Arizona Science Standards

Adopted 2018

Arizona Department of Education

Placemats

Standards and Elements for

Core Ideas, Science and Engineering Practices, and Crosscutting Concepts

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. **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 observable events that can be explained or explored.** Science aims to explain the causes of these events, or phenomena, using scientific ideas, concepts, and practices (3-dimensions). Sense-making in science 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.

Purpose of the Arizona Science Standards

The Arizona Science Standards present a vision of what it means to be scientifically literate, and college and career ready. These 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 thirteen 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.

AzSS Snapshot: What Students Are "Doing," "Thinking," "Knowing," and "Using" in Science

Dimension 1: Science and Engineering Practices
The actions students perform in science.

DO

1. Asking questions and defining problems (p. 54)*
2. Developing and using models (p. 56)*
3. Planning and carrying out investigations (p. 59)*
4. Analyzing and interpreting data (p. 61)*
5. Using mathematics and computational thinking (p. 64)*
6. Constructing explanations and designing solutions (p. 67)*
7. Engaging in argument from evidence (p. 71)*
8. Obtaining, evaluating, and communicating information (p. 74)*

Dimension 2: Crosscutting Concepts
The unifying ideas across science disciplines.

THINK

1. Patterns (p. 85)*
2. Cause and effect (p. 87)*
3. Scale, proportion, and quantity (p. 89)*
4. Systems and system models (p. 91)*
5. Energy and matter (p. 94)*
6. Structure and function (p. 96)*
7. Stability and change (p. 98)*

Dimension 3: Core Ideas of Knowing Science and Core Ideas of Using Science

Knowing Science
The fundamental ideas within science disciplines.

KNOW

<u>Physical Science (p. 105)*</u>
P1: All matter in the Universe is made of very small particles. (p. 20)**
P2: Objects can affect other objects at a distance. (p. 21)**
P3: Changing the movement of an object requires a net force to be acting on it. (p. 22)**
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. (p. 23)**

<u>Earth and Space Science (p. 171)*</u>
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. (p. 24)**
E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe. (p. 25)**

<u>Life Science (p. 142)*</u>
L1: Organisms are organized on a cellular basis and have a finite life span. (p. 26)**
L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms. (p. 27)**
L3: Genetic information is passed down from one generation of organisms to another. (p. 28)**
L4: The unity and diversity of organisms, living and extinct, is the result of evolution. (p. 29)*

Using Science
The application of science and engineering.

USE

U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised. (p.30 & 31)**

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products. (p.32)**

U3: Applications of science often have ethical, social, economic, and/or political implications. (p. 23)**

A Framework for K-12 Science Education*, 2011 ***Working with Big Ideas of Science Education*, 2015 **Updated May 2025

Distribution of Core Ideas of Knowing Science Across All Grade Levels

Knowing Science	Knowing Science	K	1	2	3	4	5	6	7	8	HS
P1 Physical Science	All matter in the Universe is made of very small particles.										
P2: Physical Science	Objects can affect other objects at a distance.										
P3: Physical Science	Changing the movement of an object requires a net force to be acting on it.										
P4: Physical Science	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.										

Knowing Science	Knowing Science	K	1	2	3	4	5	6	7	8	HS
E1 Earth & Space Science	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: Earth & Space Science	The Earth and our solar system are a very small part of one of many galaxies within the Universe.										

Knowing Science	Knowing Science	K	1	2	3	4	5	6	7	8	HS
L1 Life Science	Organisms are organized on a cellular basis and have a finite life span.										
L2: Life Science	Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.										
L3: Life Science	Genetic information is passed down from one generation of organisms to another.										
L4: Life Science	The unity and diversity of organisms, living and extinct, is the result of evolution.										

Arizona Science Standards Science and Engineering Practices for K-2 | For use with Arizona Science Standards

Asking Questions and Defining Problems

A science practice is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested.

- Ask questions based on observations of the natural and/or designed world.
- Define a simple problem that can be solved through the development of a new or improved object or tool.

Using Mathematics and Computational Thinking

Mathematics and computation are fundamental tools for representing physical variables and their relationships in both science and engineering,

- Decide when to use qualitative vs. quantitative data.
- Use counting and numbers to identify and describe patterns in the natural and designed worlds.
- Describe, measure, and compare quantitative attributes of different objects and display the data using simple graphs.
- Use quantitative data to compare two alternative solutions to a problem.

