Arizona Science Standards
March 2018 DRAFT

Arizona Department of Education

High Academic Standards for Students

DRAFT March 2018 DRAFT

Introduction

Students are naturally curious about the world and their place in it. Sustaining this curiosity and giving it a scientific foundation must be a high priority in Arizona schools. Scientific thinking enables Arizona students to strengthen skills that people use every day: solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing lifelong learning. Science education is much more than merely learning content. It is the active process of investigation and the critical review of evidence related to the world around us, both visible and invisible. Science is a dynamic process of gathering and evaluating information, looking for patterns, and testing possible explanations or design solutions. Active engagement in scientific investigation leads students to think critically and to develop reasoning skills that allow them to become independent, lifelong learners.

A fundamental goal of science education is to help students determine how the world works and make sense of phenomena in the natural world. Phenomena are events or situations that are observed to exist or happen, especially those whose causes or explanations are in question. Science sense-making is a conceptual process in which a learner actively engages with phenomena in the natural world to construct logical and coherent explanations that incorporate their current understanding of science, or a model that represents it, and are consistent with the available evidence. To develop a scientific understanding of the natural world, students must be able to ask questions, gather information, reason about that information and connect it to scientific principles, theories, or models, and then effectively communicate their understanding and reasoning.

This sense-making occurs at the intersection of three major dimensions; each intersects with the others and plays an essential role. These dimensions are:

- **crosscutting concepts** (shown as the outer section of Figure 1)
- **science and engineering practices** (shown as the eight circles in Figure 1)
- **core ideas** (shown as the center circle in Figure 1)

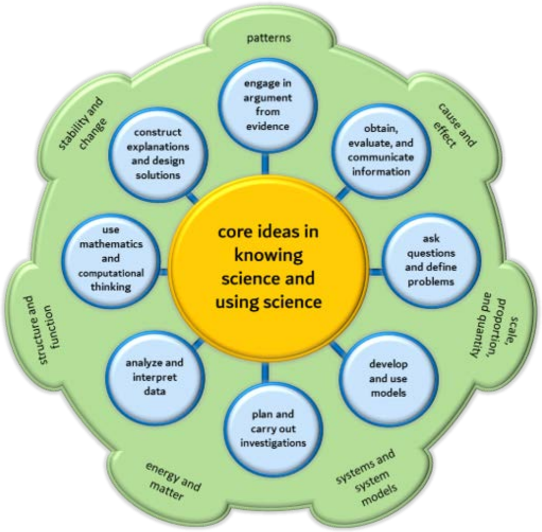


Figure 1: Three Dimensions of Science Instruction

Crosscutting Concepts

Crosscutting concepts[4] cross boundaries between science disciplines and provide an organizational framework to connect knowledge from various disciplines into a coherent and scientifically based view of the world. They bridge boundaries between science and other disciplines and connect core ideas and practices throughout the fields of science and engineering. Their purpose is to provide a lens to help students deepen their understanding of the core ideas as they make sense of phenomena in the natural and designed worlds. The crosscutting concepts identified in *A Framework for K-12 Science Education* are:

- patterns
- cause and effect
- structure and function
- systems and system models
- stability and change
- scale, proportion, and quantity
- energy and matter

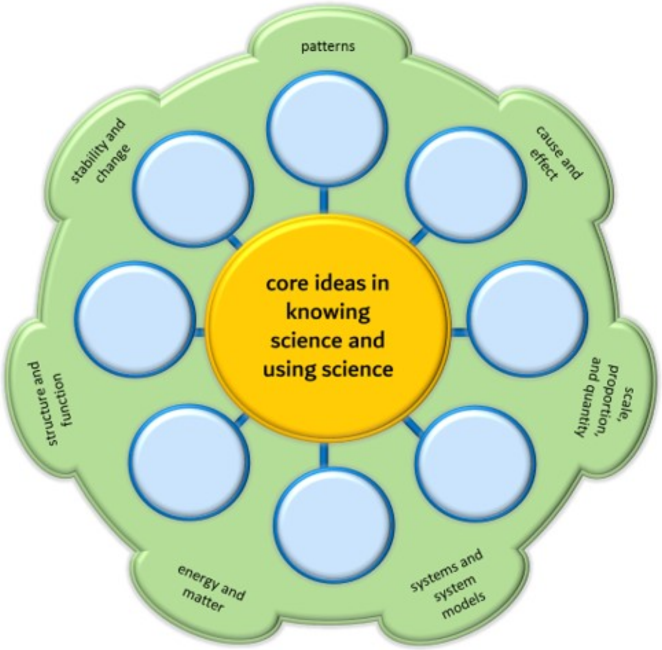


Figure 2: Crosscutting concepts provide a lens for understanding the core ideas

The Arizona Science Standards are designed for students to develop their understanding of core ideas through the lens of one or multiple crosscutting concepts. Crosscutting concepts can be combined as students find and use patterns as evidence, determine cause and effect relationships, or define systems to investigate. Students must be provided structures and opportunities to make explicit connections between their learning and the crosscutting concepts. See Appendix 1 for more details on each of the crosscutting concepts.

One example of a crosscutting concept can be seen within patterns. Patterns are present in all science disciplines and much of science is about explaining observed patterns. In life sciences, classification systems represent patterns. In physical sciences, atomic structure is a pattern. In earth and space sciences, tectonic processes follow a pattern. Using graphs, charts, maps, and statistics in combination with the science and engineering practices, students can use their knowledge of patterns to formulate investigations, answer questions, and make informed predictions about observed phenomena.

Science and Engineering Practices

Formerly known as the scientific method, the science and engineering practices[4] describe a robust process for how scientists investigate and build models and theories of the natural world or how engineers design and build systems. Rather than a linear process from hypothesis to conclusion, these practices reflect science and engineering as they are practiced and experienced. As students conduct investigations, they engage in multiple practices as they gather information to solve problems, answer their questions, reason about how the data provide evidence to support their understanding, and then communicate their understanding of phenomena. Student investigations may be observational, experimental, use models or simulations, or use data from other sources. These eight practices identified in *A Framework for K-12 Science Education* are critical components of scientific literacy, not instructional strategies:

- ask questions and define problems
- develop and use models
- plan and carry out investigations
- analyze and interpret data
- use mathematics and computational thinking
- construct explanations and design solutions
- engage in argument from evidence
- obtain, evaluate, and communicate information

The science and engineering practices are intended to be intertwined with the core ideas and crosscutting concepts across all grade levels and disciplines. See Appendix 2 for more details on each of the science and engineering practices.

Figure 3: Science and engineering practices are used to investigate core ideas in science and develop scientific literacy

Core Ideas

The Arizona Science Standards focus on fourteen core ideas in science and engineering, adapted from *Working with Big Ideas of Science Education*.[2] The ten core ideas for **Knowing Science** center on understanding the causes of phenomena in life, earth and space, and physical science. The four core ideas for **Using Science** connect scientific principles, theories, and models; engineering and technological applications; and societal implications to the content knowledge to support that understanding. The complexity of each core idea develops as students progress through each grade band. Each standard is written at the intersection of two core ideas to help students understand both the process for knowing science and using science. These core ideas occur across grade levels and provide the background knowledge for students to develop sense-making around phenomena in the natural world. See Appendix 3 for more details. The core ideas are listed below.

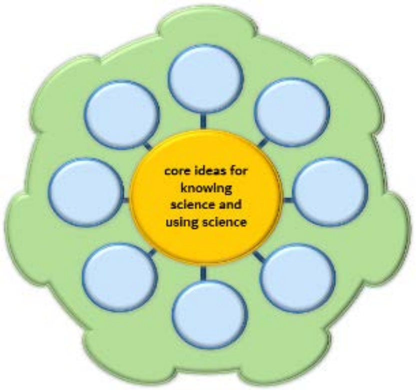


Figure 4: Core ideas intersect with the other two dimensions

Core Ideas for Knowing Science		Core Ideas for Using Science
Physical Science P1: All matter in the Universe is made of very small particles. P2: Objects can affect other objects at a distance. P3: Changing the movement of an object requires a net force to be acting on it. P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event. **Earth and Space Science** E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate. E2: The Earth and our Solar System are a very small part of one of many galaxies within the Universe. **Life Science** L1: Organisms are organized on a cellular basis and have a finite life span. L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms. L3: Genetic information is passed down from one generation of organisms to another. L4: The theory of evolution seeks to make clear the unity and diversity of living and extinct organisms.		U1: Science's purpose is to find the cause or causes of phenomena in the natural world. U2: Scientific explanations, theories, and models are those that best fit the evidence available at a particular time. U3: The knowledge produced by science is used in engineering and technologies to create products. U4: Applications of science often have both positive and negative ethical, social, economic, and political implications.

Design of the Arizona Science Standards
The Arizona Science Standards define the knowledge, understanding, and skills that need to be effectively taught and learned for all students to be scientifically literate. Students who are scientifically literate are ready to succeed in college-entry courses, in the workplace, in military service, and engage in civic responsibilities related to science issues. These standards present a vision of what it means to be a scientifically literate person.

The Arizona Science Standards outline what all students need to know, understand, and be able to do by the end of high school and reflect the following shifts for science education:

- Organize standards around fourteen core ideas and develop learning progressions to coherently and logically build scientific literacy from kindergarten through high school.
- Connect core ideas, crosscutting concepts, and science and engineering practices, to make sense of the natural world and understand how science and engineering are practiced and experienced.
- Focus on fewer, broader standards that allow for greater depth, more connections, deeper understanding, and more applications of content.

The standards are neither curriculum nor instructional practices.
While the Arizona Science Standards serve as the basis for a district's or school's science curriculum, they are not the curriculum. Therefore, identifying the sequence of instruction at each grade – what will be taught and for how long – requires concerted effort and attention at the local level. Curricular tools, including textbooks, are selected by the district/school and adopted through the local governing board. The Arizona Department of Education defines standards, curriculum, and instruction as:

- **Standards** are what a student needs to know, understand, and be able to do by the end of each grade. They build across grade levels in a progression of increasing understanding and through a range of cognitive demand levels. Standards are adopted at the state level by the Arizona State Board of Education.
- **Curriculum** refers to resources used for teaching and learning the standards. Curricula are adopted at the local level.
- **Instruction** refers to the methods or methodologies used by teachers to teach their students. Instructional techniques are employed by individual teachers in response to the needs of the students in their classes to help them progress through the curriculum to master the standards. Decisions about instructional practice and techniques are made at a local level.

The Arizona Science Standards assume students have regular standards-based science instruction every year. The amount of time individual students need to learn these standards will vary. The chart below specifies the expected science instructional time necessary for students to learn these standards.

Grade	Assumed Minutes per Week	Assumed Average Minutes per Day
K	90 minutes/week	18 minutes/day
1	150 minutes/week	30 minutes/day
2	150 minutes/week	30 minutes/day
3	200 minutes/week	40 minutes/day
4	225 minutes/week	45 minutes/day
5	225 minutes/week	45 minutes/day
6	250 minutes/week	50 minutes/day
7	250 minutes/week	50 minutes/day
8	250 minutes/week	50 minutes/day
HS (3 credits)	275 minutes/week	55 minutes/day

The Arizona Science Standards have been designed so that these time assumptions provide adequate time for instruction and opportunities to learn the standards for each grade level. Depending on local factors, schools may allocate more or less time when determining curriculum programming within a specific context. Instruction on the Arizona Science Standards may be a dedicated time in the school schedule or may be integrated with instruction of other subjects. See Appendix 4 and the Standards document for connections with other content areas.

These time recommendations do not explicitly address needs of students who are far below or far above the grade level.
No set of grade-specific standards can fully reflect the variety in abilities, needs, learning rates, and achievement levels of students in any given classroom. The Arizona Science Standards do not define the intervention methods to support students who are far below or far above grade level or do not speak English as their first language. See Appendix 5 for strategies to support equity and diversity in science.

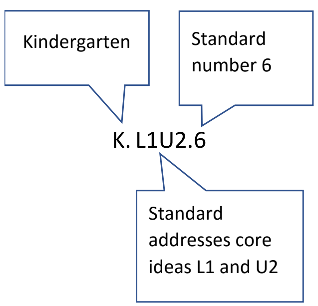
Safety Expectations

While there are no specific standards that address laboratory or field safety, it is a required part of science education to instruct and guide students in using appropriate safety precautions for all investigations. Reducing risk and preventing accidents in science classrooms begins with planning that meets all local, state, and federal requirements, including Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) requirements for safe handling and disposal of laboratory materials. The following four steps are recommended in carrying out a hazard and risk assessment for any investigation:

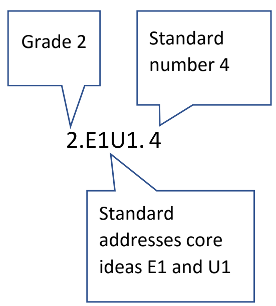
1) Identify hazards. Hazards may be physical, chemical, health, or environmental.
2) Evaluate the type of risk associated with each hazard.
3) Instruct students on all procedures and necessary safety precautions in such a way as to eliminate or reduce the risk associated with each hazard.
4) Prepare for any emergency that might arise despite all the required safety precautions.

Coding of the K-8 Science Standards

Each K-8 standard represents the intersection of core ideas for knowing science and using science. This intersection stresses that content in physical science, earth and space science, and life science is not learned independently from ideas about the nature of science, applications of science, or the social implications of using science. The coding of the standard captures this intersection. Students engage in multiple practices as they gather information to solve problems, answer their questions, reason about how the data provide evidence to support their understanding, and then communicate their understanding of phenomena, applications, or social implications. They use the crosscutting concepts to support their understanding of patterns, cause and effect relationships, and systems thinking as they make sense of phenomena. The standard number at the end of the code is designed for recording purposes and does not imply instructional sequence or importance. **At left** are examples and descriptions of coding of the K-8 Standards.



K.L1U2.6. Observe and explain the differences between and properties of living and nonliving things.



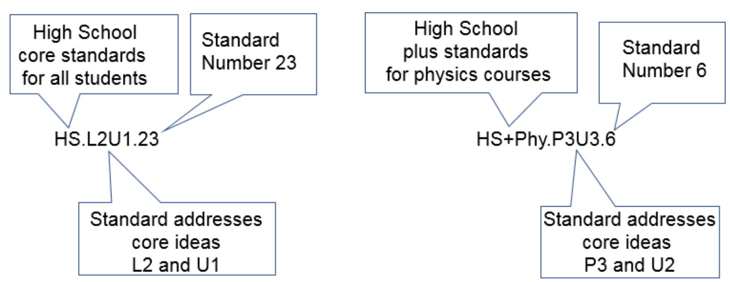
2.E1U1.4. Observe, describe, and predict how wind and water change the shape of the land resulting in a variety of landforms.

Coding of the High School Science Standards

In Arizona, students are required to take 3 credits of high school science aligned to standards in physical, earth and space, and life sciences to meet graduation requirements, but there is no mandatory course sequence across the state. Because of this, the high school standards are written at two levels: essential and plus.

- All high school essential standards (HS) should be learned by every high school student regardless of the 3-credit course sequence they take. The full set of essential high school (HS) standards is designed to be taught over a 3-year period.
- The high school plus (HS+) standards are designed to enhance the rigor of general science courses by extending the essential standards within general chemistry (HS+C), physics (HS+Phy), earth and space sciences (HS+E), or biology (HS+B) courses. These HS+ standards are intended to provide the additional rigor of these courses to prepare students for college courses for science majors.

Like K-8, each high school standard represents the intersection of core ideas for knowing science and using science. This intersection stresses that content in physical science, earth and space science, and life science is not learned independently from ideas about the nature of science, applications of science, or the social implications of using science. The coding of the standard captures this intersection. Students engage in multiple practices as they gather information to solve problems, answer their questions, reason about how the data provide evidence to support their understanding, and then communicate their understanding of phenomena, applications, or social implications. They use the crosscutting concepts to support their understanding of patterns, cause and effect relationships, and systems thinking as they make sense of phenomena. The standard number at the end of the code is designed for recording purposes and does not imply instructional sequence or importance. **At right** are examples and descriptions of coding of the High School Science Standards.



HS.L2U1.23. Construct an explanation demonstrating how organisms combine carbon and other atoms from the environment to form macromolecules.

HS+Phy.P3U3.6. Design, evaluate, and refine a device that minimizes or maximizes the force on a macroscopic object during a collision.

Grades K-2 Science Standards

The K-2 Science Standards are designed to provide opportunities for students to develop understanding of all fourteen core ideas (see Appendix 3) across the K-2 grade band. To provide opportunity for students to sufficiently demonstrate knowledge, understanding, and performance of each standard, not every core idea is included in every grade.

