. (1.L2U1.8) • Animals depend on their surroundings to get what they need, including food, water, shelter, and a favorable temperature. • 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. (1.L2U1.8) **1.L2U1.8** • All animals need food in order to live and grow. They obtain their food from plants or from other animals. (1.L2U2.7) • Plants depend on air, water, minerals (in the soil), and light to grow. (1.L2U2.7) • Animals can move around, but plants cannot, and they often depend on	**3.L2U1.7** • The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants. Either way, they are "consumers." • Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil for plants to use. (3.L2U1.8) • Organisms can survive only in environments in which their particular needs are met. 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. **3.L2U1.8** • Animals need food that they can break down, which comes either directly by eating plants (herbivores) or by eating animals (carnivores) which have eaten plants or other animals. • Animals are ultimately dependent on plants for their survival. The relationships among organisms can be represented as food chains and food webs. Some animals are dependent on plants in other ways as well as for food. Plants also depend on animals in various ways. (3.L2U1.8)	**6.L2U3.11** • Human activity which controls the growth of certain plants and animal changes an ecosystem. • 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. • Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of many other species. (6.L2U3.12) ***Note:*** *Supports the 8th grade standard, 8.E1U3.8.* • Changes to Earth's environments can have different impacts (negative and positive) for different living things. ***Note:*** *Supports the 8th grade standard, 8.E1U3.8.* **6.L2U3.12** • Ecosystems are dynamic in nature, their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. • Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of many other species. (6.L2U3.11) ***Note:*** *Supports the 8th grade standard, 8.E1U3.8.*	**HS.L2U3.18** • Anthropogenic changes (induced by human activity) in the environment — including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change — can disrupt an ecosystem and threaten the survival of some species. • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e. the ecosystem is resilient) as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. **HS.L2U1.19** • Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil,

animals for pollination or to move their seeds around. (1.L2U2.7) • Different plants survive better in different settings because they have varied needs for water, minerals, and sunlight. • 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. (1.L2U1.7) **2.L2U1.9** • All living things need food as their source of energy as well as air, water, and certain temperature conditions. Plants can use sunlight to make the food they need and can store food that they do not immediately use. (2.L2U1.10) • Animals need food that they can break down, which comes either directly by eating plants or by eating animals which have eaten plants or other animals. Animals are ultimately dependent on plants for their survival. (2.L2U1.10) **2.L2U1.10** • All living things need food as their source of energy as well as air, water, and certain temperature conditions. Plants use sunlight to make the food they need and can store food that they do not immediately use. (2.L2U1.9) • Animals need food that they can break down, which comes either directly by eating plants or by eating animals which have eaten plants or other animals. Animals are ultimately dependent on plants for their survival. (2.L2U1.9)	• Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as “decomposers.” Decomposition eventually restores (recycles) some materials back to the soil for plants to use. (3.L2U1.7)	**6.L2U1.13** • 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. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. **6.L2U1.14** • Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, water, and minerals from the environment and release waste matter (gas, liquid, or solid) back into the environment. • Energy resources pass through the ecosystem. When food is used by organisms for life processes some energy is dissipated as heat but is replaced in the ecosystem by radiation from the Sun being used to produce plant food. • Food webs are models that demonstrate how matter and energy are transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are	and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. **HS.L2U1.21** • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. • Photosynthesis and cellular respiration are important components of the carbon cycle in which carbon is exchanged among the biosphere, atmosphere, and oceans, and geosphere through chemical, physical, geologic, and biological processes.

• The relationships among organisms can be represented as a food chain.		cycles repeatedly between the living and nonliving parts of the ecosystem. **7.L2U1.12** • Plants, algae (including phytoplankton) and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.	

L3: Genetic information is passed down from one generation of organisms to another.

K-2	3-5	6-8	9-12
1.L3U1.9 • Living things produce offspring of the same kind, but offspring are not identical with each other or with their parents. • Plants and animals, including humans, resemble their parents in many features because information is passed from one generation to the next. • Organisms have characteristics that can be similar or different.	**5.L3U1.9** • Many characteristics of organisms are inherited from their parents. • Different organisms vary in how they look and function because they have different inherited information. **5.L3U1.10** • Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (5.L4U3.12) • The environment also affects the traits that an organism develops. Differences in where they grow or in the food they consume may cause organisms that are related to end up looking or behaving differently.	**8.L3U1.9** • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of a specific protein, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. • In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. • In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. (8.L3U3.10) **8.L3U3.10** • In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations.	**HS.L3U1.24** • In sexual reproduction, a specialized type of cell division called meiosis occurs and results in the production of sex cells, such as gametes (sperm and eggs) or spores, which contain only one member from each chromosome pair in the parent cell. • In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS.L3U1.25) • Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors. **HS.L3U1.25** • Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some

		Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. (8.L3U1.9) • In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.	segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. • In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS.L1U3.24) **HS.L3U3.26** • The overall sequence of genes of an organism is known as its genome. More is being learned all the time about genetic information by mapping the genomes of different kinds of organisms. • When sequences of genes are known genetic material can be artificially changed to give organisms certain features. • In gene therapy special techniques are used to deliver into human cells genes that are beginning to help in curing disease. • Biotechnology has made possible the production of genetically identical organisms through artificial cloning in a range of species.

L4: The unity and diversity of organisms, living and extinct, is the result of evolution.

K-2	3-5	6-8	9-12
1.L4U1.10 • Animals and plants are classified into groups and subgroups according to their similarities. **1.L4U3.11** • There are many different kinds of plants and animals in the world today and many kinds that once lived but are now extinct. • 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.	**4.L4U1.11** • When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. • Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments. • For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. **5.L4U3.11** • Populations of organisms live in a variety of habitats and change in those habitats affects the organisms living there. • Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful. For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. **5.L4U3.12** • Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. • Other characteristics result from individuals' interactions with the	**8.L4U1.11** • Natural selection leads to the predominance of certain traits in a population and the suppression of others. • Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.(8.L4U1.12) **8.L4U1.12** • The natural selection of organisms with certain features that enable them to survive in particular environmental conditions has been going since the first form of life appeared on Earth. • Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (8.L4U1.11) • In separated populations with different conditions, the changes can be large enough that the populations, provided they remain separated (a process called reproductive isolation), evolve to become separate species.	**HS.L4U1.27** • Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. • The traits that positively affect survival are more likely to be reproduced and thus are more common in the population. • Adaptation also means that the distribution of traits in a population can change when conditions change. • Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' evolution is lost. • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). **HS.L4U1.28** • Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of

	environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (5.L3U1.10)		individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. • Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline-and sometimes the extinction of some species. • Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.

Core Ideas of Using Science: K-12 Progression of Elements

For use with *Arizona Science Standards*

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.			
K-2	**3-5**	**6-8**	**9-12**
• Science investigations begin with a question. • Science uses different ways to study the world. • Scientists look for patterns and order when making observations about the world. • Science knowledge can change when new information is found. • Science uses drawings, sketches, and models as a way to communicate ideas. • Science searches for cause-and effect relationships to explain natural events. • Science knowledge helps us know about the world. • Science assumes natural events happen today as they happened in the past.	• Science investigations use a variety of methods, tools, and techniques. • Science findings are limited to questions that can be answered with empirical evidence. • Science findings are based on recognizing patterns. • Science explanations can change based on new evidence. • Science theories are based on a body of evidence and many tests. • Science explanations describe the mechanisms for natural events. • Science is both a body of knowledge and processes that add new knowledge. • Science assumes consistent patterns in natural systems.	• Science investigations use a variety of methods and tools to make measurements and observations. • Science limits its explanations to systems that lend themselves to observation and empirical evidence. • Science investigations are guided by a set of values to ensure accuracy of measurements, observations, and objectivity of findings. • What people expect to happen can influence what they observe, so it is good practice for observations to be made by several people independently and for results to be reported clearly enough to be checked by others. • Science depends on evaluating proposed explanations. • Science knowledge is based upon logical and conceptual connections between evidence and explanations. • Science disciplines share common rules of obtaining and evaluating empirical evidence. • Scientific explanations are subject to revision and improvement in light of new evidence. • The certainty and durability of science findings vary. • Theories are explanations for observable phenomena based on a body of evidence developed over time. • The term “theory” as used in science is very	• Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge. • New technologies advance scientific knowledge. • Scientific inquiry is characterized by a common set of values that include logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings. • The discourse practices of science are organized around disciplinary domains that share exemplars for making decisions regarding the values, instruments, methods, models, and evidence to adopt and use. • Not all questions can be answered by science. Science knowledge is based on empirical evidence. • Science includes the process of coordinating patterns of evidence with current theory. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation. • Scientific explanations can be probabilistic. • Most scientific knowledge is quite durable but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. • Theories and laws provide explanations in science, but theories do not with time become laws or facts. • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed. • Through observation and experiment, the science