Engaging in Argument from Evidence

Argumentation is the process by which explanations and solutions are reached. Reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem in science and engineering.

- Identify arguments that are supported by evidence.
- Listen actively to others' explanations and arguments and ask questions for clarification.
- Make a claim about the effectiveness of an object, tool, or solution that is based on relevant evidence.

Planning and Carrying Out Investigations

Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually.

- With guidance, design and conduct investigations in collaboration with peers.
- Design and conduct investigations collaboratively.
- Evaluate different ways of observing and/or measuring an attribute of interest.
- Make direct or indirect observations and/or measurements to collect data, which can be used to make comparisons.
- Identify questions and make predictions based on prior experiences.
- Make direct or indirect observations and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal.

Developing and Using Models

A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations.

- Distinguish between a model and the actual object, process, and/or events the model represents.
- Compare models to identify common features and differences.
- Develop and/or use models (i.e., diagrams, drawings, physical replicas, dioramas, dramatizations, or storyboards) that represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed worlds.
- Develop a simple model that represents a proposed object or tool.

Obtaining, Evaluating, and Communicating Information

Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate.

- Read and comprehend grade appropriate texts and media to acquire scientific and/or technical information.
- Critique and/or communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers.
- Record observations, thoughts, and ideas.
- Explain how specific images (e.g., a diagram showing how a machine works) contribute to and clarify a text.
- Obtain information by using various text features (e.g., headings, tables of contents, glossaries, electronic menus, icons).

Constructing Explanations and Designing Solutions

The end-products of science are explanations and the end products of engineering are solutions. The goal of science is the construction of theories that provide explanatory accounts of the world. The goal of engineering design is to find a systematic solution to problems that is based on scientific knowledge and models of the material world.

- Use information from direct or indirect observations to construct explanations.
- Use tools and materials provided to design a device or solution to a specific problem.
- Distinguish between opinions and evidence in one's own explanations.
- Generate and compare multiple solutions to a problem.

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

Analyzing and Interpreting Data

Scientific investigations produce data that must be analyzed in order to derive meaning. Engineering investigations include analysis of data collected in the tests of designs.

- Use and share pictures, drawings, and/or writings of observations.
- Use observations to describe patterns and/or relationships in the natural and designed worlds in order to answer scientific questions and solve problems.
- Make measurements of length to quantify data.
- Analyze data from tests of an object or tool to determine if a proposed object or tool functions as intended.

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Arizona Science Standards Crosscutting Concepts for K-2 | For use with Arizona Science Standards

Patterns

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.
  - *What do you observe?*
  - *Is there a pattern?*
  - *What pattern do you notice?*
  - *Can you describe the pattern?*
  - *What predictions are possible based on the pattern?*
  - *What is the same? What is different?*
  - *How often does this happen?*
  - *The pattern I notice is _____.*
  - *From the pattern _____ I predict that _____ because _____ .*

Structure and Function

The way an object is shaped or structured determines many of its properties and functions.

- The shape and stability of structures of natural and designed objects are related to their function(s).
  - *How does the shape (or structure) of ... make it work better?*
  - *What material is best to ...? Why?*
  - *What is the function of ...?*
  - *How can this structure be improved?*
  - *What shape is best to ...?*
  - *How does this work?*
  - *What is the purpose of ...?*
  - *How is the structure related to the function?*
  - *The important structures of _____ are _____ , _____ , _____.*
  - *The _____ (structure) of a _____ is for _____ (function).*

Systems and System Models

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Objects and organisms can be described in terms of their parts.
- Systems in the natural and designed world have parts that work together.
  - *What are the parts that make this up?*
  - *What does each part do?*
  - *How do the parts work together?*
  - *Can you draw a picture (or diagram) of the system?*
  - *What is the system?*
  - *How do the parts of the system interact?*
  - *What process is occurring? Can you describe it?*
  - *The parts of the system are _____ , _____ , _____…*
  - *In this system _____ interacts with _____ to cause _____.*

Energy and Matter

Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.