Within each grade, students engage in multiple science and engineering practices (formerly the scientific method) as they gather information to answer their questions or solve design problems, reason about how the data provide evidence to support their understanding, and then communicate their understanding of phenomena in physical, earth and space, and life science (knowing science). They apply their knowledge of core ideas to understand how scientists continue to build understanding of phenomena and see how people are impacted by natural phenomena or to construct technological solutions (using science). The crosscutting concepts support their understanding of patterns, cause and effect relationships, and systems thinking as students make sense of phenomena in the natural and designed worlds.

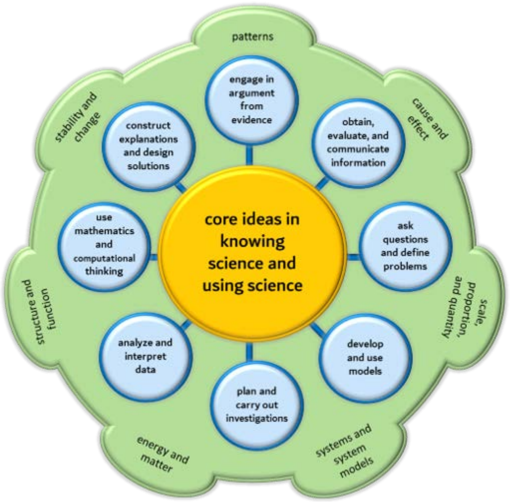


Figure 1: Three Dimensions of Science Instruction

- In kindergarten, students use their senses to help them make observations about the world around them, recognizing patterns and causal relationships.
- In first grade, students develop an understanding of causal relationships as they investigate how objects can impact other objects, from a distance or by contact with each other. They also develop systems thinking as they investigate how organisms interact with the Earth for survival and how life systems have cycles.
- In second grade, students apply systems thinking by understanding energy and matter to how water helps change the surface features of Earth, how water cycles through the environment, and how water is a critical resource of life on Earth.

The organization of the standards within this document does not indicate instructional sequence or importance. Decisions about curriculum and instruction are made locally by individual school districts and classroom teachers; these standards can be sequenced, combined, or integrated with other content areas to best meet the local curriculum or student needs (See Appendices 4 and 5). Suggestions for key concepts and connections to other content area standards are included to assist teachers when implementing the Science Standards and are not intended to be the minimum or maximum content limits.

Kindergarten: Focus on Patterns; Structure and Function

By the end of Kindergarten, students learn to use their senses to help them make observations and predictions about the world and living things around them. In this grade level, students will learn how light and sound are impacted by senses, observe weather patterns and their influences on plants and animals, and differentiate between systems and structures of living and non-living things. Student investigations focus on collecting and making sense of observational data and simple measurements using the science and engineering practices: ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematics and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate, and communicate information. While individual lessons may include connections to any of the crosscutting concepts, the standards in this grade focus on helping students understand phenomena through the crosscutting concepts of patterns and structure and function.

Physical Sciences: Students explore how their senses can detect light, sound, and vibration and how technology can be used to extend their senses.

Physical Science Standards	Key concepts include but are not limited to:
K.P2U2.1	
Investigate how the five senses and their associated body parts can detect light, sound, and vibrations even when they come from far away; use the collected evidence to **develop and support an explanation**.	Refer to standard
K.P2U3.2	
Design and evaluate a tool that helps people extend their senses.	Evaluation of student-designed tools and evaluation of existing tools

Earth and Space Sciences: Students develop an understanding of patterns to understand changes in local weather, seasonal cycles, and daylight.

Earth and Space Standards	Key concepts include but are not limited to:
K.E1U1.3	
Observe, record, and ask questions about temperature, precipitation, and other weather data to identify patterns or changes in local weather.	Weather, seasons, weather patterns, sun, temperature, thermometer, clouds, types of precipitation (snow, rain, fog)
K.E1U1.4	
Observe, describe, ask questions, and predict seasonal weather patterns; understand how those patterns influence plants and animals (including humans).	Those listed in grade level standard K.E1U1.3 and basic weather graphs and charts, weather symbols, seasonal movement, leaf loss (evergreen, deciduous), plant growth, shedding, hibernation, shelter

Life Sciences: Students develop an understanding that the world is comprised of living and non-living things. They investigate the relationship between structure and function in living things and how plants and animals use specialized external parts to help them meet their needs and survive.

Life Science Standards	Key concepts include but are not limited to:
K.L1U1.5	
Obtain, evaluate, and communicate how the human body has different systems that carry out life processes.	Body systems that allow living things to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, take in food, water, and air
K.L2U2.6	
Ask questions about and explain the differences between properties of living and nonliving things.	Living properties (grow, reproduce) and nonliving properties (air, food, water, energy)
K.L4U2.7	
Ask questions about and explain how specialized structures found on a variety of plants and animals (including humans) help them sense and respond to their environment.	Types of leaves, seeds, stem, root systems, farming, water, nutrients, shelter, air, soil, light, senses

Commented [LE1]: Obtain, evaluate, and communicate evidence that?

Commented [LE2]: Living systems require an input of energy, air, food, water. Rephrase?

Kindergarten Connections to Other Academic Disciplines

Connection to the Arizona Health Standards for Grade Band Pre-K to 2

- Strand 1: Comprehension of Health Promotion and Disease Prevention Concepts
    - Concept 1: Understand relationship between health behaviors and health; PO 1 identify that healthy behaviors affect personal health and overall well-being
    - Concept 3: Understanding personal health; PO 1 describe ways to prevent communicable diseases
    - Concept 3: Understanding personal health; PO 2 identify that foods are classified into food groups and that a variety of food is needed for personal health, growth, and development
    - Concept 3: Understanding personal health; PO 3 identify that physical activity is integral to good health
- Strand 7: Ability to Practice Health-Enhancing Behaviors
    - Concept 2: Healthy practices and behaviors; PO 1 demonstrate healthy practices and behaviors to maintain or improve personal health
    - Concept 2: Healthy practices and behaviors; PO 2 demonstrate behaviors that avoid or reduce health risks

Connection to the Arizona English Language Arts Standards for Kindergarten

- Use age-appropriate scientific texts and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards

Connection to the Arizona Mathematics Standards for Kindergarten

- Standards for Mathematical Practices
    - Make sense of problems and persevere in solving them
    - Use appropriate tools strategically
    - Look for and make use of structure
    - Look for and express regularity in repeated reasoning
- Counting and Cardinality
    - Develop competence with counting and cardinality
    - Develop understanding of addition and subtraction within 10
- Measurement and Data
    - Describe and compare measurable attributes
    - Classify objects and count the number of objects in each category

See also Appendix 4

First Grade: Focus on Cause and Effect; Stability and Change (cycles)

By the end of first grade, students make observations to understand connections between earth materials and the ability for the Earth to sustain a variety of organisms. In this grade level, students learn how light and sound waves interact within the environment, how organisms interact with Earth materials, and how life systems have cycles. Student investigations focus on collecting and making sense of observational data and simple measurements using the science and engineering practices: ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematics and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate, and communicate information. While individual lessons may include connections to any of the crosscutting concepts, the standards in first grade focus on helping students understand phenomena through cause and effect and stability and change.

Physical Sciences: Students develop an understanding of the effects of forces and waves and how they can impact, or be impacted by, objects near and far away. They explore the relationships between sound and vibrating materials and between light and materials, including its ability to travel from place to place (using transparent, opaque, and translucent materials, prisms, and mirrors).

Physical Science Standards	Key concepts include but are not limited to:
1.P2U1.1	
Plan and carry out investigations demonstrating the effect of placing objects made with different materials in the path of a beam of light and **predict** how objects with similar properties will affect the beam of light.	Concepts taught in K.P2U2.1 and light waves, prisms, mirrors, reflection, opaque, translucent, transparent, lenses, visible light color spectrum
1.P2U2.2	
Use models to provide evidence that vibrating matter creates sound and sound can make matter vibrate.	Concepts taught in K.P2U2.1 and sound waves, pitch, intensity, may also include discussions surrounding vocalization and hearing in humans and other animals
1.P3U1.3	
Plan and carry out investigations which demonstrate how equal forces can balance objects and how that unequal forces can push, pull, or twist objects, making them change their speed, direction, or shape.	Refer to standard
1.P4U3.4	
Design and evaluate solutions to increase or reduce heat from friction between two objects.	The evaluation of student-designed simple machines and evaluation of existing simple machines (tools, lubricants, rollers, friction)

Commented [LE3]: That lving

Commented [LE4]: to

Commented [LE5]: that

Commented [LE6]: that

Commented [LE7]: machines that

Earth and Space Sciences: Students develop an understanding that organisms depend on earth materials and other living organisms for survival.

Earth and Space Standards	Key concepts include but are not limited to:
1.E1U1.5	
Obtain, evaluate, and communicate information about the properties of earth materials.	Materials such as water, air, rocks, soils, sand

Commented [LE8]: These are not concepts, but a list of objects. What properties or concepts are students required to understand?

Life Sciences: Students develop an understanding that the Earth has supported, and continues to support, a large variety of organisms which can be distinguished by their physical characteristics, life cycles, and their different resource needs for survival. Different types of organisms live where there are different earth resources, such as food, air, and water.

Life Science Standards	Key concepts include but are not limited to:
1.L1U1.6	
Observe, describe, and predict life cycles of animals and plants.	Birth, growth, reproduction, death, metamorphosis
1.L2U2.7	
Develop and use models about how living things use resources to grow and survive; **design and evaluate** habitats for organisms using earth materials.	Concepts taught in K.L2U2.6 and environment, habitat types, nutrients, sunlight, soil, sand, air, rocks, water
1.L2U1.8	
Construct an explanation describing how organisms obtain resources from the environment including materials that are used again by other organisms.	Concepts taught in K.L1U1.5, K.L4U2.7 and cycles, introduction to obtaining resources through body systems; behaviors which limit system functions
1.L3U2.9	
Obtain, evaluate, and communicate information to support an evidence-based explanation that plants and animals produce offspring of the same kind, but offspring are generally not identical to each other or their parents.	Refer to standard
1.L4U2.10	
Develop a model to describe how animals and plants are classified into groups and subgroups according to their similarities.	Classification of invertebrates, vertebrates
1.L4U4.11	
Engage in argument from evidence to support a claim about the factors that cause organisms or entire species to go extinct and analyze how humans can positively or negatively impact those factors.	Refer to standard

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First Grade Connections to Other Academic Disciplines

Life Science Connections to the Arizona Health Standards for Grade Band Pre-K to 2

Strand 1: Comprehension of Health Promotion and Disease Prevention Concepts

- Concept 1: Understand relationship between health behaviors and health; PO 1 identify that healthy behaviors affect personal health and overall well-being
- Concept 2: Understanding multiple dimensions of health; PO 1 recognize what the human body is and what it means to be healthy
- Concept 3: Understanding personal health; PO 1 describe ways to prevent communicable diseases
- Concept 3: Understanding personal health; PO 2 identify that foods are classified into food groups and that a variety of food is needed for personal health, growth, and development
- Concept 5: Understanding use of health care; PO 1 describe why it is important to seek health care

Strand 5: Use of Decision-Making Skills to Enhance Health

- Concept 1: Influences on healthy decision making; PO 1 identify circumstances that can help or hinder healthy decision making

Strand 6: Use of Goal-Setting Skills to Enhance Health

- Concept 2: Health-related goal setting; PO 1 identify a short-term personal health goals and take action toward achieving the goal

Strand 7: Ability to Practice Health-Enhancing Behaviors

- Concept 2: Healthy practices and behaviors; PO 1 demonstrate healthy practices and behaviors to maintain or improve personal health
- Concept 2: Healthy practices and behaviors; PO 2 demonstrate behaviors that avoid or reduce health risks

Connection to the Arizona English Language Arts Standards for First Grade

- Use age-appropriate scientific texts and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards.

Connection to the Arizona Mathematics Standards for First Grade

- Standards for Mathematical Practice
  - Make sense of problems and persevere in solving them
  - Use appropriate tools strategically
  - Construct viable arguments and critique the reasoning of others
  - Attend to precision
  - Look for and make use of structure
  - Look for and express regularity in repeated reasoning
- Measurement and Data
  - Measure lengths indirectly and by iterating length units
  - Represent and interpret data
- Geometry
  - Reason with shapes and their attribute

See also Appendix 4

Second Grade: Focus on Energy and Matter; Systems and System Models

By the end of second grade, students understand the basic concept that energy can transform and is necessary for life. In this grade level, students begin constructing understanding of energy and matter, the formation of Earth's surface features, water cycles and energy flow, changing patterns in the sky, and the conditions necessary for life on Earth. Student investigations focus on collecting and making sense of observational data and simple measurements using the science and engineering practices: ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematics and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate, and communicate information. While individual lessons may include connections to any of the crosscutting concepts, the standards in second grade focus on helping students understand phenomena through energy and matter and systems and system models.

Physical Sciences: Students develop an understanding of observable properties of matter and how changes in energy (heating or cooling) can affect matter or materials.

Physical Science Standards	Key concepts include but are not limited to:
2.P1U2.1	
Plan and carry out an investigation to determine that matter has mass, takes up space, and is recognized by its observable properties; use the collected evidence to **develop and support an explanation**.	Physical properties such as, length, volume, texture, size, shape, color, temperature
2.P1U2.2	
Plan and carry out investigations to gather evidence to support an explanation on how heating or cooling can cause a transformation (solid, liquid, gas).	Refer to standard
2.P4U1.3	
Gather, reason, and communicate information about ways heat energy can cause change in objects or materials.	Refer to standard

Commented [LE10]: transform what? BE transformed from one form to another?

Commented [LE11]: Of what?

Commented [LE12]: How or that?

Commented [LE13]: phase

Earth and Space Sciences: Students develop an understanding of the distribution and role of water and wind in weather, shaping land, where organisms live, and changing environments. They learn that humans and other organisms can change environments. Students also develop an understanding of changing patterns in the sky, including the position of Sun, Moon, and stars, and the shape of the Moon.

Earth and Space Standards	Key concepts include but are not limited to:
2.E1U1.4	
Observe, describe, and predict how wind and water change the shape of the land resulting in a variety of landforms.	Erosion, physical properties of the land, formation of physical landforms
2.E1U2.5	
Develop and use models to represent that water can exist in different states and is found in oceans, glaciers, lakes, rivers, ponds, and the atmosphere (water cycle).	Refer to standard
2.E1U3.6	
Analyze patterns in weather conditions of various regions of the world and **design, test, and refine solutions** to protect humans from severe weather conditions.	Refer to standard and concepts first taught in K.E1U1.3, K.E1U1.4
2.E1U4.7	
Construct an argument from evidence regarding positive or negative changes in water and land systems that impact humans and the environment.	Recycle, reuse, pollution, litter, conserve, resources, composting, examples of use of resources may include farming, mining, logging, forest health
2.E2U1.8	
Analyze and interpret data to explain the Earth's position in relation to the Sun at different times during a twenty-four-hour period and changes in the apparent shape of the Moon from one night to another.	Rotation, revolution, axis, sunrise, sunset, sun is a star

Life Sciences: Students develop an understanding that life on Earth depends on the energy from the Sun or the energy from other organisms (food) to survive.

Life Science Standards	Key concepts include but are not limited to:
2.L2U1.9	
Obtain, analyze, and communicate evidence that organisms need a source of energy, air, water, and certain temperature conditions to survive.	Refer to standard and concepts taught in 1.L2U2.7
2.L2U1.10	
Construct a model representing how life on Earth depends on energy from the Sun and energy from other organisms.	Review of content taught in K.P2U2.1, K.L1U1.5 and habitats, food chain, food web, energy flow, producers, consumers, decomposers, the balance of nature

Commented [LE14]: that

Second Grade Connections to Other Academic Disciplines

Life Science Connections to the Arizona Health Standards for Grade Band Pre-K to 2

Strand 1: Comprehension of Health Promotion and Disease Prevention Concepts

- Concept 1: Understand relationship between health behaviors and health; PO 1 identify that healthy behaviors affect personal health and overall well-being
- Concept 3: Understanding personal health; PO 2 identify that foods are classified into food groups and that a variety of food is needed for personal health, growth, and development
- Concept 3: Understanding personal health; PO 3 identify that physical activity is integral to good health

Strand 6: Use of Goal-Setting Skills to Enhance Health

- Concept 2: Health-related goal setting; PO 1 identify a short-term personal health goals and take action toward achieving the goal

Strand 7: Ability to Practice Health-Enhancing Behaviors

- Concept 2: Healthy practices and behaviors; PO 1 demonstrate healthy practices and behaviors to maintain or improve personal health
- Concept 2: Healthy practices and behaviors; PO 2 demonstrate behaviors that avoid or reduce health risks

Connection to the Arizona English Language Arts Standards for Second Grade

- Use age-appropriate scientific texts and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards.