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.			
K-2	**3-5**	**6-8**	**9-12**
• Many events are repeated. • Scientists study the natural and material world.	• Basic laws of nature are the same everywhere in the universe.	different from the common use outside of science. • Laws are statements or mathematical descriptions of the observable phenomena. • A hypothesis is used by scientists as an idea that may contribute important new knowledge for the evaluation of a scientific theory. • Science is both a body of knowledge and the processes and practices used to add to that body of knowledge. • Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. • Science carefully considers and evaluates anomalies in data and evidence. • Scientific knowledge is constrained by human capacity, technology, and materials.	community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. • Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. • Laws are statements or descriptions of the relationships among observable phenomena. • Scientists often use hypotheses to develop and test theories and explanations. • Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise, and extend this knowledge. • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. • Science assumes the universe is a vast single system in which basic laws are consistent.

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.			
K-2	**3-5**	**6-8**	**9-12**
• 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. • 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.	• 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. • 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. • 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.	• The use of scientific ideas in technologies has made considerable changes in many aspects of human activity. • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. • Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. • There are usually many factors to be considered in optimizing a solution, such as cost, availability of materials and impact on users and on the environment, which may constrain choices. • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. • There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. • It is important to describe optimal solutions to a problem, explain how it was developed, and describe the	• Complicated problems may need to be broken down into simpler components in order to develop and test solutions. • When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability, and aesthetics and to consider social, cultural, and environmental impacts. • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. • Design criteria and constraints, which typically reflect the needs of the end-user of a technology or possess, address such things as the product's or system's function, it's durability and limits on its size and cost. • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. • Both physical models and computers can be used in various ways to aid in the engineering design process. Physical models, or prototypes, are helpful in testing product ideas or the properties of different materials. • Science and engineering complement each other in the cycle known as research and development (R&D). • Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to aclient about how a given design will meet their needs.

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.			
K-2	**3-5**	**6-8**	**9-12**
• 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. • Technologies have been created by people to provide the things they need or can use.	• Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. • Technologies are developed using engineering, which involves identifying problems and using ideas of science and other ideas to design and develop possible solutions.	features that make it successful. • Models of all kinds are important for testing solutions. The ability to build and use physical, graphical, and mathematical models is an essential part of translating a design idea into a finished product, such as a machine, building, or any other working systems. • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design. • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.	• Criteria may need to be broken down into simpler ones thatcan be approached systematically, and decisions about thepriority of certain criteria over others (trade-offs) may be needed. • Science, engineering and technology are closely inter-connected. The application of science in making new materials is an example of how scientific knowledge has led advances in technology and provided engineers with a wider choice in designing constructions. • Technological advances have helped scientific developments by improving instruments for observation and measuring, automating processes that might otherwise be too dangerous or time consuming to undertake, and particularly through the provision of computers. • Technology aids scientific advances which in turn can be used in designing and making things for people to use. • The aim of engineering is not simply to find a solution to a problem but to design the best solution under the given constraints and criteria. Optimization can be complex, however, for a design problem with numerous desired qualities or outcomes. • Testing should lead to design improvements through an interactive process, and computer simulations are one useful way of running such tests.

Core Ideas of Using Science: K-12 Progression of Elements

For use with *Arizona Science Standards*

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.			
K-2	**3-5**	**6-8**	**9-12**
• Every human-made product is designed by applying some knowledge of the natural world and is built by using natural materials. • Taking natural materials to make things impacts the environment. • There are generally both positive and negative consequences of the applications of science. • People depend on various technologies in their lives; human life would be very different without technology.	• People's needs and wants change over time, as do their demands for new and improved technologies. • Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. • When new technologies become available, they can bring about changes in the way people live and interact with one another. • There are generally both positive and negative consequences of the applications of science. • While technological solutions have improved the lives and health of many people in countries across the world, it has to be recognized that they may use materials from the natural world which may be in short supply or may be detrimental to the environment.	• All human activity draws on natural resources and has both short- and long term consequences, positive as well as negative, for the health of people and the natural environment. • The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. • Technology use varies over time and from region to region. • There are many examples of how technological and engineering advances have unintended consequences. If the detrimental effects are known, the trade-off between the advantages and the disadvantages of the application of science needs careful consideration. • Goals, priorities, and limits are needed for regulating new technologies, which can have deep impacts on society and the environment. The impacts may not have been anticipated when the technologies were introduced or may build up over time to levels that require mitigation. • Science knowledge can describe consequences of actions but is not responsible for society's decisions.	• Modern civilization depends on major technological systems, including those related to agriculture, health, water, energy, transportation, manufacturing, construction, and communications. • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. • The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. • Technology use varies over time and from region to region. • There are many examples of how technological and engineering advances have unintended consequences. If the detrimental effects are known, the trade-off between the advantages and the disadvantages of the application of science needs careful consideration. • Goals, priorities, and limits are needed for regulating new technologies, which can have deep impacts on society and the environment. The impacts may not have been anticipated when the technologies were introduced or may build up over time to levels that require mitigation. • Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. • Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. • Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.