- Objects may break into smaller pieces, be put together into larger pieces, or change shapes.
  - *What are the properties of ...?*
  - *Do the properties stay the same? Are they different?*
  - *Can you break this up into smaller pieces?*
  - *Can you put it back together again? How?*
  - *What is the weight before and after?*
  - *What happened to the energy? Where did it go?*
  - *How was the energy transferred?*
  - *How is the energy moving in/out/within/between an object(s)?*
  - *I claim that _____ (matter) changed because _____.*
  - *I noticed evidence of energy when _____ happened.*

Stability and Change

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Some things stay the same while other things change.
- Things may change slowly or rapidly.
  - *What is changing or staying the same?*
  - *Describe if this happens slow or fast.*
  - *How does this change over a long period of time?*
  - *How often does this change?*
  - *Does this have a repeating cycle or pattern?*
  - *What could you change to make this better?*
  - *Is that stable?*
  - *I claim ____ is changing/staying the same, because our evidence shows ____.*
  - *Over a long period of time, _____ stays the same/changes, because _____.*

Cause and Effect

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Events have causes that generate observable patterns.
- Simple tests can be designed to gather evidence to support or refute student ideas about causes.
  - *How/Why did that happen?*
  - *What is causing this to happen?*
  - *When will it happen again? Can you make it happen again?*
  - *What is the effect from the change?*
  - *Can you identify the cause and the effect?*
  - *What do you predict will happen if...?*
  - *How do you know that the cause and effect are connected?*
  - *One cause of _____ (effect) might be _____.*
  - *From the cause-effect relationship, I would claim that _____.*

Scale, Proportion, and Quantity

It is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change when considering phenomena,

- Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower).
- Standard units are used to measure length.
  - *Which is hotter/cooler? What is the difference in temperature?*
  - *Which is bigger/smaller? How much larger/smaller?*
  - *Which happens faster/slower? What is the difference in time?*
  - *How long does that take?*
  - *How can you measure that? What measurement could you take?*
  - *What tool and units will you use?*
  - *When comparing _____ to _____ , I noticed _____.*
  - *I used _____ units to measure because _____.*

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

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Arizona Science Standards - Kindergarten

Three Dimensions of Science

Sensemaking in science occurs with the integration of three essential dimensions.

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
- Obtain, Evaluate, and Communicate Information

Crosscutting Concepts

- Patterns
- Cause and Effect
- Structure and Function
- Systems and System Models
- Stability and Change
- Scale, Proportion, and Quantity
- Energy and Matter

Core Ideas

Core Ideas for Knowing Science

Physical Science

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

P2: Objects can affect other objects at a distance.

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

P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event.

Earth and Space Science

E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.

E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe.

Life Science

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

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

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

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

Core Ideas for Using Science

U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

Physical Science Standards

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

K.P2U1.1	Investigate how senses can detect light, sound, and vibrations even when they come from far away; use the collected evidence to develop and support an explanation.
K.P2U2.2	Design and evaluate a tool that helps people extend their senses.

Earth and Space Science Standards

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

K.E1U1.3	Observe, record, and ask questions about temperature, precipitation, and other weather data to identify patterns or changes in local weather.
K.E1U1.4	Observe, describe, ask questions, and predict seasonal weather patterns; and how those patterns impact plants and animals (including humans).
K.E2U1.5	Observe and ask questions about patterns of the motion of the sun, moon, and stars in the sky.

Life Science Standards

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; plants and animals use specialized parts to help them meet their needs and survive.

K.L1U1.6	Obtain, evaluate, and communicate information about how organisms use different body parts for survival.
K.L1U1.7	Observe, ask questions, and explain how specialized structures found on a variety of plants and animals (including humans) help them sense and respond to their environment.
K.L2U1.8	Observe, ask questions, and explain the differences between the characteristics of living and non-living things.

Key Crosscutting Concepts in Kindergarten

***Patterns**; Cause and Effect; Scale, Proportion and Quantity; Systems and System Models; Energy and Matter; **Structure and Function**; Stability and Change*

Phenomena are observable events that can be explained or explored. Science aims to explain the causes of these events, or phenomena, using scientific ideas, concepts, and practices (3-dimensions).

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Arizona Science Standards - Kindergarten

Core Ideas for Knowing Science: Elements for Physical, Earth & Space, and Life Science Standards

Elements of Physical Science Standards

K.P2U1.1 Investigate how senses can detect light, sound, and vibrations even when they come from far away; use the collected evidence to develop and support an explanation.
- People use their senses to learn about the world around them. Their eyes detect light, their ears detect sound, and they can feel vibrations by touch. (K.P2U2.2)

K.P2U2.2 Design and evaluate a tool that helps people extend their senses.
- People use their senses to learn about the world around them. Their eyes detect light, their ears detect sound, and they can feel vibrations by touch. (K.P2U1.1)
- People also use a variety of devices to communicate (send and receive information) over long distances.