Connection to the Arizona Mathematics Standards for Second Grade

- Standards for Mathematical Practice
  - Make sense of problems and persevere in solving them
  - Use appropriate tools strategically
  - Construct viable arguments and critique the reasoning of others.
  - Attend to precision
  - Look for and make use of structure
  - Look for and express regularity in repeated reasoning
- Operations and Algebraic Thinking
  - Represent and solve problems involving addition and subtraction
- Number and Operations in Base Ten
  - Use place value understanding and properties of operations to add and subtract
- Measurement and Data
  - Represent and interpret data

See also Appendix 4

Distribution of K-2 Standards

	U1: Science's purpose is to find the cause or causes of phenomena in the natural world.	**U2**: Scientific explanations, theories, and models are those that best fit the evidence available at a particular time.	**U3**: The knowledge produced by science is used in engineering and technologies to create products.	**U4**: Applications of science often have both positive and negative ethical, social, economic, and political implications.
P1: All matter in the Universe is made of very small particles.		2.P1U2.1 2.P1U2.2		
P2: Objects can affect other objects at a distance.	1.P2U1.1	K.P2U2.1 1.P2U2.2	K.P2U3.2	
P3: Changing the movement of an object requires a net force to be acting on it.	1.P3U1.3			
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.	2.P4U1.3		1.P4U3.4	
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.E1U1.3 K.E1U1.4 1.E1U1.5 2.E1U1.4	2.E1U2.5	2.E1U3.6	2.E1U4.7
E2: The Earth and our Solar System are a very small part of one of many galaxies within the Universe.	2.E2U1.8			
L1: Organisms are organized on a cellular basis and have a finite life span.	K.L1U1.5 1.L1U1.6			
L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.	1.L2U1.8 2.L2U1.9 2.L2U1.10	K.L2U2.6 1.L2U2.7		
L3: Genetic information is passed down from one generation of organisms to another.		1.L3U2.9		
L4: The theory of evolution seeks to make clear the unity and diversity of living and extinct organisms.		K.L4U2.7 1.L4U2.10		1.L4U4.11

Grades 3-5 Science Standards

The Grades 3-5 Science Standards are designed to provide opportunities for students to develop understanding of all fourteen core ideas (see Appendix 3) across the 3-5 grade band. To provide opportunity for students to sufficiently demonstrate knowledge, understanding, and performance of each standard, not every core idea is included in every grade.

Within each grade, students engage in multiple science and engineering practices (formerly the scientific method) as they gather information to answer their questions or solve design problems, reason about how the data provide evidence to support their understanding, and then communicate their understanding of phenomena in physical, earth and space, and life science (knowing science). They apply their knowledge of core ideas to understand how scientists continue to build understanding of phenomena and see how people are impacted by natural phenomena or to construct technological solutions (using science). The crosscutting concepts support their understanding of patterns, cause and effect relationships, and systems thinking as students make sense of phenomena in the natural and designed worlds. These practices and crosscutting concepts help students develop transferable skills and understandings from one grade to the next and between content areas.

- In third grade, students use cause and effect relationships to understand how the Sun provides the primary source of energy for supporting life on Earth.
- In fourth grade, students apply systems thinking as they understand that Earth systems are impacted by different forms of energy.
- In fifth grade, students apply their understanding of scale at micro levels as they investigate changes in matter and at macro levels as they investigate patterns.

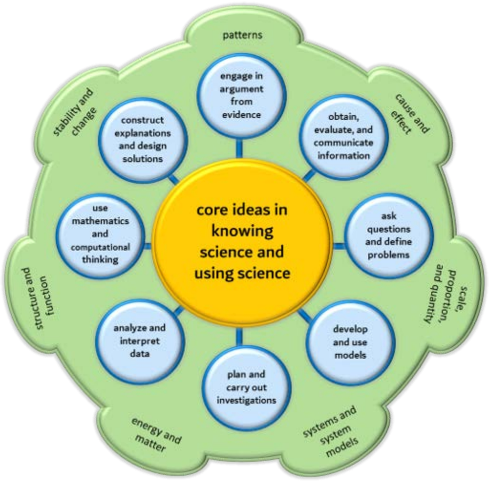

Figure 1: Three Dimensions of Science Instruction

The organization of the standards within this document does not indicate instructional sequence or importance. Decisions about curriculum and instruction are made locally by individual school districts and classroom teachers; these standards can be sequenced, combined, or integrated with other content areas to best meet the local curriculum or student needs (See Appendices 4 and 5). Suggestions for key concepts and connections to other content area standards are included to assist teachers when implementing the Science Standards and are not intended to be the minimum or maximum content limits.

Third Grade: Focus on Cause and Effect; Energy and Matter

By the end of third grade, students will gain understanding of how the Sun provides energy for life on Earth. In this grade level, students apply their understanding of light and sound waves; how they travel, are detected, and transfer energy. Students learn that organisms have different structures and functions which increase their chances of survival. Student investigations focus on collecting and making sense of observational data and simple measurements using the science and engineering practices: ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematics and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate, and communicate information. While individual lessons may include connections to any of the crosscutting concepts, the standards in third grade focus on helping students understand phenomena through cause and effect and energy and matter.

Physical Sciences: Students develop an understanding of the sources, properties, characteristics, and types of waves and how waves can transfer energy.

Physical Science Standards	Key concepts include but are not limited to:
3.P2U1.1	
Ask questions and investigate the relationship between light, lenses, and parts of the human eye.	Concepts taught in 1.P2U1.1 and characteristics such as speed and shadows
3.P2U2.2	
Collect data and construct arguments based on evidence to explain how sound waves affect objects at varying distances and parts of the human ear.	Concepts taught in 1.P2U1.2 and sounds travel through different mediums, vibrations, pitch, intensity
3.P4U1.3	
Construct an explanation of how light and sound waves transfer energy.	Refer to standard

Earth and Space Sciences: Students develop an understanding of how the Sun provides light and energy for the Earth.

Earth and Space Standards	Key concepts include but are not limited to:
3.E1U1.4	
Construct an explanation describing how the Sun is the primary source of energy for the Earth.	Refer to standard

Life Sciences: Students develop an understanding that light provides the source of energy for plants and plants provide the source of energy for animals. They also understand that plants and animals (including humans) have specialized internal and external structures and can respond to stimuli to increase survival.

Life Science Standards	Key concepts include but are not limited to:
3.L1U1.5	
Obtain, evaluate, and communicate how the human body has different systems that carry out life processes.	Review of content taught in 2.L2U1.10 and body systems of the muscular system, skeletal system, nervous system (see eye and ear in physical science; 3.P2U1.1 light and 3.P2U2.2 sound), the organization of cells, tissues, organs, organ systems
3.L1U2.6	
Develop and use models to explain that plants and animals have internal and external structures that serve various functions that aid in growth, survival, behavior, and reproduction.	Classification systems, herbivore, carnivore, omnivore
3.L2U2.7	
Plan and carry out investigations to demonstrate ways plants and animals react to stimuli.	Refer to standard
3.L2U1.8	
Use food chains as **system models** to describe the exchange of energy between the Sun, plants, and animals.	Concepts taught in 2.L2U1.10 and classification systems, producers, consumers herbivore, carnivore, omnivore
3.L2U3.9	
Design, test, and refine a solution to reduce damaging effects of sunlight on plants or animals.	Refer to standard

Commented [LE15]: Obtain, evaluate, and communicate evidence that

Third Grade Connections to Other Academic Disciplines

Life Science Connections to the Arizona Health Standards for Grade Band 3 to 5

Strand 1: Comprehension of Health Promotion and Disease Prevention Concepts

- Concept 1: Understand relationship between health behaviors and health; PO 1 identify that healthy behaviors affect personal health and overall well-being
- Concept 3: Understanding personal health; PO 2 describe the key nutrients contained in the food groups and how these nutrients affect heath and learning
- Concept 3: Understanding personal health; PO 3 describe how physical activity impacts health

Strand 6: Use of Goal-Setting Skills to Enhance Health

- Concept 2: Health-related goal setting; PO 1 set a personal health goal and track progress towards its achievement

Strand 7: Ability to Practice Health-Enhancing Behaviors

- Concept 2: Healthy practices and behaviors; PO 1 demonstrate a variety of healthy practices and behaviors to maintain or improve personal health
- Concept 2: Healthy practices and behaviors; PO 2 demonstrate a variety of behaviors that avoid or reduce health risks

Connection to the Arizona English Language Arts Standards for Third Grade

- Use age-appropriate scientific texts and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards.

Connection to the Arizona Mathematics Standards for Third Grade

- Standards for Mathematical Practice
  - Make sense of problems and persevere in solving them
  - Reason abstractly and quantitatively
  - Construct viable arguments and critique the reasoning of others
  - Use appropriate tools strategically
  - Attend to precision
  - Look for and make use of structure
  - Look for and express regularity in repeated reasoning
- Operations and Algebraic Thinking
  - Represent and solve problems involving addition and subtraction
- Number and Operations in Base Ten
  - Use place value understanding and properties of operations to preform multi-digit arithmetic
- Number and Operations – Fractions
  - Understand fractions as numbers
- Measurement and Data
  - Solve problems involving measurement
  - Represent and interpret data

See also Appendix 4

Fourth Grade: Systems and System Models; Stability and Change

By the end of fourth grade, students understand that Earth systems are impacted by different forms of energy. In this grade level, students expand their understanding of electricity and magnetism. Students also understand how weather, climate, human interactions, and geological systems change and shape the earth and the factors impacting organism diversity. Student investigations focus on collecting and making sense of observational data and simple measurements using the science and engineering practices: ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematics and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate, and communicate information. While individual lessons may include connections to any of the crosscutting concepts, the standards in fourth grade focus on helping students understand phenomena through systems and system models and stability and change.

Physical Sciences: Students develop an understanding of how Earth's resources can be transformed into different forms of energy. Students develop a better understanding of electricity and magnetism and how they are forms of energy.

Physical Science Standards	Key concepts include but are not limited to:
4.P4U2.1	
Develop and use a model to demonstrate how a system transfers energy from one object to another even when the objects are not touching.	Radiation, heat, sun energy
4.P4U2.2	
Develop and use a model that demonstrates how energy is moved from place to place through electric and magnetic currents.	Concepts taught in 1.P3U1.3 and magnet composition, magnetic: forces, poles, fields, attraction, static electricity, electric current, circuits, conductors, insulators, electromagnets, electrical charge (protons, electrons), safety
4.P4U4.3	
Construct an explanation and engage in argument from evidence on the use of renewable and nonrenewable resources to provide energy.	Refer to standard

Commented [LE16]: that

Earth and Space Sciences: Students develop an understanding of the different Earth systems and how they interact with each other. They understand how geological systems change and shape the Earth and the evidence that is used to understand these changes. They also understand how weather, climate, and human interactions can impact the environment.

Earth and Space Standards	Key concepts include but are not limited to:
4.E1U2.4	
Use models to explain seismic waves and their effect on the Earth.	Review of content taught in 3.P2U2.2, 3.P4U1.3 and earthquakes, crustal plates, seismograph, Richter scale, tsunamis, mountain formation (land form and oceanic)
4.E1U1.5	
Plan and carry out an investigation to explore the interactions between Earth's major systems.	Geosphere, hydrosphere, atmosphere (troposphere, stratosphere, mesosphere, thermosphere, exosphere), biosphere, Sun
4.E1U2.6	
Obtain, analyze, and communicate information to support an argument on whether the locations of fossils, rocks, mountain ranges, volcanos, deep ocean trenches, and ocean floor structures provide evidence of past plate movements.	Rocks (metamorphic, igneous, sedimentary), formation of fossil fuels, minerals
4.E1U2.7	
Develop and/or revise a model using various rock types and fossils to show evidence that Earth has changed over time.	Those listed in 4.E1U2.6 and crust, mantle, core, weather, erosion
4.E1U2.8	
Collect, analyze, and interpret data to explain weather and climate patterns.	Concepts taught in 2.E1U3.6 and weather, climate, fronts, forecasting, barometric pressure, cloud types
4.E1U4.9	
Construct and support an evidence-based argument about the impact of water's availability on life.	Concepts taught in 2.E1U2.5 and fresh water, salt water, precipitation, aquifers, water table, water pollution, oceans, streams, lakes, rivers, water shed, runoff
4.E1U3.10	
Identify the causes and effects of natural disasters, **define the problem(s),** and **design solution(s)** to minimize those effects on humans.	Refer to standard

Commented [LE17]:

Life Sciences: Students develop an understanding of the diversity of past and present organisms, factors impacting organism diversity, and evidence of change of organisms over time.

Life Science Standards	Key concepts include but are not limited to:
4.L4U2.11	
Analyze and interpret environmental **data** that demonstrate that species either adapt and survive or go extinct over time.	Fossil record, availability of water, adaptations, mutations, weather records
4.L4U4.12	
Engage in argument from evidence to support a claim about the factors that cause species to go extinct and how humans can impact those factors.	Refer to standard

Fourth Grade Connections to Other Academic Disciplines

Life Science Connections to the Arizona Health Standards for Grade Band 3 to 5

Strand 1: Comprehension of Health Promotion and Disease Prevention Concepts

- Concept 1: Understand relationship between health behaviors and health; PO 1 identify that healthy behaviors affect personal health and overall well-being

Strand 6: Use of Goal-Setting Skills to Enhance Health

- Concept 2: Health-related goal setting; PO 1 set a personal health goal and track progress towards its achievement

Strand 7: Ability to Practice Health-Enhancing Behaviors

- Concept 2: Healthy practices and behaviors; PO 1 demonstrate a variety of healthy practices and behaviors to maintain or improve personal health
- Concept 2: Healthy practices and behaviors; PO 2 demonstrate a variety of behaviors that avoid or reduce health risks

Connection to the Arizona English Language Arts Standards for Fourth Grade

- Use age-appropriate scientific texts and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards.

Connection to the Arizona Mathematics Standards for Fourth Grade

- Standards for Mathematical Practice
  - Make sense of problems and persevere in solving them
  - Construct viable arguments and critique the reasoning of others
  - Use appropriate tools strategically
  - Attend to precision
  - Look for and make use of structure
  - Look for and express regularity in repeated reasoning
- Operations and Algebraic Thinking
  - Generate and analyze patterns
- Number and Operations in Base Ten
  - Use place value understanding and properties of operations to preform multi-digit arithmetic
- Number and Operations – Fractions
  - Understand decimal notation for fractions and compare decimal fractions
- Measurement and Data
  - Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit
  - Represent and interpret data

See also Appendix 4

Fifth Grade: Scale, Proportion, and Quantity; Patterns

By the end of fifth grade, students apply their understanding of scale at macro (time and space) and micro (particles of matter) levels to understand patterns and scale across life, earth and space, and physical sciences. In this grade level, students will develop a basic understanding of conservation of matter, forces, patterns of Sun, moon, and starts, and genetic inheritance. Student investigations focus on collecting and making sense of observational data and measurements using the science and engineering practices: ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematics and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate, and communicate information. While individual lessons may include connections to any of the crosscutting concepts, the standards in fifth grade focus on helping students understand phenomena through scale, proportion and quantity and patterns.

Commented [LE18]: stars

Physical Sciences: Students develop an understanding that changes can occur to matter/objects on Earth or in space, but both energy and matter are conserved during those changes.

Physical Science Standards	Key concepts include but are not limited to:
5.P1U1.1	
Analyze and interpret data to explain that matter of any type can be subdivided into particles too small to see (atom) and, in a closed system, if properties change or reactions occur, the amount of matter stays the same.	Mass, volume, density, atomic structure, elements, introduction to periodic table
5.P1U1.2	
Plan and carry out investigations to demonstrate that some substances combine to form new substances with different properties and others can be mixed without taking on new properties.	Solutions, suspensions, mixtures, molecules, compounds, chemical change, reactions, physical change
5.P2U1.3	
Construct an explanation using evidence to demonstrate that objects can affect other objects even when they are not touching.	Concepts taught in 4.P4U2.2 and chemical bonds, forces (such as gravity)
5.P3U1.4	
Obtain, analyze, and communicate evidence of the effects that balanced and unbalanced forces have on the motion of objects.	Gravity, magnetic forces, normal force, potential energy, friction, velocity, kinetic energy, magnitude, direction of force, momentum
5.P3U3.5	
Apply scientific ideas to de**fine problems** and **design solutions** pertaining to force and motion.	Application of key concepts outlined in 5.P3U1.4

Commented [LE19]: What data can 5th graders be provided with to allow them to come up with the concept of the atom?