K-12 Science and Engineering Practices* Progression Matrix of Elements

For use with *Arizona Science Standards*

Science and Engineering Practices	K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Asking Questions and Defining Problems A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested. Engineering questions clarify problems to determine criteria for successful solutions and identify constraints to solve problems about the designed world. Both scientists and engineers also ask questions to clarify ideas.	Asking questions and defining problems in grades K–2 builds on prior experiences and progresses to simple descriptive questions that can be tested. ▪ Ask questions based on observations of the natural and/or designed world. ▪ Define a simple problem that can be solved through the development of a new or improved object or tool.	Asking questions and defining problems in grades 3–5 builds from grades K–2 experiences and progresses to specifying qualitative relationships. ▪ Identify scientific (testable) and non-scientific (non-testable) questions. ▪ Ask questions based on careful observations of phenomena and information. ▪ Ask questions to clarify ideas or request evidence. ▪ Ask questions that relate one variable to another variable. ▪ Ask questions to clarify the constraints of solutions to a problem. ▪ Use prior knowledge to describe problems that can be solved. ▪ Define a simple design problem that can be solved through the development of an object, tool or process and includes several criteria for success and constraints on materials, time, or cost. ▪ Formulate questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.	Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to formulating and refining empirically testable models that support explanations of phenomena or solutions to problems. ▪ Ask questions that arise from careful observation of phenomena, models, or unexpected results. ▪ Ask questions to clarify or identify evidence and the premise(s) of an argument. ▪ Ask questions to determine relationships between independent and dependent variables. ▪ Ask questions that challenge the interpretation of a data set. ▪ Ask questions to clarify and refine a model, an explanation, or an engineering problem. ▪ Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. ▪ Formulate a question that can be investigated within the scope of the classroom, school laboratory, or field with available resources and, when appropriate, frame a hypothesis (a possible explanation that predicts a particular and stable outcome) based on a model or theory.	Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design solutions using models and simulations. ▪ Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results. ▪ Ask questions that require relevant empirical evidence to answer. ▪ Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables. ▪ Ask and evaluate questions that challenge the premise of an argument, the interpretation of a data set, or the suitability of a design. ▪ Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations

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Science and Engineering Practices	K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Developing and Using Models A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations. Modeling tools are used to develop questions, predictions and explanations; analyze and identify flaws in systems; and communicate ideas. Models are used to build and revise scientific explanations and proposed engineered systems. Measurements and observations are used to revise models and designs.	Modeling in K–2 builds on prior experiences and progresses to include identifying, using, and developing models that represent concrete events or design solutions. ▪ Distinguish between a model and the actual object, process, and/or events the model represents. ▪ Compare models to identify common features and differences. ▪ Develop and/or use models (i.e., diagrams, drawings, physical replicas, dioramas, dramatizations, or storyboards) that represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed worlds. ▪ Develop a simple model that represents a proposed object or tool.	Modeling in 3–5 builds on K–2 models and progresses to building and revising simple models and using models to represent events and design solutions. ▪ Develop and revise models collaboratively to measure and explain frequent and regular events. ▪ Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. ▪ Use simple models to describe or support explanations for phenomena and test cause and effect relationships or interactions concerning the functioning of a natural or designed system. ▪ Identify limitations of models. ▪ Develop a diagram or simple physical prototype to convey a proposed object, tool or process. ▪ Use a simple model to test cause and effect relationships concerning the functioning of a proposed object, tool or process.	Modeling in 6–8 builds on K–5 and progresses to developing, using, and revising models to support explanations, describe, test, and predict more abstract phenomena and design systems. ▪ Use and/or develop models to predict, describe, support explanations, and/or collect data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales. ▪ Develop models to describe unobservable mechanisms. ▪ Modify models—based on their limitations—to increase detail or clarity, or to explore what will happen if a component is changed. ▪ Use and develop models of simple systems with uncertain and less predictable factors. ▪ Develop a model that allows for manipulation and testing of a proposed object, tool, process or system. ▪ Evaluate limitations of a model for a proposed object or tool.	Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and explain relationships between systems and their components in the natural and designed world. ▪ Use multiple types of models to represent and support explanations of phenomena, and move flexibly between model types based on merits and limitations. ▪ Develop, revise, and use models to predict and support explanations of relationships between systems or between components of a system. ▪ Use models (including mathematical and computational) to generate data to support explanations and predict phenomena, analyze systems, and solve problems. ▪ Design a test of a model to ascertain its reliability. ▪ Develop a complex model that allows for manipulation and testing of a proposed process or system. ▪ Evaluate merits and limitations of two different models of the same proposed tool, process, or system in order to select or revise a model that best fits the evidence or design criteria.