Elements of Earth and Space Science Standards

K.E1U1.3 Observe, record, and ask questions about temperature, precipitation, and other weather data to identify patterns or changes in local weather.
- Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. (K.E1U1.4)
- Weather is determined by the conditions and movement of the air.

K.E1U1.4 Observe, describe, ask questions, and predict seasonal weather patterns; and how those patterns impact plants and animals (including humans).
- Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. (K.E1U1.3)

K.E2U1.5 Observe and ask questions about patterns of the motion of the sun, moon, and stars in the sky.
- Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted.

Elements of Life Science Standards

K.L1U1.6 Obtain, evaluate, and communicate information about how organisms use different body parts for survival.
- All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water, and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive, grow, and produce more plants. (K.L1U1.7)

K.L1U1.7 Observe, ask questions, and explain how specialized structures found on a variety of plants and animals (including humans) help them sense and respond to their environment.
- All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water, and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive, grow, and produce more plants. (K.L1U1.6)
- Animals have body parts that capture and convey different kinds of information needed for growth and survival—for example, eyes for light, ears for sounds, and skin for temperature or touch. Animals respond to these inputs with behaviors that help them survive (e.g., find food, run from a predator).

K.L2U1.8 Observe, ask questions, and explain the differences between the characteristics of living and non-living things.
- There is a wide variety of living things, including plants and animals. They are distinguished from non-living things by their ability to move, reproduce, and react to certain stimuli.

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

Arizona Science Standards - 1st Grade

Three Dimensions of Science

Sensemaking in science occurs with the integration of three essential dimensions.

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
- Obtain, Evaluate, and Communicate Information

Crosscutting Concepts

- Patterns
- Cause and Effect
- Structure and Function
- Systems and System Models
- Stability and Change
- Scale, Proportion, and Quantity
- Energy and Matter

Core Ideas

Core Ideas for Knowing Science

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U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

Physical Science Standards

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, as well as light and materials including the ability of sound and light to travel from place to place.

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.
1.P2U1.2	Use models to provide evidence that vibrating matter creates sound and sound can make matter vibrate.
1.P3U1.3	Plan and carry out investigations which demonstrate how equal forces can balance objects and how unequal forces can push, pull, or twist objects, making them change their speed, direction, or shape.
1.P4U2.4	Design and evaluate ways to increase or reduce heat from friction between two objects.

Earth and Space Science Standards

Students develop an understanding that earth materials are essential for organism's survival.

1.E1U1.5	Obtain, evaluate, and communicate information about the properties of Earth materials and investigate how humans use natural resources in everyday life.

Life Science Standards

Students develop an understanding that Earth has supported, and continues to support, a large variety of organisms. These organisms 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.

1.L1U1.6	Observe, describe, and predict life cycles of animals and plants.
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.
1.L2U1.8	Construct an explanation describing how organisms obtain resources from the environment including materials that are used again by other organisms.
1.L3U1.9	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.
1.L4.U1.10	Develop a model to describe how animals and plants are classified into groups and subgroups according to their similarities.
1.L4.U3.11	Ask questions and explain how factors can cause species to go extinct.

Phenomena are observable events that can be explained or explored. Science aims to explain the causes of these events, or phenomena, using scientific ideas, concepts, and practices (3-dimensions).

Key Crosscutting Concepts in 1st Grade

*Patterns; **Cause and Effect;** Scale, Proportion and Quantity; Systems and System Models; Energy and Matter; Structure and Function; **Stability and Change***

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Arizona Science Standards - 1st Grade

Core Ideas for Knowing Science: Elements for Physical, Earth & Space, and Life Science Standards

Elements of Physical Science Standards

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.
- Some materials allow light to pass through them, others allow only some light through, and others block all the light and create a dark shadow on any surface beyond them where the light cannot reach. Mirrors can be used to redirect a light beam.

Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.

1.P2U1.2 Use models to provide evidence that vibrating matter creates sound and sound can make matter vibrate.
- Sound can make matter vibrate, and vibrating matter can make sound.
- Sound comes from things that vibrate and can be detected at a distance from the source because the air or other material around is made to vibrate. Sounds are heard when the vibrations in the air enter our ears.