Physical Science Standards	Key concepts include but are not limited to:
5.P4U1.6	
Analyze and interpret data to determine whether energy is present and can be transferred whenever there are moving objects.	Patterns related to the transfer of energy

Earth and Space Sciences: Students develop an understanding of the how forces (gravity) in space cause observable patterns due to the position of the Earth, Sun, Moon, and stars.

Earth and Space Standards	Key concepts include but are not limited to:
5.E2U1.7	
Develop and use models based on evidence to construct explanations about the movement of the Earth and Moon within our Solar System.	Sun, planets, orbit, rotation, sunrise, sunset, lunar/solar eclipse
5.E2U2.8	
Obtain, analyze, and communicate evidence to support an explanation that the gravitational force of Earth on objects is directed down (towards the center of the spherical Earth).	Refer to standard

Life Sciences: Students develop an understanding of patterns and how genetic information is passed from generation to generation. They also develop the understanding of how genetic information and environmental features impact the survival of an organism.

Life Science Standards	Key concepts include but are not limited to:
5.L3U1.9	
Obtain, evaluate, and communicate information about patterns between the offspring of plants and animals (including humans) and construct an explanation on how genetic information is passed from one generation to the next.	Concepts taught in 1.L1U1.6 and life cycles, reproduction, traits, characteristics
5.L3U2.10	
Construct an explanation based on evidence that changes in an environment can affect the development of the traits in a population of organisms.	Concepts taught in 4.L4U2.11 and adaptations, mutations, environmental fitness
5.L4U4.11	
Obtain, evaluate, and communicate evidence about how natural and human caused changes to habitats or climate can impact populations.	Natural disasters, drought, selective breeding, pollution

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Commented [LE21]: What information and patterns will allow students to explain HOW genetic information is transmitted from one generation to the next?

Fifth Grade Connections to Other Academic Disciplines

Life Science Connections to the Arizona Health Standards for Grade Band 3 to 5

Strand 1: Comprehension of Health Promotion and Disease Prevention Concepts

- Concept 1: Understand relationship between health behaviors and health; PO 1 identify that healthy behaviors affect personal health and overall well-being

Strand 6: Use of Goal-Setting Skills to Enhance Health

- Concept 2: Health-related goal setting; PO 1 set a personal health goal and track progress towards its achievement

Strand 7: Ability to Practice Health-Enhancing Behaviors

- Concept 2: Healthy practices and behaviors; PO 1 demonstrate a variety of healthy practices and behaviors to maintain or improve personal health
- Concept 2: Healthy practices and behaviors; PO 2 demonstrate a variety of behaviors that avoid or reduce health risks

Connection to the Arizona English Language Arts Standards for Fifth Grade

- Use age-appropriate scientific texts and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards.

Connection to the Arizona Mathematics Standards for Fifth Grade

- Standards for Mathematical Practice
  - Make sense of problems and persevere in solving them
  - Reason abstractly and quantitatively
  - Construct viable arguments and critique the reasoning of others
  - Model with mathematics
  - Use appropriate tools strategically
  - Attend to precision
  - Look for and make use of structure
  - Look for and express regularity in repeated reasoning
- Operations and Algebraic Thinking
  - Write and interpret numerical expressions
  - Analyze patterns and relationships
- Measurement and Data
  - Convert like measurement units within a given measurement system
  - Represent and interpret data
  - Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit
  - Geometric measurement; understand concepts of volume and relate volume to multiplication and division

See also Appendix 4

Distribution of Grades 3-5 Standards

	U1: Science's purpose is to find the cause or causes of phenomena in the natural world.	**U2**: Scientific explanations, theories, and models are those that best fit the evidence available at a particular time.	**U3**: The knowledge produced by science is used in engineering and technologies to create products.	**U4**: Applications of science often have both positive and negative ethical, social, economic, and political implications.
P1: All matter in the Universe is made of very small particles.	5.P1U1.1 5.P1U1.2			
P2: Objects can affect other objects at a distance.	3.P2U1.1 5.P2U1.3	3.P2U2.2 4.P2U2.1		
P3: Changing the movement of an object requires a net force to be acting on it.	5.P3U1.4		5.P3U3.5	
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.	3.P4U1.3 5.P4U1.6	4.P4U2.2		4.P4U4.3
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.	3.E1U1.4 4.E1U1.5	4.E1U2.4 4.E1U2.6 4.E1U2.7 4.E1U2.8	4.E1U3.10	4.E1U4.9
E2: The Earth and our Solar System are a very small part of one of many galaxies within the Universe.	5.E2U1.7	5.E2U2.8		
L1: Organisms are organized on a cellular basis and have a finite life span.	3.L1U1.5	3.L1U2.6		
L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.	3.L2U1.8	3.L2U2.7	3.L2U3.9	
L3: Genetic information is passed down from one generation of organisms to another.	5.L3U1.9	5.L3U2.10		
L4: The theory of evolution seeks to make clear the unity and diversity of living and extinct organisms.		4.L4U2.11		4.L4U4.12 5.L4U4.11

Grades 6-8 Science Standards

The Grades 6-8 Science Standards are designed to provide opportunities for students to develop understanding of all fourteen core ideas (see Appendix 3) across the 6-8 grade band. To provide opportunity for students to sufficiently demonstrate knowledge, understanding, and performance of each standard, not every core idea is included in every grade.

Within each grade, students engage in multiple science and engineering practices (formerly the scientific method) as they gather information to answer their questions or solve design problems, reason about how the data provide evidence to support their understanding, and then communicate their understanding of phenomena in physical, earth and space, and life science (knowing science). They apply their knowledge of core ideas to understand how scientists continue to build understanding of phenomena and see how people are impacted by natural phenomena or to construct technological solutions (using science). The crosscutting concepts support their understanding of patterns, cause and effect relationships, and systems thinking as students make sense of phenomena in the natural and designed worlds. These practices and crosscutting concepts help students develop transferable skills and understandings from one grade to the next.

- In sixth grade, students apply their understanding of structure and function and scale, from the very small scales in atoms, molecules, and cells to the very large scale of the Solar System.
- In seventh grade, students will explore how forces cause changes in motion and how energy is transferred in geologic, atmospheric, and environmental processes.
- In eighth grade, students will describe how the constant interaction of stability and change and the process of cause and effect influence the natural world.

The organization of the standards within this document does not indicate instructional sequence or importance. Decisions about curriculum and instruction are made locally by individual school districts and classroom teachers; these standards can be sequenced, combined, or integrated with other content areas to best meet the local curriculum or student needs (See Appendices 4 and 5). Suggestions for key concepts and connections to other content area standards are included to assist teachers when implementing the Science Standards and are not intended to be the minimum or maximum content limits.

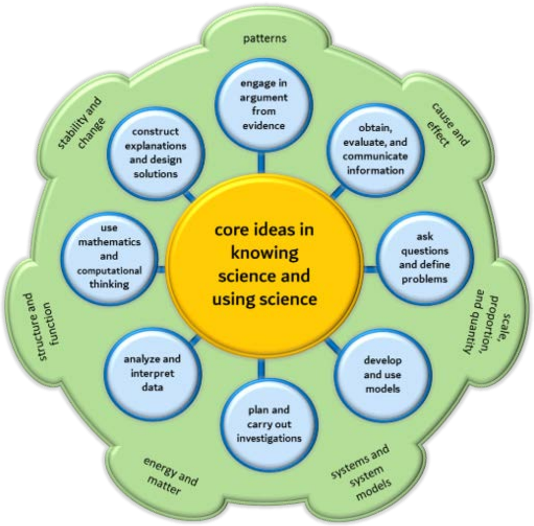

Figure 1: Three Dimensions of Science Instruction

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

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

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

Physical Science Standards	Key concepts include but are not limited to:
6.P1U1.1	
Analyze and interpret data to show how changes in states of matter are caused by different rates of movement of atoms in solids, liquids, and gases (Kinetic Theory).	Buoyancy, density, physical changes, energy transfer
6.P1U1.2	
Plan and carry out an investigation to demonstrate how variations in temperature and/or pressure affect changes in state of matter.	Refer to standard
6.P1U2.3	
Develop and use models to demonstrate that matter is made up of smaller particles called atoms.	Concepts taught in 5.P1U1.1 and Bohr model, John Dalton, atom structure
6.P3U2.4	
Plan and carry out an investigation that can support an evidence-based explanation of how objects on Earth are affected by gravitational forces.	Concepts taught in 5.P2U1.3, 5.P3U1.4, 5.P3U3.5, 5.E2U2.8 and non-algebraic mathematics and computational thinking of Newton's law of universal gravitation, force, gravity Grade level connection to 6.E1U1.7, 6E1U2.11
6.P4U3.5	
Analyze how humans use technology to store (potential) and/or use (kinetic) energy.	Refer to standard

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

Earth and Space Standards	Key concepts include but are not limited to:
6.E1U1.6	
Investigate and construct an explanation demonstrating how radiation from the Sun provides energy and is absorbed to warm the Earth's surface and atmosphere.	Extension of those taught in 4.P4U2.1, 4.E1U1.5
6.E2U1.7	
Evaluate how gravitational forces affect the motion of objects in our Solar System.	Stars, galaxies, plants in orbit
6.E2U1.8	
Use ratios and proportions to **analyze and interpret data** related to scale, properties, and relationships among objects in our Solar System.	Gravity on moon vs Earth, planetary distances, grade level connection: 6.P3U2.4
6.E2U2.9	
Develop and use models to explain how constellations and other night sky patterns appear to move due to Earth's rotation and revolution.	Grade level connection: 6.P3U2.4
6.E2U3.10	
Construct an explanation from evidence that correlates patterns in the night sky to human navigation and agricultural practices.	Refer to standard
6.E2U2.11	
Develop and use models to construct an explanation of how eclipses, moon phases, and tides occur within the Sun-Earth-Moon system.	Concepts taught in 4.E1U2.4 and gravitational forces, orbit around the Sun, oceanic currents, grade level connection: 6.P3U2.4
6.E2U1.12	
Use a model to show how the tilt of Earth's axis causes variations in the length of the day and gives rise to seasons.	Refer to standard

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Life Sciences: Students develop an understanding of purposes of internal cell structures and their roles in life processes.

Life Science Standards	Key concepts include but are not limited to:
6.L1U2.13	
Carry out an investigation to provide evidence that all living things are made of cells, cells come from existing cells, and cells are the basic structural and functional unit of all living things.	Refer to standard
6.L1U1.14	
Develop and use a model to explain the organizational levels of structures in multicellular organisms consisting of organ systems, organs, tissues, and cells.	Concepts taught in 3.L1U1.5 and how the body is a system of interacting subsystems composed of groups of cells and the normal functioning of those systems (plant and animal)
6.L1U2.15	
Construct an explanation to demonstrate the relationship between major cell structures and cell functions (plant and animal).	Application of key concepts outlined in grade level connection to 6.L1U1.14
6.L2U1.16	
Construct an explanation for how some cells use light energy through the process of photosynthesis.	Refer to standard

Sixth Grade Connections to Other Academic Disciplines

Life Science Connections to the Arizona Health Standards for Grade Band 6 to 8

Strand 1: Comprehension of Health Promotion and Disease Prevention Concepts

- Concept 1: Understand relationship between health behaviors and health; PO 1 analyze the relationship between healthy behaviors and personal health
- Concept 3: Understanding personal health; PO 2 analyze how food provides energy and nutrients for growth and development, that nutrition requirements vary from person to person, and how food intake affects heath

Strand 6: Use of Goal-Setting Skills to Enhance Health

- Concept 2: Health-related goal setting; PO 1 develop a goal to adopt, maintain, or improve a personal health practice

Strand 7: Ability to Practice Health-Enhancing Behaviors

- Concept 2: Healthy practices and behaviors; PO 1 demonstrate healthy practices and behaviors that will maintain or improve the health of self and others
- Concept 2: Healthy practices and behaviors; PO 2 demonstrate behaviors that avoid or reduce health risks to self and others

Connection to the Arizona English Language Arts Standards for Sixth Grade

- Use age-appropriate scientific texts and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards.

Connection to the Arizona Mathematics Standards for Sixth Grade

- Standards for Mathematical Practice
  - Make sense of problems and persevere in solving them
  - Reason abstractly and quantitatively
  - Construct viable arguments and critique the reasoning of others
  - Model with mathematics
  - Use appropriate tools strategically
  - Attend to precision
  - Look for and make use of structure
  - Look for and express regularity in repeated reasoning
- Ratios and Proportional Relationships
  - Understand ratio concepts and use ratio reasoning to solve problems
- Expressions and Equations
  - Represent and analyze quantitative relationships between dependent and independent variable
- Geometry
  - Solve mathematical problems and problems in real-world context involving area, surface area, and volume

See also Appendix 4

Seventh Grade: Focus on Patterns; Cause and Effect; Structure and Function

By the end of seventh grade, students will explore how forces cause changes in motion and how energy is transferred in geologic, atmospheric, and environmental processes. In this grade level, students investigate forces and motion in a wide variety of systems, model how heat energy drives cycles in weather and climate, and explain how ecosystems maintain structure and stability. Student investigations focus on collecting and making sense of observational data and measurements using the science and engineering practices: ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematics and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate, and communicate information. While individual lessons may include connections to any of the crosscutting concepts, the standards in seventh grade focus on helping students understand phenomena though patterns, cause and effect, and structure and function.

Physical Sciences: Students will explore how forces and motion take place within and between a wide variety of systems, from forces on individual objects to the forces that shape our Earth.

Physical Science Standards	Key concepts include but are not limited to:
7.P2U1.1	
Collect and analyze data demonstrating how electric and magnetic forces can be attractive or repulsive and can vary in strength.	Concepts taught in 4.P4U2.2 and magnitude of charge, electromagnet, current, magnetic strength, quantitative data
7.P2U2.2	
Develop and use a model to predict how forces act on objects at a distance.	Concepts taught in 6.E2U2.11 and electric, magnetic, gravitational
7.P3U2.3	
Use non-algebraic **mathematics and computational thinking** to explain Newton's laws of motion.	Concepts taught in 6.P1U1.1, 6.P4U3.5 and inertia, balanced and unbalanced forces, action/reaction pairs, proportionate relationship between force, mass and acceleration

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Earth and Space Sciences: Students develop an understanding of the role of heat energy in warming the Earth and driving cycles in weather and climate.

Earth and Space Standards	Key concepts include but are not limited to:
7.E1U2.4	
Construct a model that shows the cycling of matter and flow of energy in the atmosphere, hydrosphere, and geosphere.	Concepts taught in 6.E1U1.6 and hydrologic cycle (transportation, evaporation, condensation, crystallization, precipitation, percolation), interconnecting oceanic currents, atmospheric flow patterns, carbon cycle, geochemical cycles
7.E1U2.5	
Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.	Concepts taught in 4.E1U2.6, 4.E1U2.7, 4.L4U2.11 and similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), plate tectonics, the locations of ocean structures (such as ridges, fracture zones, and trenches)
7.E1U3.6	
Construct an explanation for how the technology scientists use to predict weather and to explore Earth has evolved over time.	Refer to standard

Life Sciences: Students develop an understanding of how energy from the Sun is transferred through ecosystems and how organisms' internal structures and processes maintain homeostasis.