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Science and Engineering Practices	K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Planning and Carrying Out Investigations Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters. Engineering investigations identify the effectiveness, efficiency, and durability of designs under different conditions.	Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. ▪ With guidance, design and conduct investigations in collaboration with peers. ▪ Design and conduct investigations collaboratively. ▪ Evaluate different ways of observing and/or measuring an attribute of interest. ▪ Make direct or indirect observations and/or measurements to collect data, which can be used to make comparisons. ▪ Identify questions and make predictions based on prior experiences. ▪ Make direct or indirect observations and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal.	Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. ▪ Design and conduct investigations collaboratively, using fair tests in which variables are controlled and the number of trials considered. ▪ Evaluate appropriate methods and tools for collecting data. ▪ Make observations and/or measurements, collect appropriate data, and identify patterns that provide evidence for an explanation of a phenomenon or test a design solution. ▪ Make measurements of two different models of the same proposed object, tool or process to determine which better meets criteria for success.	Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. ▪ Conduct an investigation and evaluate and revise the experimental design to ensure that the data generated can meet the goals of the experiment. ▪ Design an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how much data are needed to support their claim. ▪ Evaluate the accuracy of various methods for collecting data. ▪ Collect data and generate evidence to answer scientific questions or test design solutions under a range of conditions. ▪ Collect data about the performance of a proposed object, tool, process or system under a range of conditions.	Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that build, test, and revise conceptual, mathematical, physical, and empirical models. ▪ Design an investigation individually and collaboratively and test designs as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. ▪ Design and conduct an investigation individually and collaboratively, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. ▪ Select appropriate tools to collect, record, analyze, and evaluate data. ▪ Design and conduct investigations and test design solutions in a safe and ethical manner including considerations of environmental, social, and personal impacts. ▪ Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables. ▪ Use investigations to gather evidence to support explanations or concepts.

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Analyzing and Interpreting Data Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing secondary sources for analysis. Engineering investigations include analysis of data collected in the tests of designs. This allows comparison of different solutions and determines how well each meets specific design criteria—that is, which design best solves the problem within given constraints. Like scientists, engineers require a range of tools to identify patterns within data and interpret the results. Advances in science make analysis of proposed solutions more efficient and effective.	Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations. ▪ Use and share pictures, drawings, and/or writings of observations. ▪ Use observations to describe patterns and/or relationships in the natural and designed worlds in order to answer scientific questions and solve problems. ▪ Make measurements of length to quantify data. ▪ Analyze data from tests of an object or tool to determine if a proposed object or tool functions as intended.	Analyzing data in 3–5 builds on K–2 and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. ▪ Display data in tables and graphs, using digital tools when feasible, to reveal patterns that indicate relationships. ▪ Use data to evaluate claims about cause and effect. ▪ Compare data collected by different groups in order to discuss similarities and differences in their findings. ▪ Use data to evaluate and refine design solutions. ▪ Interpret data to make sense of and explain phenomena, using logical reasoning, mathematics, and/or computation. ▪ Analyze data to refine a problem statement or the design of a proposed object, tool or process.	Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. ▪ Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible. ▪ Construct, analyze, and interpret graphical displays of data to identify linear and nonlinear relationships. ▪ Consider limitations of data analysis (e.g., measurement error), and seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials). ▪ Analyze and interpret data in order to determine similarities and differences in findings. ▪ Distinguish between causal and correlational relationships. ▪ Use graphical displays (e.g., maps) of large data sets to identify temporal and spatial relationships. ▪ Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success.	Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. ▪ Use tools, technologies, and/or models (e.g., computational, mathematical) to generate and analyze data in order to make valid and reliable scientific claims or determine an optimal design solution. ▪ Consider limitations (e.g., measurement error, sample selection) when analyzing and interpreting data. ▪ Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. ▪ Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. ▪ Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success. ▪ Evaluate the impact of new data on a working explanation of a proposed process or system.