1.P3U1.3 Plan and carry out investigations which demonstrate how equal forces can balance objects and how unequal forces can push, pull, or twist objects, making them change their speed, direction, or shape.
- Forces can push, pull or twist objects, making them change their motion or shape.
- Pushes and pulls can have different strengths and directions.
- Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.
- The movement of objects is changed if the forces acting on them are not in balance.

1.P4U2.4 Design and evaluate ways to increase or reduce heat from friction between two objects.
- When two objects rub against each other, this is called friction.
- Friction between two surfaces can warm both of them (e.g., rubbing hands together).
- There are ways to reduce the friction between two objects.

Elements of Earth and Space Science Standards

1.E1U1.5 Obtain, evaluate, and communicate information about the properties of Earth materials and investigate how humans use natural resources in everyday life.
- Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

Elements of Life Science Standards

1.L1U1.6 Observe, describe, and predict life cycles of animals and plants.
- Adult plants and animals can have young.
- Plants and animals grow and change. Plants and animals have predictable characteristics at different stages of development.

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.
- All animals need food in order to live and grow. They obtain their food from plants or from other animals. (1.L2U1.8)
- Plants depend on air, water, minerals (in the soil), and light to grow. (1.L2U1.8)
- Animals can move around, but plants cannot, and they often depend on animals for pollination or to move their seeds around. (1.L2U1.8)
- Animals depend on their surroundings to get what they need, including food, water, shelter, and a favorable temperature.
- Organisms obtain the materials they need to grow and survive from the environment. Many of these materials come from organisms and are used again by other organisms. (1.L2U1.8)

1.L2U1.8 Construct an explanation describing how organisms obtain resources from the environment including materials that are used again by other organisms.
- All animals need food in order to live and grow. They obtain their food from plants or from other animals. (1.L2U2.7)
- Plants depend on air, water, minerals (in the soil), and light to grow. (1.L2U2.7)
- Animals can move around, but plants cannot, and they often depend on animals for pollination or to move their seeds around. (1.L2U2.7)
- Different plants survive better in different settings because they have varied needs for water, minerals, and sunlight.
- Organisms obtain the materials they need to grow and survive from the environment. Many of these materials come from organisms and are used again by other organisms. (1.L2U1.7)

1.L3U1.9 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.
- Living things produce offspring of the same kind, but offspring are not identical with each other or with their parents.
- Plants and animals, including humans, resemble their parents in many features because information is passed from one generation to the next.
- Organisms have characteristics that can be similar or different.

1.L4.U1.10 Develop a model to describe how animals and plants are classified into groups and subgroups according to their similarities.
- Animals and plants are classified into groups and subgroups according to their similarities.

1.L4.U3.11 Ask questions and explain how factors can cause species to go extinct.
- There are many different kinds of plants and animals in the world today and many kinds that once lived but are now extinct.
- Living things can survive only where their needs are met. If some places are too hot or too cold or have too little water or food, plants and animals may not be able to live there.

Arizona Science Standards - 2nd Grade

Three Dimensions of Science

Sensemaking in science occurs with the integration of three essential dimensions.

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
- Obtain, Evaluate, and Communicate Information

Crosscutting Concepts

- Patterns
- Cause and Effect
- Structure and Function
- Systems and System Models
- Stability and Change
- Scale, Proportion, and Quantity
- Energy and Matter

Core Ideas

Core Ideas for Knowing Science

Physical Science

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

P2: Objects can affect other objects at a distance.

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

P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event.

Earth and Space Science

E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.

E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe.

Life Science

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

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

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

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

Core Ideas for Using Science

U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

Physical Science Standards

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

2.P1U1.1	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.
2.P1U1.2	Plan and carry out investigations to gather evidence to support an explanation on how heating or cooling can cause a phase change in matter.
2.P4U1.3	Obtain, evaluate and communicate information about ways heat energy can cause change in objects or materials.

Life Science Standards

Students develop an understanding that life on Earth depends on energy from the Sun or energy from other organisms to survive.

2.L2U1.9	Obtain, analyze, and communicate evidence that organisms need a source of energy, air, water, and certain temperature conditions to survive.
2.L2U1.10	Develop a model representing how life on Earth depends on energy from the Sun and energy from other organisms.

Phenomena are observable events that can be explained or explored. Science aims to explain the causes of these events, or phenomena, using scientific ideas, concepts, and practices (3-dimensions).