Life Science Standards	Key concepts include but are not limited to:
7.L1U1.7	
Explain how organisms maintain internal stability and evaluate the effect of the external factors on organisms' internal stability.	Homeostasis, equilibrium, regulation, feedback loops, disruptions to homeostasis
7.L1U3.8	
Obtain and evaluate information about devices developed to help humans maintain homeostasis.	Refer to standard
7.L2U2.9	
Develop and use models to demonstrate the interdependence of organisms and their environment including biotic and abiotic factors.	Concepts taught in 2.L2U1.10 and biotic, abiotic, mutualism, symbiotic relationships, types of environments (freshwater, oceanic, forest, desert, grassland, tundra, mountain, etc.), succession, population growth
7.L2U2.10	
Construct an explanation of how organisms use energy sources in ecosystems.	Concepts taught in 3.L2U1.8 and energy flow, producers, primary consumers, secondary consumers, tertiary consumers, Sun
7.L2U4.11	
Use evidence to **construct an argument** regarding the impact of human activities on the environment and how they positively and negatively affect the competition for energy and resources in ecosystems.	Refer to standard

Seventh Grade Connections to Other Academic Disciplines

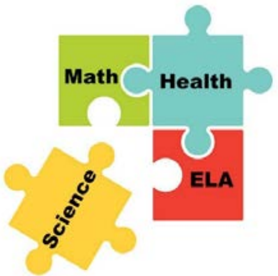
<u>Life Science Connections to the Arizona Health Standards for Grade Band 6 to 8</u>
Strand 1: Comprehension of Health Promotion and Disease Prevention Concepts
- Concept 1: Understand relationship between health behaviors and health; PO 1 analyze the relationship between healthy behaviors and personal health
- Concept 3: Understanding personal health; PO 2 analyze how food provides energy and nutrients for growth and development, that nutrition requirements vary from person to person, and how food intake affects heath

Strand 6: Use of Goal-Setting Skills to Enhance Health
- Concept 2: Health-related goal setting; PO 1 develop a goal to adopt, maintain, or improve a personal health practice

Strand 7: Ability to Practice Health-Enhancing Behaviors
- Concept 2: Healthy practices and behaviors; PO 1 demonstrate healthy practices and behaviors that will maintain or improve the health of self and others
- Concept 2: Healthy practices and behaviors; PO 2 demonstrate behaviors that avoid or reduce health risks to self and others

<u>Connection to the Arizona English Language Arts Standards for Seventh Grade</u>
- Use age-appropriate scientific texts and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards.

<u>Connection to the Arizona Mathematics Standards for Seventh Grade</u>
- Standards for Mathematical Practice
  - Make sense of problems and persevere in solving them
  - Reason abstractly and quantitatively
  - Construct viable arguments and critique the reasoning of others
  - Model with mathematics
  - Use appropriate tools strategically
  - Attend to precision
  - Look for and make use of structure
  - Look for and express regularity in repeated reasoning
- Statistics and Probability
  - Use random sampling to draw inferences about a population
  - Draw informal comparative inferences about two populations
  - Investigate chance processes and develop, use, and evaluate probability models



See also <u>Appendix 4</u>

Eighth Grade: Focus on Cause and Effect; Stability and Change; Energy and Matter

By the end of eighth grade, students will describe how the constant interaction of stability and change and the process of cause and effect influence changes in the natural world. In this grade level, students will apply energy principles to chemical reactions, explore changes within Earth and understand how genetic information is passed down to produce variation among the populations. Student investigations focus on collecting and making sense of observational data and measurements using the science and engineering practices: ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematics and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate, and communicate information. While individual lessons may include connections to any of the crosscutting concepts, the standards in eighth grade focus on helping students understand phenomena through cause and effect, stability and change, and energy and matter.

Physical Sciences: Students explore chemical properties of matter and chemical reactions to further understand energy and matter.

Physical Science Standards	Key concepts include but are not limited to:
8.P1U2.1	
Develop and use a model to demonstrate how atoms and molecules can be combined or rearranged in chemical reactions to form new compounds with the total number of each type of atom conserved.	Concepts introduced in 6.P1U1.1, and 6.P1U2.3 and covalent bond, ionic bond, chemical formulas, types of reactions
8.P1U3.2	
Obtain and evaluate information regarding how scientists use technology to identify substances based on unique physical and chemical properties.	Refer to standard
8.P4U1.3	
Construct an explanation on how energy can be transferred from one energy store to another.	Energy (motion, heat, light, sound), types of energy transfer (conduction, convection, radiation), types of energy stores (chemical, nuclear, gravitational, mechanical), renewable and nonrenewable power types (biomass, electrical, wind, water, geothermal, solar)
8.P4U1.4	
Evaluate how energy affects wave characteristics and interactions **using mathematical models**.	Concepts taught in 7.E1U2.4 and wavelength, amplitude, speed, frequency
8.P4U3.5	
Develop a solution to increase efficiency when transferring energy from one source to another.	Refer to standard

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Earth and Space Sciences: Students explore natural and human-induced changes in Earth systems over time.

Earth and Space Standards	Key concepts include but are not limited to:
8.E1U1.6	
Develop and use a model of Earth's geological column to **communicate** relative ages of rock layers and fossils.	Concepts taught in 7.E1U2.5 and paleontology, geologic time (eras), radioactive (radiometric) dating, strata
8.E1U3.7	
Obtain, evaluate, and communicate information about technologies that use data and historical patterns to predict natural hazards.	Fractals, mathematical modeling, seismology
8.E1U4.8	
Construct and support an argument about how human consumption of limited resources impacts the geosphere.	Refer to standard

Commented [LE27]: Develop and use a model of a stratigraphic column, the use of fossils in biostratigraphy and geologic cross sections to communicate the Law of Superposition and the relative ages of rock layers.

Life Sciences: Students develop an understanding of patterns and how genetic information is passed from generation to generation. They also develop the understanding of how traits within populations change over time.

Life Science Standards	Key concepts include but are not limited to:
8.L3U1.9	
Explain how the transfer of genetic information from each parent produces variation in offspring.	Concepts taught in 5.L3U1.9 and stress on the impact of gene transmission vs the mechanism, chromosomes which determine gender at conception (XX, XY), cell division, chromosomes, genes, meiosis, mitosis, growth, reproduction (sexual, asexual), acquired vs inherited traits, Mendelian genetics, deoxyribonucleic acid (DNA), DNA structure
8.L3U4.10	
Communicate how advancements in technology have furthered the field of genetic research and **use evidence to support an argument** about whether or not genetic research has improved human lives.	Genetic engineering, selective breeding, genomics
8.L4U2.11	
Develop and use a model to explain how natural selection may lead to increases and decreases of specific traits in populations over time.	Probability, statistics, modeling Hardy Weinberg equilibrium calculations are not introduced until high school

Commented [LE28]: HOW depends on the concept of mutations.

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Life Science Standards	Key concepts include but are not limited to:
8.L4U2.12	
Gather and communicate evidence on the processes by which a species may change over time in response to environmental conditions.	Concepts taught in 5.L3U2.10 and extinction, speciation, population change, adaptation, mutation, process of natural selection, limited resources, genetic drift, mate selection, X-linked

Eighth Grade Connections to Other Academic Disciplines

Life Science Connections to the Arizona Health Standards for Grade Band 6 to 8

Strand 1: Comprehension of Health Promotion and Disease Prevention Concepts

- Concept 1: Understand relationship between health behaviors and health; PO 1 analyze the relationship between healthy behaviors and personal health
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Connection to the Arizona English Language Arts Standards for Eighth Grade

- Use age-appropriate scientific texts and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards.

Connection to the Arizona Mathematics Standards for Eighth Grade

- Standards for Mathematical Practice
  - Make sense of problems and persevere in solving them
  - Reason abstractly and quantitatively
  - Construct viable arguments and critique the reasoning of others
  - Model with mathematics
  - Use appropriate tools strategically
  - Attend to precision
  - Look for and make use of structure
  - Look for and express regularity in repeated reasoning
- Expressions and Equations
  - Understand the connections between proportional relationships, lines, and linear equations
- Functions
  - Use functions to model relationships between quantities
- Statistics and Probability
  - Investigate patterns of association in bivariate data
  - Investigate chance processes and develop, use, and evaluate probability models

See also Appendix 4

Distribution of the Grades 6-8 Standards

	U1: Science's purpose is to find the cause or causes of phenomena in the natural world.	**U2**: Scientific explanations, theories, and models are those that best fit the evidence available at a particular time.	**U3**: The knowledge produced by science is used in engineering and technologies to create products.	**U4**: Applications of science often have both positive and negative ethical, social, economic, and political implications.
P1: All matter in the Universe is made of very small particles.	6.P1U1.1 6.P1U1.2	6.P1U2.3 8.P1U2.1	8.P1U3.2	
P2: Objects can affect other objects at a distance.	7.P2U1.1	7.P2U2.2		
P3: Changing the movement of an object requires a net force to be acting on it.		6.P3U2.4 7.P3U2.3		
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.	8.P4U1.3 8.P4U1.4		6.P4U3.5 8.P4U3.5	
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.	6.E1U1.6 8.E1U1.6	7.E1U2.4 7.E1U2.5	7.E1U3.6 8.E1U3.7	8.E1U4.8
E2: The Earth and our Solar System are a very small part of one of many galaxies within the Universe.	6.E2U1.7 6.E2U1.8 6.E2U1.12	6.E2U2.9 6.E2U2.11	6.E2U3.10	
L1: Organisms are organized on a cellular basis and have a finite life span.	6.L1U1.14 7.L1U1.7	6.L1U2.13 6.L1U2.15	7.L1U3.8	
L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.	6.L2U1.16	7.L2U2.9 7.L2U2.10		7.L2U4.11
L3: Genetic information is passed down from one generation of organisms to another.	8.L3U1.9			8.L3U4.10
L4: The theory of evolution seeks to make clear the unity and diversity of living and extinct organisms.		8.L4U2.11 8.L4U2.12		

High School Science Standards

In Arizona, students are required to take 3 credits of high school science to meet graduation requirements, but there is no mandatory course sequence across the state. Because of this, the high school standards are written at two levels: essential and plus.

- All high school essential standards (HS) should be learned by every high school student regardless of the 3-credit course sequence they take. The full set of high school (HS) essential standards should be taught over that 3-year period. Essential High School Science Standards are designed to provide opportunities for students to develop understanding of all 14 core ideas (see page 4) across three credits of high school science.
- The High School Plus (HS+) standards are designed to enhance the rigor of general science courses by extending the essential standards within chemistry (HS+C), physics (HS+Phy), earth and space sciences (HS+E), or biology (HS+B) to prepare students for entry level college courses.

Figure 1: Three Dimensions of Science Instruction

Throughout grades K through 8, students are engaged in multiple science and engineering practices, formerly the scientific method, as they gather information to answer their questions or solve design problems, reason about how the data provide evidence to support their understanding, and then communicate their understanding of phenomena in physical, earth and space, and life science (knowing science). The High School standards continue this pattern, and educators should seek ways to integrate the science and engineering practices as students apply their knowledge of core ideas to understand how scientists continue to build understanding of phenomena and see how people are impacted by natural phenomena or to construct solutions (using science). The crosscutting concepts support their understanding of patterns, cause and effect relationships, and systems thinking as students make sense of phenomena in the natural and designed worlds. In all disciplines, educators should incorporate scientific measurement skills appropriate to that discipline such as the international system of units, scientific notation, conversion factors, and significant figures.

The organization of the standards within this document does not indicate instructional sequence or importance. Decisions about curriculum and instruction are made locally by individual school districts and classroom teachers; these standards can be sequenced, combined, or integrated with other content areas to best meet the local curriculum or student needs (See Appendices 4 and 5). Suggestions for key concepts and connections to other content area standards are included to assist teachers when implementing the Science Standards and are not intended to be the minimum or maximum content limits.

High School Physical Sciences

Physical science encompasses physical and chemical subprocesses that occur within systems. At the high school level, students gain an understanding of these processes at both the micro and macro levels through the intensive study of matter, energy, and forces.[4] Students are expected to apply these concepts to real-world phenomena to gain a deeper understanding of both natural and human-made processes. The essential standards are those that every high school student is expected to know and understand. Plus standards in chemistry and physics are designed to extend the concepts learned in the essential standards to prepare students for entry level college courses.

Note:

- The standard number is designed for recording purposes and does not imply instructional sequence or importance.
- In all disciplines, educators should incorporate scientific measurement skills appropriate to that discipline.

Discipline Area	**Physical Science Essential Standards** HS Essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Physical Science Plus (+) Standards** HS+ Standards are designed for students taking a high school chemistry (C) or physics (Phy) course.	**Key Concepts may include those listed in the essential standards and:**
Chemistry	**HS.P1U2.1** Use the structure of atoms and their properties to explain patterns in the Periodic Table and describe how these models are revised with new evidence. Connections: 6.P1U2.3, HS.E2U1.15, HS.L2U1.25	Atomic structure, periodic table, Periodic Law, periodic properties, atomic mass, atomic number, isotopes	**HS+C.P1U1.1** Use the quantum mechanical model to explain how valence electrons can be used to predict properties and behaviors of elements and compounds.	Quantum model vs Bohr model, electron configurations, quantum theory, uncertainty principle, 4 quantum numbers
			HS+C.P1U3.2 Engage in argument, from evidence, to explain how changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay have been used to positively and negatively serve human ends. Connection: 8.E1U1.6, HS.E1U2.13	Nuclear processes, fission, fusion, radioactive decay, neutrino, nuclear reactors, binding energy, Relativistic energy, activation energy
			HS+C.P1U2.3 Use a historical model of the atom to evaluate qualitatively the evidence supporting claims about how atoms absorb and emit energy in the form of electromagnetic radiation.	Electromagnetic spectrum, energy states, atom theory models and discoveries
			HS+C.P1U1.4 Use mathematical representation to determine stoichiometric relationships in all phases of matter in chemical reactions.	Stoichiometry, linear equations, mass to mass conversions, mole theory, dimensional analysis, volume/particle conversions, Avogadro's number

Discipline Area	**Physical Science Essential Standards** HS Essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Physical Science Plus (+) Standards** HS+ Standards are designed for students taking a high school chemistry (C) or physics (Phy) course.	**Key Concepts may include those listed in the essential standards and:**
Chemistry	**HS.P1U1.2** Describe patterns in the transfer or sharing of electrons to predict the formation of ions, molecules, and compounds in both natural and synthetic processes. Connections: 5.P1U1.2, 8.P1U1.2, HS.E2U1.15, HS.L2U1.25	Reactants, products, cations, anions, bond types, valence levels, conservation of matter (atoms), conservation of energy, equilibrium, entropy, solution, mixture, solubility	**HS+C.P1U2.5** Develop and use models to predict and explain forces within and between molecules.	Bond energy, intermolecular forces, differences between states of matter
			HS+C.P1U2.6 Develop and use models to explain the differences between chemical compounds using patterns as a method for identification.	Covalent compounds, ionic compounds, metallic compounds
Chemistry	**HS.P1U4.3** Engage in argument from evidence about how the use of chemical reactions has positive and negative ethical, social, economic, and/or political implications.	Both historical and current examples are appropriate for this standard	**HS+C.P1U1.7** Plan and conduct investigations to test predictions of the outcomes of chemical reactions, based on patterns of chemical properties. Connection: HS.P1U2.1	Types of reactions, molecular structure, polyatomic ions, solubility, activity series, valence shell election pair repulsion (VSEPR) model
			HS+C.P1U4.8 Construct an explanation, design a solution, or refine the design of a chemical system in equilibrium to maximize production.	Le Chatelier's Principle, dynamic equilibrium, oxidation/reduction, hydrolysis, activation energy

Discipline Area	**Physical Science Essential Standards** HS Essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Physical Science Plus (+) Standards** HS+ Standards are designed for students taking a high school chemistry (C) or physics (Phy) course.	**Key Concepts may include those listed in the essential standards and:**
Chemistry	**HS.P1U1.4** Plan and carry out investigations to explore the cause and effect relationship between reaction rate factors. Connections: 8.P1U2.1, HS.E2U1.15	Reactants, temperature, concentration, surface area, physical state, solvent, catalyst	**HS+C.P1U1.9** Plan and conduct investigations to gather evidence of the relationships between kinetic molecular theory and gas laws.	Kinetic molecular theory, Amontons' Law, Boyle's Law, Charles' Law, Gay-Lussac's Law, Avogadro's Hypothesis, Ideal Gas Law, Non-Ideal ~~gas~~gases, van der Waal's equation, Dalton's Law of Partial Pressure, combined gas laws
Physics	**HS.P2U1.5** Construct an explanation for a field's strength and influence on an object (electric, gravitational, magnetic). Connections: 4.P4U2.2, 5.P3U1.4, 7.P2U1.1, 7.P2U2.2, HS.E2U2.16	Types of forces, gravitational field, force field, electrical field, magnetic field,	**HS+Phy.P2U1.1** Plan and conduct investigations to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.	Electric current, circuit, changing magnetic field
Physics	**HS.P2U3.6** Investigate and communicate how fields (electric, gravitational, magnetic) are utilized and how they influence the structure and function of different technologies. Connections: 8.P4U1.3, HS.E2U2.16	Application of key concepts outlined in HS.P2U1.5 using technology for different types of structures and functions	**HS+Phy.P2U3.2** Design, build, and refine a device that works within given constraints to demonstrate that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.	Application of key concepts outlined in HS+Phys.P2U1.1

Commented [LE30]: I do not teach chemistry, so take this with a big crystal of salt. I know all these laws underlie the rates of reaction, but is it realistic to expect that students will come away with an understanding of all these relationships? Because I am pretty sure most of these things are challenging students at the Intro Chem level in college.