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Science and Engineering Practices	K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Using Mathematics and Computational Thinking In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; solving equations exactly or approximately; and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable scientists and engineers to predict the behavior of systems and test the validity of such predictions.	Mathematical and computational thinking at the K–2 level builds on prior experience and progresses to recognizing that mathematics can be used to describe the natural and designed world ▪ Decide when to use qualitative vs. quantitative data. ▪ Use counting and numbers to identify and describe patterns in the natural and designed worlds. ▪ Describe, measure, and compare quantitative attributes of different objects and display the data using simple graphs. ▪ Use quantitative data to compare two alternative solutions to a problem.	Mathematical and computational thinking at the 3–5 level builds on K–2 and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to compare alternative design solutions. ▪ Use mathematical thinking and/or computational outcomes to compare alternative solutions to an engineering problem. ▪ Organize simple data sets to reveal patterns that suggest relationships. ▪ Describe, measure, estimate, and graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems. ▪ Decide if qualitative or quantitative data is best to determine whether a proposed object or tool meets criteria for success.	Mathematical and computational thinking at the 6–8 level builds on K–5 and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. ▪ Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. ▪ Create algorithms (a series of ordered steps) to solve a problem. ▪ Apply concepts of ratio, rate, percent, basic operations, and simple algebra to scientific and engineering questions and problems. ▪ Use mathematical arguments to describe and support scientific conclusions and design solutions. ▪ Use digital tools, mathematical concepts, and arguments to test and compare proposed solutions to an engineering design problem.	Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ▪ Use mathematical or algorithmic representations of phenomena or design solutions to describe and support claims and explanations, and create computational models or simulations. ▪ Apply techniques of algebra and functions to represent and solve scientific and engineering problems. ▪ Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. ▪ Create a simple computational model or simulation of a designed device, process, or system.

* Adapted by Achieve from: National Research Council (2011). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academy Press. Chapter 3: Science and Engineering Practices.

K-12 Science and Engineering Practices* Progression Matrix of Elements

For use with *Arizona Science Standards*

Science and Engineering Practices	K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Constructing Explanations and Designing Solutions *The end-products of science are explanations and the end-products of engineering are solutions.* The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories. The goal of engineering design is to find a systematic solution to problems that is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. The optimal choice depends on how well the proposed solutions meet criteria and constraints.	Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence or ideas in constructing explanations and designing solutions. ▪ Use information from direct or indirect observations to construct explanations. ▪ Use tools and materials provided to design a device or solution to a specific problem. ▪ Distinguish between opinions and evidence in one's own explanations. ▪ Generate and compare multiple solutions to a problem.	Constructing explanations and designing solutions in 3–5 builds on prior experiences in K–2 and progresses to the use of evidence in constructing multiple explanations and designing multiple solutions. ▪ Construct explanations of observed quantitative relationships (e.g., the distribution of plants in the back yard). ▪ Use evidence (e.g., measurements, observations, patterns) to construct a scientific explanation or design a solution to a problem. ▪ Identify the evidence that supports particular points in an explanation. ▪ Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation. ▪ Apply scientific knowledge to solve design problems. ▪ Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the problem.	Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. ▪ Construct explanations for either qualitative or quantitative relationships between variables. ▪ Apply scientific reasoning to show why the data are adequate for the explanation or conclusion. ▪ Base explanations on evidence obtained from sources (including their own experiments) and the assumption that natural laws operate today as they did in the past and will continue to do so in the future. ▪ Undertake design projects, engaging in the design cycle, to construct and implement a solution that meets specific design criteria and constraints. ▪ Apply scientific knowledge and evidence to explain real-world phenomena, examples, or events. ▪ Construct explanations from models or representations. ▪ Apply scientific knowledge to design, construct, and test a design of an object, tool, process or system. ▪ Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing.	Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories. ▪ Make quantitative and qualitative claims regarding the relationship between dependent and independent variables. ▪ Apply scientific reasoning, theory, and models to link evidence to claims to assess the extent to which the reasoning and data support the explanation or conclusion. ▪ Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review. ▪ Base causal explanations on valid and reliable empirical evidence from multiple sources and the assumption that natural laws operate today as they did in the past and will continue to do so in the future. ▪ Apply scientific knowledge and evidence to explain phenomena and solve design problems, taking into account possible unanticipated effects. ▪ Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

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K-12 Science and Engineering Practices* Progression Matrix of Elements