Earth and Space Science Standards

Students develop an understanding of the distribution and role of water and wind in weather, shaping the land, and where organisms live. Wind and water can also change environments, and students learn humans and other organisms can change environments too. Students develop an understanding of changing patterns in the sky including the position of Sun, Moon, and stars, and the apparent shape of the Moon.

2.E1U1.4	Observe and investigate how wind and water change the shape of the land resulting in a variety of landforms.
2.E1U1.5	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.
2.E1U2.6	Analyze patterns in weather conditions of various regions of the world and design, test, and refine solutions to protect humans from severe weather conditions.
2.E1U3.7	Construct an argument from evidence regarding positive and negative changes in water and land systems that impact humans and the environment.
2.E2U1.8	Observe and explain the Sun's position at different times during a twenty-four-hour period and changes in the apparent shape of the Moon from one night to another.

Key Crosscutting Concepts in 2rd Grade

Patterns; Cause and Effect; Scale, Proportion and Quantity; ***Systems and System Models; Energy and Matter****; Structure and Function; Stability and Change*

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Arizona Science Standards - 2nd Grade

Core Ideas for Knowing Science: Elements for Physical, Earth & Space, and Life Science Standards

Elements of Physical Science Standards

2.P1U1.1 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.
- All the 'stuff' encountered in everyday life, including air, water, and different kinds of solid substances, is called matter because it has mass and takes up space.
- Different materials are recognizable by their properties, some of which are used to classify them as being solid or liquid, depending on temperature. Matter can be described by its observable properties. (2.P1U1.2)

Note: According to the text, Disciplinary Core Ideas: Teaching & Learning, the study of states of matter are limited to studying solids and liquids, gases are not included. Since gases cannot be observed and are therefore much more difficult to study, students should not be asked to study gases till they are able to use equipment to make observations of gases. (Disciplinary Core Ideas: Teaching & Learning (pg.17))

2.P1U1.2 Plan and carry out investigations to gather evidence to support an explanation on how heating or cooling can cause a phase change in matter.
- Different materials are recognizable by their properties, some of which are used to classify them as being solid or liquid, depending on temperature. (2.P1U1.1)
- Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.
- Heating can cause change, as in cooking, melting solids or changing water to vapor.

2.P4U1.3 Obtain, evaluate and communicate information about ways heat energy can cause change in objects or materials.
- Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.

Elements of Life Science Standards

2.L2U1.9 Obtain, analyze, and communicate evidence that organisms need a source of energy, air, water, and certain temperature conditions to survive.
- All living things need food as their source of energy as well as air, water, and certain temperature conditions. Plants can use sunlight to make the food they need and can store food that they do not immediately use. (2.L2U1.10)
- Animals need food that they can break down, which comes either directly by eating plants or by eating animals which have eaten plants or other animals. Animals are ultimately dependent on plants for their survival. (2.L2U1.10)

2.L2U1.10 Develop a model representing how life on Earth depends on energy from the Sun and energy from other organisms.
- All living things need food as their source of energy as well as air, water, and certain temperature conditions. Plants use sunlight to make the food they need and can store food that they do not immediately use. (2.L2U1.9)
- Animals need food that they can break down, which comes either directly by eating plants or by eating animals which have eaten plants or other animals. Animals are ultimately dependent on plants for their survival. (2.L2U1.9)
- The relationships among organisms can be represented as a food chain.

Elements of Earth and Space Science Standards

2.E1U1.4 Observe and investigate how wind and water change the shape of the land resulting in a variety of landforms.
- Wind and water can change the shape of the land.

2.E1U1.5 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 is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.

2.E1U2.6 Analyze patterns in weather conditions of various regions of the world and design, test, and refine solutions to protect humans from severe weather conditions.
- Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events.
- The temperature, pressure, direction, speed of movement and the amount of water vapor in the air combine to create the weather. Measuring these properties over time enables patterns to be found that can be used to predict the weather.

2.E1U3.7 Construct an argument from evidence regarding positive and negative changes in water and land systems that impact humans and the environment.
- Plants and animals can change their environment.
- Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air and other living things.

2.E2U1.8 Observe and explain the Sun's position at different times during a twenty-four-hour period and changes in the apparent shape of the Moon from one night to another.
- There are patterns in the position of the Sun seen at different times of the day and in the shape of the Moon from one night to another.

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

Arizona Science Standards Science and Engineering Practices for 3-5 | For use with Arizona Science Standards

Asking Questions and Defining Problems

A science practice is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested.