Discipline Area	**Physical Science Essential Standards** HS Essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Physical Science Plus (+) Standards** HS+ Standards are designed for students taking a high school chemistry (C) or physics (Phy) course.	**Key Concepts may include those listed in the essential standards and:**
Physics	**HS.P3U2.7** Develop a mathematical model, using Newton's laws, to predict the change in motion of an object or system in ***one dimension***. Connections: 6.P3U2.4, 7.P3U2.3, HS.E2U2.16	Kinematics, vectors, Newton's laws, inertia, acceleration, friction, displacement, velocity, balanced forces, unbalanced forces, motion graphs, free fall, conservation of momentum	**HS+Phy.P3U2.3** Develop a mathematical model, using Newton's laws, to predict the change in motion of an object or system in ***two dimensions*** (projectile and circular motion).	Projectile motion, uniform circular motion, relative motion, rotational motion, tangential and centripetal acceleration, Kepler's laws
			HS+Phy.P3U1.4 Develop and use mathematical representations of Newton's law of gravitation and Coulomb's law to describe and predict the gravitational and electrostatic forces between objects.	Universal gravitation, Coulomb's law, electrostatics
			HS+Phy.P3U1.5 Engage in an argument, from evidence, regarding the claim that the total momentum of a system is conserved when there is no net force on the system.	Conservation of momentum, defining systems
Physics	**HS.P3U3.8** Analyze mathematically how Newton's laws are used in engineering and technologies to create products to serve human ends.	Kinematic equations impulse, pressure, friction, momentum, elastic and inelastic collisions	**HS+Phy.P3U3.6** Design, evaluate, and refine a device that minimizes or maximizes the force on a macroscopic object during a collision.	Application of key concepts outlined in HS.P3U3.8 and impulse

<table>
<tr><th>Discipline Area</th><th>Physical Science Essential Standards
HS Essential Standards are intended for ALL students to learn across 3 credits of high school science courses.</th><th>Key Concepts include but should not be limited to:</th><th>Physical Science Plus (+) Standards
HS+ Standards are designed for students taking a high school chemistry (C) or physics (Phy) course.</th><th>Key Concepts may include those listed in the essential standards and:</th></tr>
<tr><td rowspan="4">Physics</td><td rowspan="4">HS.P4U1.9

Engage in argument from evidence that the net change of energy in a system is always equal to the total energy exchanged between the system and the surroundings.

Connections: 7.E1U2.4, 7.L2U2.10, 8.P4U1.3</td><td rowspan="4">Conservation of energy, equilibrium, entropy, potential energy, kinetic energy, open and closed systems</td><td>HS+Phy.P4U1.7

Determine the graphical and mathematical relationships among the frequency, wavelength, and speed of waves traveling in various media.</td><td>Frequency, wavelength, speed of waves, types of media, amplitude, resonance, interference, diffraction, reflection</td></tr>
<tr><td>HS+Phy.P4U1.8

Determine the graphical and mathematical relationships between power, current, voltage, and resistance.
Connection: 4.P4U2.2</td><td>Ohm's law, circuits, power, current, voltage, resistance</td></tr>
<tr><td>HS+Phy.P4U1.9

Analyze and interpret data to quantitatively describe changes in energy within a system and/or energy flows in and out of a system.</td><td>Systems of two or three components, various types of energy, electric fields</td></tr>
<tr><td>HS+Phy.P4U3.10

Engage in argument, from evidence, that electromagnetic radiation can be described either by a wave model or a particle model, and, that for some situations in engineering and technology, one model is more beneficial than the other.</td><td>Photoelectric effect, theories can be modified with new evidence, absorption</td></tr>
</table>

Discipline Area	**Physical Science Essential Standards** HS Essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Physical Science Plus (+) Standards** HS+ Standards are designed for students taking a high school chemistry (C) or physics (Phy) course.	**Key Concepts may include those listed in the essential standards and:**
Physics	**HS.P4U4.10** Engage in argument from evidence regarding the ethical, social, economic, and/or political benefits and liabilities of energy usage and transfer.	Application of concepts outlined in HS.P4U1.9	**HS+Phy.P4U4.11** Engage in argument, from evidence, regarding the ethical, social, economic, and/or political benefits and liabilities of fission, fusion, and radioactive decay.	Alpha, beta, gamma, radioactive decay, specific energy usage
			HS+Phy.P4U1.12 Plan and conduct investigations to determine the power and efficiency in the change of energy storage modes within various systems.	Output, input, efficiency, power Connection: HS.P4U1.9
			HS+Phy.P4U3.13 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.	Qualitative and quantitative evaluations of devices: Rube Goldberg devices, devices that utilize renewable or non-renewable energy sources

High School Earth and Space Sciences

Earth and space science encompass processes that occur on Earth while also addressing Earth's place within our Solar System and galaxy. At the high school level, students gain an understanding of these processes through a wide scale: unimaginably large to invisibly small.[1] Earth and Space Sciences, more than any other discipline, are rooted in other scientific disciplines. Students, through the close study of earth and space, will find clear applications for their knowledge of gravitation, energy, magnetics, cycles, and biological processes. Educators should use the "connections" designations within these standards to assist students in making connections between scientific disciplines. Additionally, students are expected to apply these concepts to real-world phenomena to gain a deeper understanding of both natural and human-made processes. The essential standards are those that every high school student is expected to know and understand. Plus standards in earth and space science are designed to extend the concepts learned in the essential standards to prepare students for entry level college courses.

Note:

- The standard number a is designed for recording purposes and does not imply instructional sequence or importance.
- In all disciplines, educators should incorporate scientific measurement skills appropriate to that discipline.

Discipline Area	**Earth and Space Science Essential Standards** HS Essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Earth and Space Science Plus (+) Standards** HS+ Standards are designed for students taking a high school Earth and space sciences (E) course.	**Key Concepts may include those listed in the essential standards and:**
Earth Science	**HS.E1U1.11** Analyze and interpret data to determine how energy from the Sun affects weather patterns and climate. Connections: 7.E1U2.6, 8.P4U1.3, HS.P4U1.9	Ultra-violet radiation, ozone, atmospheric layers, clouds, impact of solar activity (solar flares, sunspots), climate models, Earth's angle, differential heating of land and water	**HS+E.E1U1.1** Construct an evidence-based explanation for how the Sun's energy transfers between Earth's systems.	Build upon and apply concepts from HS.E1U1.11
			HS+E.E1U1.2 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.	
			HS+E.E1U2.3 Analyze geoscience data and the results from global climate models to make evidence-based predictions of the current rate and scale of global or regional climate changes.	

Discipline Area	**Earth and Space Science Essential Standards** HS Essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Earth and Space Science Plus (+) Standards** HS+ Standards are designed for students taking a high school Earth and space sciences (E) course.	**Key Concepts may include those listed in the essential standards and:**
Earth Science	**HS.E1U2.12** Develop and use a model of the Earth that explains the role of energy in Earth's constantly changing internal and external systems (geosphere, hydrosphere, atmosphere, biosphere). Connections: 7.E1U2.4, HS.L2U4.18	Parts that make up the four spheres, sphere interactions, interconnectedness of spheres Biogeochemical cycles: carbon, oxygen, nitrogen	**HS+E.E1U1.4** Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.	Build upon and apply concepts from HS.E1U2.12
			HS+E.E1U2.5 Develop and use a model, based on the characteristics of Earth's interior, to describe the cycling of matter.	
			HS+E.E1U1.6 Plan and conduct investigations on the effect of water on Earth materials, surface processes, and groundwater systems.	
			HS+E.E1U2.7 Develop and use a quantitative model to describe the cycling of matter among the hydrosphere, atmosphere, geosphere, and biosphere.	

Discipline Area	**Earth and Space Science Essential Standards** HS essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Earth and Space Science Plus (+) Standards** HS+ Standards are designed for students taking a high school Earth and space sciences (E) course.	**Key Concepts may include those listed in the essential standards and:**
Earth Science	**HS.E1U2.13** Evaluate explanations and theories about the role of energy and matter in geologic changes over time. Connections: 7.E1U2.4, 7.L2U2.9, 8.E1U1.6	Systems (tectonic~~,~~ ~~hydrologic~~, glacial, groundwater, shoreline, (a)eolian, fluvial, lacustrine, global air circulation); Energy (heat, chemical, radiant, nuclear, elastic, electrical); heat transfer; rock cycle, Plutonic activity; time (geologic, relative, radiometric)	**HS+E.E1U1.8** Evaluate evidence of the Theory of Plate Tectonics to explain the differences in age, structure, and composition of Earth's crust. **HS+E.E1U2.9** Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to explain Earth's formation and early history. **HS+E.E1U2.10** Develop and use a model to illustrate how Earth's internal and surface processes operate over time to form, modify, and recycle continental and ocean floor features. **HS+E.E1U1.11** Construct an argument, based on evidence, about the impact of changes in Earth's systems on the biosphere.	Build on and apply concepts from HS.E1U2.13

Discipline Area	**Earth and Space Science Essential Standards** HS essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Earth and Space Science Plus (+) Standards** HS+ Standards are designed for students taking a high school Earth and space sciences (E) course.	**Key Concepts may include those listed in the essential standards and:**
Earth Science	**HS.E1U4.14** Engage in argument from evidence about the availability of natural resources, occurrence of natural hazards, changes in climate, and human activity and how they influence each other. Connections: 5.L4U4.11, 8.E1U3.7, HS.L2U4.18, HS.L2U2.24, HS.L2U4.25 Note: The topic of natural resources provides the teacher an opportunity to integrate content with Social Sciences through supply/demand considerations and the tendency of organisms to populate areas near water and other resources	Natural hazards include but are not limited to those which occur from a variety of systems and sources such as atmospheric, hydrologic, oceanographic, volcanologic, seismic, neotectonic Volcanic regions, warning systems	**HS+E.E1U3.12** Evaluate competing design solutions for developing, managing, and utilizing mineral resources. **HS+E.E1U4.13** Construct an explanation, based on evidence, for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. **HS+E.E1U4.14** Evaluate a solution to a complex problem, based on prioritized criteria and tradeoffs, that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. **HS+E.E1U4.15** Design a quantitative model to illustrate the relationships among Earth systems and the degree to which those relationships are being modified due to human activity.	Build on and apply concepts from HS.E1U4.14

Discipline Area	**Earth and Space Science Essential Standards** HS essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Earth and Space Science Plus (+) Standards** HS+ Standards are designed for students taking a high school Earth and space sciences (E) course.	**Key Concepts may include those listed in the essential standards and:**
Space Science	**HS.E2U1.15** Construct an explanation based on evidence to illustrate the role of nuclear fusion in the life cycle of a star. Connections: HS.P1U1.1, HS.P1U2.2, HS.P1U1.3	Star life cycle, Nebular theory, energy production, astronomical time periods	**HS+E.E2U2.16** Develop and use a model to relate the role of nuclear fusion in the Sun's core to the life cycles of stars. **HS+E.E2U1.17** Communicate scientific ideas about the way stars, throughout their stellar stages, produce elements and energy.	Build on and apply concepts from HS.E2U4.15
Space Science	**HS.E2U2.16** Apply mathematical and/or computational representations of Kepler's laws as they relate to the movement of planets and objects in the solar system. Connections: 6.P3U2.4, HS.P2U1.5, HS.P2U3.6, HS.P2U2.7	Comets, asteroids, Law of Orbits, Law of Areas, Law of Periods, gravitational forces, algebraic computation, ratios	**HS+E.E2U1.18** Analyze how gravitational forces are influenced by mass, density, and radius. **HS+E.E2U1.19** Construct an explanation of how gravitational forces impact the evolution of planetary structure, surfaces, atmospheres, moons, and rings.	Build on and apply concepts from HS.E1U2.16 Refer also to HS+Phy.P3U2.3

Discipline Area	**Earth and Space Science Essential Standards** HS essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Earth and Space Science Plus (+) Standards** HS+ Standards are designed for students taking a high school Earth and space sciences (E) course.	**Key Concepts may include those listed in the essential standards and:**
Space Science	**HS.E2U2.17** Analyze, interpret, and critique theories related to the scale and expansion of the universe.	Scientific theories vs scientific laws, scientific investigation, phase change, theories and scientific evidence surrounding the origin of universe, galaxies, constellations, stars	**HS+E.E2U1.20** Analyze how the nebular theory explains solar system formation with distinct regions characterized by different types of planetary and other bodies.	Build on and apply concepts from HS.E2U2.17
			HS+E.E2U1.21 Obtain, evaluate, and communicate information about patterns of size and scale of the solar system, our galaxy, and the Universe.	
			HS+E.E2U3.22 Evaluate the impact of technology on human understanding of the formation, scale, and composition of the Universe.	

High School Life Sciences

Life science focuses on the patterns, processes, and relationships of living organisms. At the high school level, students apply concepts learned in earlier grades to real-world situations and investigations using the science and engineering practices to fully explore phenomena and to develop solutions to societal problems related to food, energy, health, and environment. The field of life science is rapidly advancing and new technology and information related to the study of life processes is being developed daily. Students in high school should have access to up-to-date information in the field while simultaneously gaining understanding of the historical developments which shaped today's understandings within the field. The Standards for life science encompass the areas of cells and organisms; ecosystems, interactions, energy and dynamics; heredity; and biological diversity. Like Earth and space sciences and physical sciences, "connections" with the life science standards allow educators to make connections across scientific disciplines. The essential standards are those that every high school student is expected to know and understand. Plus standards in life science are designed to extend the concepts learned in the essential standards to prepare students for entry level college courses.

Note:

- The standard number is designed for recording purposes and does not imply instructional sequence or importance.
- In all disciplines, educators should incorporate scientific measurement skills appropriate to that discipline.

Discipline Area	**Life Science Essential Standards** HS Essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Life Science Plus (+) Standards** HS+ Standards are designed for students taking a high school Biology (B) course.	**Key Concepts may include those listed in the essential standards and:**
Ecosystems	**HS.L2U4.18** Obtain, evaluate, and communicate information about the positive and negative ethical, social, economic, and political implications of human activity on the biodiversity of an ecosystem. Connections: 5.L4U4.11, HS.E1U2.12, HS.E1U4.14	Biodiversity, habitat, pollution, harvesting of natural resources, air/water quality, diseases	**HS+B.L2U2.1** Graph and model the relationship between limiting factors and carrying capacity in ecosystems.	Limiting factors, carrying capacity
			HS+B.L2U1.2 Predict how changes to an environment impact biodiversity and carrying capacity.	Refer to standard
			HS+B.L2U3.3 Evaluate the positive and negative human impacts on ecosystems and design solutions to mitigate negative impacts.	Refer to standard
			HS+B.L4U1.4 Evaluate evidence supporting claims that changes in environmental conditions or human interventions may change species diversity in an ecosystem.	Geographic isolation, founder effect, reduction in gene flow, reproductive isolation

Discipline Area	**Life Science Essential Standards** HS Essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Life Science Plus (+) Standards** HS+ Standards are designed for students taking a high school Biology (B) course.	**Key Concepts may include those listed in the essential standards and:**
Ecosystems	**HS.L2U2.19** Develop and use models that show how changes in the transfer of matter and energy within an ecosystem may affect organisms and their environment. Connections: 7.L2U2.10, 8.P4U1.3	Trophic level transfer efficiency, biomagnification	**HS+B.L2U2.5** Use mathematical representations to support claims for the cycling of matter and flow of energy through trophic levels in an ecosystem.	Biomass, transfer of energy, conservation of matter, 10% rule
			HS+B.L2U2.6 Model the cycling of carbon and nitrogen among the biotic and abiotic components of an ecosystem.	Conservation of carbon and nitrogen
Cells & Organisms	**HS.L1U1.20** Generate questions and/or predictions based on observations and evidence to explain cellular organization, structure, and function. Connection: 6.L1U2.15	Prokaryotes, eukaryotes, organelle structure and function, subcellular structure as it relates to life of cell	**HS+B.L1U2.7** Calculate and model the effects of surface area, volume, and cell shape on the overall rate of diffusion of nutrients and wastes.	Passive transport, hypertonic, hypotonic, isotonic

Discipline Area	**Life Science Essential Standards** HS Essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Life Science Plus (+) Standards** HS+ Standards are designed for students taking a high school Biology (B) course.	**Key Concepts may include those listed in the essential standards and:**
Cells & Organisms	**HS.L2U2.21** Use a model to develop a scientific explanation that illustrates how photosynthesis transforms light energy into stored chemical energy. Connection: 6.L2U1.16	Chloroplasts, chlorophyll, light dependent/independent reactions	**HS+B.L2U2.8** Obtain, evaluate, and communicate data showing the relationship of photosynthesis and cellular respiration; flow of energy and cycling of matter.	Calvin cycle, Krebs cycle (citric acid cycle) electron transport chain, fermentation
Cells & Organisms	**HS.L2U2.22** Use a model to develop a scientific explanation that illustrates how cellular respiration transforms glucose into stored chemical energy. Connections: HS.P1U2.1, HS.P1U2.2	Mitochondria, ADP/ATP, glycolysis, aerobic/anaerobic respiration,		
Cells & Organisms	**HS.L1U1.23** Construct an explanation for how organisms regulate internal functions. Connections: 7.L1U1.7, 7.L1U1.8	Negative feedback, positive feedback, homeostasis	**HS+B.L1U1.9** Analyze and interpret data which demonstrates how the properties of water impact cellular function.	Osmosis, surface tension, cohesion, adhesion, polar
			HS+B.L1U2.10 Use models to show how transport mechanisms function in cells.	Active transport, cell membrane structure, molecular structure, phagocytosis, pinocytosis, endocytosis, exocytosis

Commented [LE31]: Cellular function, or tissue function?