For use with *Arizona Science Standards*

Science and Engineering Practices	K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Engaging in Argument from Evidence *Argumentation is the process by which explanations and solutions are reached.* In science and engineering, reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem. Scientists and engineers use argumentation to listen to, compare, and evaluate competing ideas and methods based on merits. Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to identify strengths and weaknesses of claims.	Engaging in argument from evidence in K–2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world. ▪ Identify arguments that are supported by evidence. ▪ Listen actively to others' explanations and arguments and ask questions for clarification. ▪ Make a claim about the effectiveness of an object, tool, or solution that is based on relevant evidence.	Engaging in argument from evidence in 3–5 builds from K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world. ▪ Construct and/or support scientific arguments with evidence, data, and/or a model. ▪ Compare and refine arguments based on the strengths and weaknesses of the evidence presented. ▪ Respectfully provide and receive critiques on scientific arguments with peers by citing relevant evidence and posing specific questions. ▪ Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.	Engaging in argument from evidence in 6–8 builds from K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. ▪ Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation for a phenomenon or a solution to a problem. ▪ Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. ▪ Respectfully provide and receive critiques on scientific arguments by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. ▪ Compare two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. ▪ Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system, based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.	Engaging in argument from evidence in 9–12 builds from K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world. Arguments may also come from current scientific or historical episodes in science. ▪ Critique and evaluate competing arguments, models, and/or design solutions in light of new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. ▪ Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. ▪ Construct a counter-argument that is based on data and evidence that challenges another proposed argument. ▪ Make and defend a claim about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence. ▪ Evaluate a claim for a design solution to a real-world problem based on scientific knowledge, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

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K-12 Science and Engineering Practices* Progression Matrix of Elements

For use with *Arizona Science Standards*

Science and Engineering Practices	K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Obtaining, Evaluating, and Communicating Information Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity. Communicating information and ideas can be done in multiple ways: using tables, diagrams, graphs, models, and equations as well as orally, in writing, and through extended discussions. Scientists and engineers employ multiple sources to acquire information that is used to evaluate the merit and validity of claims, methods, and designs.	Obtaining, evaluating, and communicating information in K–2 builds on prior experiences and uses observations and texts to communicate new information. ▪ Read and comprehend grade-appropriate texts and media to acquire scientific and/or technical information. ▪ Critique and/or communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers. ▪ Record observations, thoughts, and ideas. ▪ Explain how specific images (e.g., a diagram showing how a machine works) contribute to and clarify a text. ▪ Obtain information by using various text features (e.g., headings, tables of contents, glossaries, electronic menus, icons).	Obtaining, evaluating, and communicating information in 3–5 builds on K–2 and progresses to evaluating the merit and accuracy of ideas and methods. ▪ Compare and/or combine across complex texts and/or other reliable media to acquire appropriate scientific and/or technical information. ▪ Determine the main idea of a scientific text and explain how it is supported by key details; summarize the text. ▪ Combine information in written text with that contained in corresponding tables, diagrams, and/or charts. ▪ Use multiple sources to generate and communicate scientific and/or technical information orally and/or in written formats, including various forms of media and may include tables, diagrams, and charts. ▪ Use models to share findings or solutions in oral and/or written presentations, and/or extended discussions. ▪ Obtain and combine information from books and/or other reliable media about potential solutions to a specific design problem.	Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods. ▪ Communicate scientific information and/or technical information (e.g. about a proposed object, tool, process, system) in different formats (e.g., verbally, graphically, textually, and mathematically). ▪ Gather, read, and communicate information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used. ▪ Read critically using scientific knowledge and reasoning to evaluate data, hypotheses, conclusions that appear in scientific and technical texts in light of competing information or accounts; provide an accurate summary of the text distinct from prior knowledge or opinions. ▪ Critically evaluate whether or not technical information on a device, tool or process is relevant to its suitability to solve a specific design problem.	Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. ▪ Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. ▪ Synthesize, communicate, and evaluate the validity and reliability of claims, methods, and designs that appear in scientific and technical texts or media reports, verifying the data when possible. ▪ Produce scientific and/or technical writing and/or oral presentations that communicate scientific ideas and/or the process of development and the design and performance of a proposed process or system. ▪ Compare, integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) in order to address a scientific question or solve a problem.