- Identify scientific (testable) and non-scientific (non-testable) questions.
- Ask questions based on careful observations of phenomena and information.
- Ask questions to clarify ideas or request evidence.
- Ask questions that relate one variable to another variable.
- Ask questions to clarify the constraints of solutions to a problem.
- Use prior knowledge to describe problems that can be solved.
- Define a simple design problem that can be solved through the development of an object, tool or process and includes several criteria for success and constraints on materials, time, or cost.
- Formulate questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.

Developing and Using Models

A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations.

- Develop and revise models collaboratively to measure and explain frequent and regular events.
- Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.
- Use simple models to describe or support explanations for phenomena and test cause and effect relationships or interactions concerning the functioning of a natural or designed system.
- Identify limitations of models.
- Develop a diagram or simple physical prototype to convey a proposed object, tool or process.
- Use a simple model to test cause and effect relationships concerning the functioning of a proposed object, tool or process.

Planning and Carrying Out Investigations

Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually.

- Design and conduct investigations collaboratively, using fair tests in which variables are controlled and the number of trials considered.
- Evaluate appropriate methods and tools for collecting data.
- Make observations and/or measurements, collect appropriate data, and identify patterns that provide evidence for an explanation of a phenomenon or test a design solution.
- Make measurements of two different models of the same proposed object, tool or process to determine which better meets criteria for success.

Analyzing and Interpreting Data

Scientific investigations produce data that must be analyzed in order to derive meaning. Engineering investigations include analysis of data collected in the tests of designs.

- Display data in tables and graphs, using digital tools when feasible, to reveal patterns that indicate relationships.
- Use data to evaluate claims about cause and effect.
- Compare data collected by different groups in order to discuss similarities and differences in their findings.
- Use data to evaluate and refine design solutions.
- Interpret data to make sense of and explain phenomena, using logical reasoning, mathematics, and/or computation.
- Analyze data to refine a problem statement or the design of a proposed object, tool or process.

Constructing Explanations and Designing Solutions

The end-products of science are explanations and the end products of engineering are solutions. The goal of science is the construction of theories that provide explanatory accounts of the world. The goal of engineering design is to find a systematic solution to problems that is based on scientific knowledge and models of the material world.

- Construct explanations of observed quantitative relationships (e.g., the distribution of plants in the backyard).
- Use evidence (e.g., measurements, observations, patterns) to construct a scientific explanation or design a solution to a problem.
- Identify the evidence that supports particular points in an explanation.
- Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.
- Apply scientific knowledge to solve design problems.
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the problem.

Obtaining, Evaluating, and Communicating Information

Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate.

- Compare and/or combine across complex texts and/or other reliable media to acquire appropriate scientific and/or technical information.
- Determine the main idea of a scientific text and explain how it is supported by key details; summarize the text.
- Combine information in written text with that contained in corresponding tables, diagrams, and/or charts.
- Use multiple sources to generate and communicate scientific and/or technical information orally and/or in written formats, including various forms of media and may include tables, diagrams, and charts.
- Use models to share findings or solutions in oral and/or written presentations, and/or extended discussions.
- Obtain and combine information from books and/or other reliable media about potential solutions to a specific design problem.

Engaging in Argument from Evidence

Argumentation is the process by which explanations and solutions are reached. Reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem in science and engineering.

- Construct and/or support scientific arguments with evidence, data, and/or a model.
- Compare and refine arguments based on the strengths and weaknesses of the evidence presented.
- Respectfully provide and receive critiques on scientific arguments with peers by citing relevant evidence and posing specific questions.
- Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

Using Mathematics and Computational Thinking

Mathematics and computation are fundamental tools for representing physical variables and their relationships in both science and engineering,

- Use mathematical thinking and/or computational outcomes to compare alternative solutions to an engineering problem.
- Organize simple data sets to reveal patterns that suggest relationships.
- Describe, measure, estimate, and graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems.
- Decide if qualitative or quantitative data is best to determine whether a proposed object or tool meets criteria for success.