Discipline Area	**Life Science Essential Standards** HS Essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Life Science Plus (+) Standards** HS+ Standards are designed for students taking a high school Biology (B) course.	**Key Concepts may include those listed in the essential standards and:**
Cells & Organisms	**HS.L1U2.24** Obtain, evaluate, and ~~communication~~ communicate information to show that systems of specialized cells within organisms (plant and animal) help them perform the essential functions of life. Connection: 6.L1U1.14	Relate cell and tissue structure to ~~cell purpose~~function, organ systems	**HS+B.L1U2.11** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms (plant and animal).	Nutrient uptake, water delivery, organism movement in response to stimuli, functions at the organ system level
Cells & Organisms	**HS.L2U1.25** Construct an explanation demonstrating how organisms combine carbon and other atoms from the environment to form macromolecules. Connections: HS.P1U2.1, HS.P1U1.2	Carbon, hydrogen, oxygen, nitrogen, carbohydrates, nucleic acids, lipids, proteins	**HS+B.L2U2.12** Use evidence to construct and revise an explanation regarding how bonds are broken and reformed, resulting in a net transfer of energy within an organism (plants and animals).	Specific focus on energy from food sources and oxygen application of knowledge from essential and plus standards HS.L2U2.22, HS.L2U1.25, HS+B.L2U2.8
Cells & Organisms	**HS.L3U2.26** Develop and use a model to communicate how a cell copies and separates genetic information to make replica new cells during asexual reproduction (mitosis). Connection: 8.L3U1.9	Cell cycle, replication, chromosomes, binary fission	**HS+B.L1U2.13** Construct an explanation for how cellular division (mitosis) is the process by which organisms grow and maintain complex, interconnected systems.	Differentiation, multicellular organism, fertilized egg, daughter cells, tissues, organs

Commented [LE32]: Differentiation is not a function of cellular division, in general. Should this be a topic elsewhere?

Discipline Area	**Life Science Essential Standards** HS Essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Life Science Plus (+) Standards** HS+ Standards are designed for students taking a high school Biology (B) course.	**Key Concepts may include those listed in the essential standards and:**
Cells & Organisms	**HS.L1U4.27** Evaluate and communicate the ethical, social, economic and/or political implications of the detection and treatment of abnormal cell function.	Case studies as applicable for your community and context	**HS+B.L1U3.14** Obtain, evaluate, and communicate information related to cell abnormality that contributes to the development of new technologies.	Possible concepts to explore may include blood disorders, tumor visualization, pace-makers, any medical inventions designed to detect and/or correct~~t~~
Genetics	**HS.L3U2.28** Construct an explanation of how the process of sexual reproduction contributes to genetic variation. Connection: 8.L3U1.9	Meiosis, DNA structure, ~~RNA structure,~~ nucleic acids, chromosomes, genes, alleles, crossing over, genotype, phenotype, monohybrid cross (Punnett square), codominant traits, X-linked traits polygenetic traits, chromosomes which determine gender at conception (XX, XY)	**HS+B.L3U2.15** Use mathematics and statistical probability to explain the variation and distribution of expressed traits in a population.	Hardy Weinberg, probability, dihybrid crosses (Punnett squares)
Genetics	**HS.L3U1.29** Obtain, evaluate, and communicate information about the causes and implications of DNA mutation.	Replication, transcription, translation, somatic, insertion, deletion, inversions, duplication, point, codon	**HS+B.L3U1.16** Construct an explanation for how the structure of DNA and RNA determine the structure of proteins that perform essential life functions.	Central dogma, protein structure (primary, secondary, tertiary)
			HS+B.L3U1.17	Advantageous/detrimental/ neutral alleles

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Discipline Area	**Life Science Essential Standards** HS Essential Standards are intended for ALL students to learn across 3 credits of high school science courses.	**Key Concepts include but should not be limited to:**	**Life Science Plus (+) Standards** HS+ Standards are designed for students taking a high school Biology (B) course.	**Key Concepts may include those listed in the essential standards and:**
			Analyze how mutations can lead to increased genetic variation in a population.	
Genetics	**HS.L3U4.30** Construct an argument, based on evidence, regarding the ethical, social, economic, and/or political implications, of a current genetic technology. Connection: 8.L3U4.10	Genetically modified foods, genetic engineering, human genome project, CRISPR	**HS+B.L3U1.18** Define problems and design solutions regarding the ethical, social, economic, and/or political implications of a current genetic technology.	Refer to standard
Evolution	**HS.L4U2.31** Obtain, evaluate, and communicate evidence that describes how inherited traits in a population can lead to biological diversity.	Adaptations, genetic variation, gene flow, fitness, competition for resources and mates, artificial selection, coevolution	**HS+B.L4U1.19** Construct an explanation based on evidence that the process of evolution may result from natural selection.	Vestigial structures, homologous structures, fossil record
			HS+B.L4U2.20 Gather, evaluate, and communicate multiple lines of empirical evidence to explain the change in genetic composition of a population over successive generations.	Classification, cladogram, dichotomous keys, natural selection, hybridization, mutation, inbreeding, genetic drift, phylogeny

Distribution of High School Standards, (essential standards (HS) and course-specific plus (HS+)

	U1: Science's purpose is to find the cause or causes of phenomena in the natural world.	**U2**: Scientific explanations, theories, and models are those that best fit the evidence available at a particular time.	**U3**: The knowledge produced by science is used in engineering and technologies to create products.	**U4**: Applications of science often have both positive and negative ethical, social, economic, and political implications.
P1: All matter in the Universe is made of very small particles.	HS.P1U1.2 HS.P1U1.4 HS+C.P1U1.1 HS+C.P1U1.4 HS+C.P1U1.7 HS+C.P1U1.9	HS.P1U2.1 HS+C.P1U2.3 HS+C.P1U2.5 HS+C.P1U2.6	HS+C.P1U3.2	HS.P1U4.3 HS+C.P1U4.8
P2: Objects can affect other objects at a distance.	HS.P2U1.5 HS+Phy.P2U1.1		HS.P2U3.6 HS+Phy.P2U3.2	
P3: Changing the movement of an object requires a net force to be acting on it.	HS+Phy.P3U1.4 HS+Phy.P3U1.5	HS.P3U2.7 HS+Phy.P3U2.3	HS.P3U3.8 HS+Phy.P3U3.6	
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.	HS.P4U1.9 HS+Phy.P4U1.7 HS+Phy.P4U1.8 HS+Phy.P4U1.9 HS+Phy.P4U1.12		HS+Phy.P4U3.10 HS+Phy.P4U3.13	HS.P4U4.10 HS+Phy.P4U4.11
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.	HS.E1U1.11 HS+E.E1U1.1 HS+E.E1U1.2 HS+E.E1U1.4 HS+E.E1U1.6 HS+E.E1U1.8 HS+E.E1U1.11	HS.E1U2.12 HS.E1U2.13 HS+E.E1U2.3 HS+E.E1U2.5 HS+E.E1U2.7 HS+E.E1U2.9 HS+E.E1U2.10	HS+E.E1U3.12	HS.E1U4.14 HS+E.E1U4.13 HS+E.E1U4.14 HS+E.E1U4.15

	U1: Science's purpose is to find the cause or causes of phenomena in the natural world.	**U2**: Scientific explanations, theories, and models are those that best fit the evidence available at a particular time.	**U3**: The knowledge produced by science is used in engineering and technologies to create products.	**U4**: Applications of science often have both positive and negative ethical, social, economic, and political implications.
E2: The Earth and our Solar System are a very small part of one of many galaxies within the Universe.	HS.E2U1.15 HS+E.E2U1.17 HS+E.E2U1.18 HS+E.E2U1.19 HS+E.E2U1.20 HS+E.E2U1.21	HS.E2U2.16 HS.E2U2.17 HS+E.E2U2.16	HS+E.E2U3.22	
L1: Organisms are organized on a cellular basis and have a finite life span.	HS.L1U1.20 HS.L1U1.23 HS+B.L1U1.9	HS.L1U2.24 HS+B.L1U2.7 HS+B.L1U2.10 HS+B.L1U2.11 HS+B.L1U2.13	HS+B.L1U3.14	HS.L1U4 .27
L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.	HS.L2U1.25 HS+B.L2U1.2	HS.L2U2.19 HS.L2U2.21 HS.L2U2.22 HS+B.L2U2.1 HS+B.L2U2.5 HS+B.L2U2.6 HS+B.L2U2.8 HS+B.L2U2.12	HS+B.L2U3.3	HS.L2U4.18
L3: Genetic information is passed down from one generation of organisms to another.	HS.L3U1.29 HS+B.L3U1.16 HS+B.L3U1.17 HS+B.L3U1.18	HS.L3U2.28 HS.L3U2.26 HS+B.L3U2.15		HS.L3U4.30
L4: The theory of evolution seeks to make clear the unity and diversity of living and extinct organisms.	HS+B.L4U1.4 HS+B.L4U1.19	HS.L4U2.31 HS+B.L4U2.20		

Appendices

Appendix 1: Crosscutting Concepts

The seven crosscutting concepts bridge disciplinary boundaries and unite core ideas throughout the fields of science and engineering. Their purpose is to help students deepen their understanding of the core ideas in the standards and develop a coherent and scientifically based view of the world. Students should make explicit connections between their learning and the crosscutting concepts within each grade level.

These concepts also bridge boundaries between science and other disciplines. As educators focus on crosscutting concepts, they should look for ways to integrate them into other disciplines. For example, patterns are highly prevalent in language. Indeed, phonics, an evidence-based literacy instructional strategy, is specifically designed to assist students in recognizing patterns in language. By actively incorporating these types of opportunities, educators assist students in building connections across content areas to deepen and extend learning.

The crosscutting concepts from *A Framework for K-12 Science Education*[4] are:

- **Patterns: Observed patterns of forms and events guide organization and classification and prompt questions about relationships and the factors that influence them.** Patterns are often a first step in organizing and asking scientific and engineering questions. In science, classification is one example of recognizing patterns of similarity and diversity. In engineering, patterns of system failures may lead to design improvements. Assisting children with pattern recognition facilitates learning causing the brain to search for meaning in real-world phenomena.[1] Pattern recognition progresses from broad similarities and differences in young children to more detailed, scientific descriptors in upper elementary. Middle school students recognize patterns on both the micro- and macroscopic levels, and high school students understand that patterns vary in a system depending upon the scale at which the system is studied.

- **Cause and effect: Events have causes, sometimes simple, sometimes multifaceted. A major activity of both science and engineering is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.** Like patterns, a child's ability to recognize cause and effect relationships progresses as they age. In the early grades students build upon their understanding of patterns to investigate the causes of these patterns. They may wonder what caused one seed to grow faster than another one and design a test to gather evidence. By upper elementary, students should routinely be asking questions related to cause and effect. In middle school, students begin challenging others' explanations about causes through scientific argumentation. High school continues this trend while students expand their investigation into mechanisms that may have multiple mediating factors such as changes in ecosystems over time or mechanisms that work in some systems but not in others.

- **Scale, proportion, and quantity: In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.** There are two major scales from which we study science: directly observable and those processes which required tools or scientific measurement to be quantified and studied. To understand scale, students must understand both measurement and orders of magnitude. Understanding of scale, proportion, and quantity progresses as children get older. Young children engage in relative measures such as hotter/colder, bigger/smaller, or older/younger without referring to a specific unit of measure. As students age, it is important that they recognize the need for a common unit of measure to make judgement of scale, proportion, and quantity. Elementary students start building this knowledge through length measurements and gradually progress to weight, time, temperature or other variables. Intersection with key mathematical concepts is vital to help students develop the ability to assign meaning to ratios and proportions when discussing scale, proportion, and quantity in science and engineering. By middle and high school, students apply this knowledge to algebraic thinking and are able to change variables, understand both linear and exponential growth, and engage in complex mathematical and statistical relationships.

- **Systems and system models: Because the world is too large and complex to comprehend all at once, students must define the system under study, specify its boundaries, and make explicit a model of that system provides tools for understanding and testing ideas that are applicable throughout science and engineering.** Models of systems can also be useful in conveying information about that system to others. Many engineering designs start with system models as a way to predict outcomes and test theories prior to final development ensuring that interactions between system parts and subsystems are understood. As students age, their ability to analyze and predict outcomes strengthens. In the early grades, students should be asked to express systems thinking through drawings, diagrams, or oral explanations noting relationships between parts. Additionally, even at a young age, students can be asked to develop plans for their actions or sets of instructions to help them develop the concept that others should be able to understand and use them. As student's age, they should incorporate more facets of the system including those facets which are not visible such as energy flow. By high school, students can identify the assumptions and approximations that went into making the system model and discuss how these assumptions and approximations limit the precision and reliability of predictions.

- **Energy and matter: Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.** The concept of conservation of energy within a closed system is complex and prone to misunderstanding. As a result, students in early elementary are only very generally exposed to the concept of energy. In the early grades, focus on the recognition of conservation of matter within a system and the flow of matter between systems builds the basis for understanding more complex energy concepts in later grades. In middle school and high school, students develop deeper understanding of this concept through chemical reactions and atomic structure. In high school, nuclear processes are introduced along with conservation laws related specifically to nuclear processes.

- **Structure and function: The way in which an object or living thing is shaped and its substructure determines many of its properties and functions.** Knowledge of structure and function is essential to successful design. As such, it is important that students begin investigation of structure and function at an early age. In early grades, this study takes the form of how shape and stability are related for different structures: braces make a bridge stronger, a deeper bowl holds more water. In upper elementary and middle school, students begin investigation of structures that are not visible to the naked eye: how the structure of water and salt molecules relate to solubility, the shape of the continents and plate tectonics. In high school students apply their knowledge of the relationship of structure to function when investigating the structure of the heart and the specific function it performs.

- **Stability and change: For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.** When systems are stable, small disturbances fade away, and the system returns to the stable condition. In maintaining a stable system, whether it is a natural system or a human design, feedback loops are an essential element. Young children experiment with stability and change as they build with blocks or chart growth. As they experiment with these concepts, the educator should assist them in building associated language and vocabulary as well as learning to question why some things change and others stay the same. In middle school, understanding of stability and change extends beyond those phenomena which are easily visible to more subtle form of stability and change. By high school, students bring in their knowledge of historical events to explain stability and change over long periods of time, and they also recognize that multiple factors may feed into these concepts of stability and change.

Appendix 2: Science and Engineering Practices

The science and engineering practices, formerly the scientific method, describe how scientists investigate and build models and theories of the natural world or how engineers design and build systems. They reflect science and engineering as they are practiced and experienced. As students conduct investigations, they engage in multiple practices as they gather information to solve problems, answer their questions, reason about how the data provide evidence to support their understanding, and then communicate their understanding of phenomena. Student investigations may be observational, experimental, use models or simulations, or use data from other sources. These eight practices identified in *A Framework for K-12 Science Education*[4] are critical components of scientific literacy. They are not instructional strategies.