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K-12 Crosscutting Concepts* Progression Matrix of Elements

For use with *Arizona Science Standards*

1. Patterns – Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.			
K-2 Crosscutting Statements	**3-5 Crosscutting Statements**	**6-8 Crosscutting Statements**	**9-12 Crosscutting Statements**
▪ Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.	▪ Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products. ▪ Patterns of change can be used to make predictions. ▪ Patterns can be used as evidence to support an explanation.	▪ Macroscopic patterns are related to the nature of microscopic and atomic-level structure. ▪ Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. ▪ Patterns can be used to identify cause and effect relationships. ▪ Graphs, charts, and images can be used to identify patterns in data.	▪ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. ▪ Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. ▪ Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. ▪ Mathematical representations are needed to identify some patterns. ▪ Empirical evidence is needed to identify patterns.

2. Cause and Effect: Mechanism and Prediction – Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.			
K-2 Crosscutting Statements	**3-5 Crosscutting Statements**	**6-8 Crosscutting Statements**	**9-12 Crosscutting Statements**
▪ Events have causes that generate observable patterns. ▪ Simple tests can be designed to gather evidence to support or refute student ideas about causes.	▪ Cause and effect relationships are routinely identified, tested, and used to explain change. ▪ Events that occur together with regularity might or might not be a cause and effect relationship.	▪ Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. ▪ Cause and effect relationships may be used to predict phenomena in natural or designed systems. ▪ Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.	▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ▪ Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. ▪ Systems can be designed to cause a desired effect. ▪ Changes in systems may have various causes that may not have equal effects.

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K-12 Crosscutting Concepts* Progression Matrix of Elements

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3. Scale, Proportion, and Quantity – In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.			
K-2 Crosscutting Statements	**3-5 Crosscutting Statements**	**6-8 Crosscutting Statements**	**9-12 Crosscutting Statements**
▪ Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). ▪ Standard units are used to measure length.	▪ 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.	▪ Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. ▪ The observed function of natural and designed systems may change with scale. ▪ Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. ▪ Scientific relationships can be represented through the use of algebraic expressions and equations. ▪ Phenomena that can be observed at one scale may not be observable at another scale.	▪ The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ▪ Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. ▪ Patterns observable at one scale may not be observable or exist at other scales. ▪ Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. ▪ Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

4. Systems and System Models – A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.			
K-2 Crosscutting Statements	**3-5 Crosscutting Statements**	**6-8 Crosscutting Statements**	**9-12 Crosscutting Statements**
▪ Objects and organisms can be described in terms of their parts. ▪ Systems in the natural and designed world have parts that work together.	▪ 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.	▪ Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. ▪ Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. ▪ Models are limited in that they only represent certain aspects of the system under study.	▪ Systems can be designed to do specific tasks. ▪ When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. ▪ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. ▪ Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

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K-12 Crosscutting Concepts* Progression Matrix of Elements

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5. Energy and Matter: Flows, Cycles, and Conservation – Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.			
K-2 Crosscutting Statements	**3-5 Crosscutting Statements**	**6-8 Crosscutting Statements**	**9-12 Crosscutting Statements**
▪ Objects may break into smaller pieces, be put together into larger pieces, or change shapes.	▪ Matter is made of particles. ▪ Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems. ▪ Energy can be transferred in various ways and between objects.	▪ Matter is conserved because atoms are conserved in physical and chemical processes. ▪ Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. ▪ Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). ▪ The transfer of energy can be tracked as energy flows through a designed or natural system.	▪ The total amount of energy and matter in closed systems is conserved. ▪ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. ▪ Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. ▪ Energy drives the cycling of matter within and between systems. ▪ In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

6. Structure and Function – The way an object is shaped or structured determines many of its properties and functions.			
K-2 Crosscutting Statements	**3-5 Crosscutting Statements**	**6-8 Crosscutting Statements**	**9-12 Crosscutting Statements**
▪ The shape and stability of structures of natural and designed objects are related to their function(s).	▪ Different materials have different substructures, which can sometimes be observed. ▪ Substructures have shapes and parts that serve functions.	▪ Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function. ▪ Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.	▪ Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. ▪ The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

7. Stability and Change – For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.			
K-2 Crosscutting Statements	**3-5 Crosscutting Statements**	**6-8 Crosscutting Statements**	**9-12 Crosscutting Statements**
▪ Some things stay the same while other things change. ▪ Things may change slowly or rapidly.	▪ Change is measured in terms of differences over time and may occur at different rates. ▪ Some systems appear stable, but over long periods of time will eventually change.	▪ Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale. ▪ Small changes in one part of a system might cause large changes in another part. ▪ Stability might be disturbed either by sudden events or gradual changes that accumulate over time. ▪ Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.	▪ Much of science deals with constructing explanations of how things change and how they remain stable. ▪ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. ▪ Feedback (negative or positive) can stabilize or destabilize a system. ▪ Systems can be designed for greater or lesser stability.

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