Distinguishing Science & Engineering Practices

	Science	**Engineering**
Ask Questions and Define Problems	Science often begins with a question about a phenomenon, such as “Why is the sky blue?” or “What causes cancer?” and seeks to develop theories that can provide explanatory answers to such questions. Scientists formulate empirically answerable questions about phenomena; they establish what is already known and determine what questions have yet to be satisfactorily answered.	Engineering begins with a problem, need, or desire that suggests a problem that needs to be solved. A problem such as reducing the nation’s dependence on fossil fuels may produce multiple engineering problems like designing efficient transportation systems or improved solar cells. Engineers ask questions to define the problem, determine criteria for a successful solution, and identify constraints.
Develop and Use Models	Science often involves constructing and using a variety of models and simulations to help develop explanations about natural phenomena. Models make it possible to go beyond what can be observed. Models enable predictions to be made to test hypothetical explanations.	Engineering uses models and simulations to analyze existing systems to see where flaws might occur or to test viable solutions to a new problem. Engineers use models of various sorts to test proposed systems and to recognize the strengths and limitations of their designs.
Plan and Carry Out Investigations	Scientific investigations may be conducted in the field or the laboratory. Scientists plan and carry out systematic investigations that require the identification of what is to be recorded and, if applicable, what are to be treated as the dependent and independent variables. Observations and data collected are used to test existing theories and explanations or to revise and develop new ones.	Engineers use investigations to gather data essential for specifying design criteria or parameters and to test their designs. Engineers must identify relevant variables, decide how they will be measured, and collect data for analysis. Their investigations help them to identify how effective, efficient, and durable their designs may be under a range of conditions.

	Science	Engineering
Analyze and Interpret Data	Scientific investigations produce data that must be analyzed to derive meaning. Because data usually do not speak for themselves, scientists use a range of tools, including tabulation, graphical interpretation, visualization, and statistical analysis, to identify significant features and patterns in the data, sources of error, and the calculated degree of certainty. Technology makes collecting large data sets easier providing many secondary sources for analysis.	Engineers analyze data collected during the tests of their designs and investigations; this allows them to compare different solutions and determine how well each one meets specific design criteria; that is, which design best solves the problem within the given constraints. Engineers require a range of tools to identify the major patterns and interpret the results.
Use Mathematics and Computational Thinking	In science, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks: constructing simulations, statistically analyzing data, and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable the behavior of physical systems to be predicted and tested. Statistical techniques are invaluable for assessing the significance of patterns or correlations.	In engineering**,** mathematical and computational representations of established relationships and principles are a fundamental part of design. For example, structural engineers create mathematically based analyses of designs to calculate whether they can stand up to the expected stresses of use and if they can be completed within acceptable budgets. Simulations of designs provide an effective test bed for the development
Construct Explanations and Design Solutions	In science, theories are constructed to provide explanatory accounts of phenomena. A theory becomes accepted when it has been shown to be superior to other explanations in the breadth of phenomena it accounts for and in its explanatory coherence. Scientific explanations are explicit applications of theory to a specific situation or phenomenon, perhaps with a theory-based model for the system under study. The goal for students is to construct logically coherent explanations of phenomena that incorporate their current understanding of science, or a model that represents it, and are consistent with the available evidence.	Engineering design is a systematic process for solving engineering problems and 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, feasibility, cost, safety, esthetics, and compliance with legal requirements. There is usually no single best solution but rather a range of solutions. The optimal solution often depends on the criteria used for making evaluations.

	Science	Engineering
Engage in Argument from Evidence	In science, reasoning and argument are essential for identifying the strengths and weaknesses of a line of thinking and for finding the best explanation for a phenomenon. Scientists must defend their explanations, formulate evidence, based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon being investigated.	In engineering, reasoning and argument are essential for finding the best possible solution to a problem. Engineers collaborate with their peers throughout the design process, with a critical stage being the selection of the most promising solution among a field of competing ideas. Engineers use systematic methods to compare alternatives, formulate evidence, based on test data, make arguments from evidence to defend their conclusions, evaluate critically the ideas of others, and revise their designs to achieve the best solution to the problem at hand.
Obtain, Evaluate, and Communicate Information	Science cannot advance if scientists are unable to communicate their findings clearly and persuasively or to learn about the findings of others. Scientists need to express their ideas, orally and in writing, using tables, diagrams, graphs, drawings, equations, or models and by engaging in discussions with peers. Scientists need to be able to derive meaning from texts (such as papers, the internet, symposia, and lectures) to evaluate the scientific validity of the information and to integrate that information with existing theories or explanations. Scientists routinely use technologies to extend the possibilities for collaboration and communication.	Engineers cannot produce new or improved technologies if the advantages of their designs are not communicated clearly and persuasively. Engineers need to express their ideas, orally and in writing, using tables, graphs, drawings, or models and by engaging in discussions with peers. Engineers need to be able to derive meaning from colleagues' texts, evaluate the information, and apply it usefully. Engineers routinely use technologies to extend the possibilities for collaboration and communication.

[4]Adapted from Box 3-2, National Research Council. pages 50-53

Appendix 3: Core Ideas
The core ideas encompass the content that occurs at each grade and provides the background knowledge for students to develop sense-making around phenomena. The core ideas center around understanding the causes of phenomena in physical, earth and space, and life science; the principles, theories, and models that support that understanding; engineering and technological applications; and societal implications. The Arizona Science Standards integrate learning progressions from *A Framework for K-12 Science Education* [4] to build a coherent progression of learning for these core ideas from elementary school through high school. The following fourteen big ideas for knowing science and using science are adapted from *Working with Big Ideas of Science Education*[2] and represent student understanding of each core idea at the end of high school.

Core Ideas for Knowing Science
P1: All matter in the Universe is made of very small particles.
Atoms are the building blocks of all normal matter, living and non-living. The behavior and arrangement of the atoms explains the properties of different materials. In chemical reactions atoms are rearranged to form new substances. Each atom has a nucleus, containing neutrons and protons, surrounded by electrons. The opposite electric charges of protons and electrons attract each other, keeping atoms together and accounting for the formation of some compounds. Physicists and astronomers have begun to investigate other types of matter, dark matter, antimatter, and negative matter, which are also thought to be made up of very small particles. Those particles may or may not be atoms and tend to react differently to forces than normal matter.

P2: Objects can affect other objects at a distance.
All objects have an effect on other objects without being in contact with them. In some cases, the effect travels out from the source to the receiver in the form of radiation such as visible light. In other cases, action at a distance is explained in terms of the existence of a field of influence between objects, such as a magnetic, electric, or gravitational field. Gravity is a universal force of attraction between all objects, however large or small, keeping the planets in orbit around the Sun and causing terrestrial objects to fall towards the center of the Earth.

P3: Changing the movement of an object requires a net force to be acting on it.
A force acting on an object is not seen directly but is detected by its effect on the object's motion or shape. If an object is not moving, the forces acting on it are equal in size and opposite in direction, balancing each other. Since gravity affects all objects on Earth, there is always another force opposing gravity when an object is at rest. Unbalanced forces cause change in movement in the direction of the net force. When opposing forces acting on an object are not in the same line they cause the object to turn or twist. This effect is used in some simple machines.

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.
Many processes or events involve changes and require an energy source to make them happen. Energy can be transferred from one body or group of bodies to another in various ways. In these processes, some energy becomes less easy to use. Energy cannot be created or destroyed.

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.
Radiation from the Sun heats the Earth's surface and causes convection currents in the air and oceans creating climates. Below the surface, heat from the Earth's interior causes movement in the molten rock. This in turn leads to movement of the plates which form the Earth's crust, creating volcanoes and earthquakes. The solid surface is constantly changing through the formation and weathering of rock.

E2: The Earth and our Solar System are a very small part of one of many galaxies within the Universe.
Our Sun and eight planets and other smaller objects orbiting it comprise the solar system. Day and night and the seasons are explained by the orientation and rotation of the Earth as it moves round the Sun. The Solar System is part of a galaxy of stars, gas, and dust. It is one of many billions in the Universe, enormous distances apart. Many stars appear to have planets.

L1: Organisms are organized on a cellular basis and have a finite life span.
All organisms are constituted of one or more cells. Multi-cellular organisms have cells that are differentiated according to their function. All the basic functions of life are the result of what happens inside the cells which make up an organism. Growth is the result of multiple cell divisions.

L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.
Food provides materials and energy for organisms to carry out the basic functions of life and to grow. Green plants and some bacteria are able to use energy from the Sun to generate complex food molecules. Animals obtain energy by breaking down complex food molecules and are ultimately dependent on green plants as their source of energy. In any ecosystem, there is competition among species for the energy resources and materials they need to live and reproduce.

L3: Genetic information is passed down from one generation of organisms to another.
Genetic information in a cell is held in the chemical DNA. Genes determine the development and structure of organisms. In asexual reproduction, all the genes in the offspring come from one parent. In sexual reproduction half of the genes come from each parent.

L4: The theory of evolution seeks to make clear the unity and diversity of living and extinct organisms.
Over countless generations changes resulting from natural diversity within a species are believed to lead to the selection of those individuals best suited to survive under certain conditions. Species not able to respond sufficiently to changes in their environment become extinct.

Core Ideas for Using Science
U1: Science's purpose is to find the cause or causes of phenomena in the natural world.
Science is a search to explain and understand phenomena in the natural world. There is no single scientific method for doing this; the diversity of natural phenomena requires a diversity of methods and instruments to generate and test scientific explanations. Often an explanation is in

terms of the factors that must be present for an event to take place as shown by evidence from observations and experiments. In other cases, supporting evidence is based on correlations revealed by patterns in systematic observation.

U2: Scientific explanations, theories, and models are those that best fit the evidence available at a particular time.
A scientific theory or model representing relationships between variables of a natural phenomenon must fit the observations available at the time and lead to predictions that can be tested. Any theory or model is provisional and subject to revision in the light of new data even though it may have led to predictions in accord with data in the past.

U3: The knowledge produced by science is used in engineering and technologies to create products.
The use of scientific ideas in engineering and technologies has made considerable changes in many aspects of human activity. Advances in technologies enable further scientific activity; in turn, this increases understanding of the natural world. In some areas of human activity technology is ahead of scientific ideas, but in others scientific ideas precede technology.

U4: Applications of science often have both positive and negative ethical, social, economic, and political implications.
The use of scientific knowledge in technologies makes many innovations possible. Whether particular applications of science are desirable is a matter that cannot be addressed using scientific knowledge alone. Ethical and moral judgments may be needed, based on such considerations as personal beliefs, justice or equity, human safety, and impacts on people and the environment.

Appendix 4: Interdisciplinary Connections

The crosscutting concepts and science and engineering practices provide opportunities for developing strong interdisciplinary connections across all content areas. Developing an understanding of core ideas in science can be a context for helping students master key competencies from other content areas while promoting essential career readiness skills, including communication, creativity, collaboration, and critical thinking. The overlapping skills included in the science and engineering practices and the intellectual tools provided by the crosscutting concepts build meaningful and substantive connections to interdisciplinary knowledge and skills in all content areas**.** This affords all students equitable access to learning and ensures all students are prepared for college, career, and citizenship.

English Language Arts

The science and engineering practices incorporate reasoning skills used in language arts to help students improve mastery and understanding in reading, writing, speaking, and listening. The intersections between science and ELA teach students to analyze data, model concepts, and strategically use tools through productive talk and shared activity. Evidence-based reasoning is the foundation of good scientific practice. Reading, writing, speaking, and listening in science requires an appreciation of the norms and conventions of the discipline of science, including understanding the nature of evidence used, an attention to precision and detail, and the capacity to make and assess intricate arguments, verbally and orally present findings, synthesize complex information, and follow detailed procedures and accounts of events and concepts. To support these disciplinary literacy skills, teachers must foster a classroom culture where students think and reason together, connecting around the core ideas, science and engineering practices, and the crosscutting concepts.

Mathematics

Science is a quantitative discipline, so it is important for educators to ensure that students' science learning coheres well with their understanding of mathematics. Mathematics is fundamental to modeling and providing evidence-based conclusions. It is also essential for expressing relationships in the data. The Standards for Mathematical Practice (MP) naturally link to the science and engineering practices and multiple crosscutting concepts within the Arizona Science Standards. By incorporating the Arizona Mathematics Standards and practices with critical thinking in science instruction, educators provide students with opportunities to develop literacy in mathematics instruction. The goal of using mathematical skills and practices in science is to foster a deeper conceptual understanding of the science.

Computer Science

Natural connections between science and computer science exist throughout the Standards, especially in the middle level and in high school. As students develop or refine complex models and simulations of natural and designed systems, they can use computer science to develop, test, and use mathematical or computational models to generate data. Students can apply computational thinking and coding to develop apps or streamline processes for collecting, analyzing, or interpreting data.

Technology

Technology is essential in teaching and learning science; it influences the science that is taught and enhances students' learning. Technologies in science run the range from tools for performing experiments or collecting data (thermometers, temperature probes, microscopes, centrifuges) to digital technologies for completing analysis or displaying data (calculators, computers). All of them are essential tools for teaching, learning, and doing science. Computers and other digital tools allow students to collect, record, organize, analyze, and communicate data as they engage in science learning. They can support student investigations in every area of science. When technology tools are available, students can focus on decision making, reflection, reasoning, and problem solving.

Connections to engineering, technology, and applications of science are included at all grade levels and in all domains. These connections highlight the interdependence of science, engineering, and technology that drives the research, innovation, and development cycle where discoveries in science lead to new technologies developed using the engineering design process. Additionally, these connections call attention to the effects of scientific and technological advances on society and the environment.

Social Studies

Natural connections between the core ideas for using science and social studies exist throughout the Standards. Students need a foundation in social studies to understand how ethical, social, economic, and political issues of the past and present impact the development and communication of scientific theories, engineering and technological developments, and other applications of science and engineering. Students can use historical, geographic, and economic perspectives to understand that all cultures have ways of understanding phenomena in the natural world and have contributed and continue to contribute to the fields of science and engineering. Sustainability issues and citizen science provide contemporary contexts for integrating social studies with science. Citizen science is the public involvement in inquiry and discovery of new scientific knowledge. This engagement helps students build science knowledge and skills while improving social behavior, increasing student engagement, and strengthening community partnerships. Citizen science projects enlist K-12 students to collect or analyze data for real-world research studies, which helps students develop a deep knowledge of the geography, economics, and civic issues of specific regions.

Appendix 5: Equity & Diversity in Science

All students can and should learn complex science. However, achieving equity in science education is an ongoing challenge. Students from underrepresented communities often face "opportunity gaps" in their educational experience. Inclusive approaches to science instruction can reposition youth as meaningful participants in science learning and recognize their science-related assets and those of their communities[4].

The science and engineering practices ~~have potential to be inclusive~~should provide opportunities to include ~~of~~ students who have traditionally been marginalized in the science classroom and may not see science as being relevant to their lives or future. These practices support sense-making and language use as students engage in a classroom culture of discourse[6]. While the language of science is distinct from the language used in mathematics or language arts, these practices can support bridges between literacy and numeracy needs, which is particularly helpful for non-~~dominate~~ dominant groups when addressing multiple "opportunity gaps."~~.~~ By solving problems through engineering in local contexts (gardening, improving air quality, cleaning water pollution in the community), students gain knowledge of science content, view science as relevant to their lives and future, and engage in science in socially relevant and transformative ways[7]. Science teachers need to acquire effective strategies to include all students regardless of age, racial, ethnic, cultural, linguistic, socioeconomic, and gender backgrounds[3].

Effective teaching strategies[3] for attending to equity and diversity for

- **Economically disadvantaged students** include (1) connecting science education to students' sense of "place" as physical, historical, and sociocultural dimensions in their community; (2) applying students' "funds of knowledge" and cultural practices; and (3) using project-based science learning centered on authentic questions and activities that matter to students.
- **Underrepresented racial and ethnic groups** include (1) culturally relevant pedagogy, (2) community involvement and social activism, (3) multiple representation and multimodal experiences, and (4) school support systems including role models and mentors of similar racial or ethnic backgrounds.
- **Indigenous students** include (1) learning and knowing that is land- and place-based, (2) ~~centers~~ centering (not ~~erases~~ erasing or ~~undermines~~undermining) their ways of knowing, and (3) ~~builds~~ building connections between Indigenous and western Science Technology Engineering and Mathematics (STEM), and (4) home culture connections[8].
- **Students with disabilities** include (1) multiple means of representation, (2) multiple means of action and expression, and (3) multiple means of engagement.
- **English language learners** include (1) literacy strategies for all students, (2) language support strategies with English language learners, (3) discourse strategies with English language learners, (4) home language support, and (5) home culture connections.
- **Alternative education setting for dropout prevention** include (1) structured after-school opportunities, (2) family outreach, (3) life skills training, (4) safe learning environment, and (5) individualized academic support.
- **Girls' achievement, confidence, and affinity with science** include (1) instructional strategies, (2) curricular decisions, and (3) classroom and school structure.
- **Gifted and talented students** include (1) different levels of challenge (including differentiation of content), (2) opportunities for self-direction, and (3) strategic grouping.

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