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

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Arizona Science Standards Crosscutting Concepts for 3-5 | For use with Arizona Science Standards

Patterns

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products.
- Patterns of change can be used to make predictions.
- Patterns can be used as evidence to support an explanation.
  - *What do you observe?*
  - *Is there a pattern?*
  - *What pattern do you notice?*
  - *Can you describe the pattern?*
  - *How would you classify this pattern?*
  - *What predictions are possible based on the pattern?*
  - *What is the same? What is different?*
  - *How often does this happen?*
  - *The pattern I notice is _____.*
  - *From the pattern _____ I predict that _____ because _____.*

Stability and Change

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Change is measured in terms of differences over time and may occur at different rates.
- Some systems appear stable, but over long periods of time will eventually change.
  - *What is changing or staying the same?*
  - *Describe if this happens slow or fast.*
  - *How does this change over a long period of time?*
  - *How often does this change?*
  - *Does this have a repeating cycle or pattern?*
  - *What could you change to make this better?*
  - *I claim ___ is changing/staying the same, because our evidence shows ____.*
  - *Over a long period of time, _____ stays the same/changes, because _____.*

Structure and Function

The way an object is shaped or structured determines many of its properties and functions.

- Different materials have different substructures, which can sometimes be observed.
- Substructures have shapes and parts that serve functions.
  - *How does the shape (or structure) of ... make it work better?*
  - *What material is best to ...? Why?*
  - *What is the function of ...?*
  - *How can this structure be improved?*
  - *What shape is best to ...?*
  - *How does this work?*
  - *What is the purpose of ...?*
  - *How is the structure related to the function?*
  - *The important structures of _____ are _____ , _____ , _____.*
  - *The _____ (structure) of a _____ is for _____ function).*

Energy and Matter

Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.

- Matter is made of particles.
- Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems.
- Energy can be transferred in various ways and between objects.
  - *What are the properties of ...?*
  - *Do the properties stay the same? Are they different?*
  - *Can you break this up into smaller pieces?*
  - *Can you put it back together again? How?*
  - *What is the weight before and after?*
  - *What happened to the energy? Where did it go?*
  - *How was the energy transferred?*
  - *How is the energy moving in/out/within/between an object(s)?*
  - *I claim that _____ (matter) changed because _____.*
  - *I noticed evidence of energy when _____ happened.*

Systems and System Models

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.
- A system can be described in terms of its components and their interactions.
  - *What are the parts that make this up?*
  - *What does each part do?*
  - *How do the parts work together?*
  - *Can you draw a picture (or diagram) of the system?*
  - *What is the system?*
  - *How do the parts of the system interact?*
  - *What process is occurring? Can you describe it?*
  - *The parts of the system are _____ , _____ , _____…*
  - *In this system _____ interacts with _____ to cause _____.*

Cause and Effect

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Cause and effect relationships are routinely identified, tested, and used to explain change.
- Events that occur together with regularity might or might not be a cause and effect relationship.
  - *How/Why did that happen?*
  - *What is causing this to happen?*
  - *When will it happen again? Can you make it happen again?*
  - *What is the effect from the change?*
  - *How can you show that this caused?*
  - *Can you identify the cause and the effect?*
  - *What do you predict will happen if...?*
  - *How do you know that the cause and effect are connected?*
  - *One cause of _____ (effect) might be _____.*
  - *From the cause effect relationship, I would claim that _____.*

Scale, Proportion, and Quantity

It is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change when considering phenomena,

- Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods.
- Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.
  - *Which is bigger/smaller? How much larger/smaller?*
  - *Which is hotter/cooler? What is the difference in temperature?*
  - *Which happens faster/slower? What is the difference in time?*
  - *How long does that take?*
  - *Is that a long time or a short time?*
  - *How can you measure that? What tool and units will you use?*
  - *What measurement could you take?*
  - *When comparing _____ to _____ , I noticed _____.*
  - *I used _____ units to measure because _____.*

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Arizona Science Standards - 3rd Grade

Three Dimensions of Science

Sensemaking in science occurs with the integration of three essential dimensions.

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
- Obtain, Evaluate, and Communicate Information

Crosscutting Concepts

- Patterns
- Cause and Effect
- Structure and Function
- Systems and System Models
- Stability and Change
- Scale, Proportion, and Quantity
- Energy and Matter

Core Ideas

Core Ideas for Knowing Science

Physical Science

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

P2: Objects can affect other objects at a distance.

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

P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event.

Earth and Space Science

E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.

E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe.

Life Science

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

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

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

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

Core Ideas for Using Science

U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

Physical Science Standards

Students develop an understanding of the sources, properties, and characteristics of energy along with the relationship between energy transfer and the human body.

3.P2U1.1	Ask questions and investigate the relationship between light, objects, and the human eye.
3.P2U1.2	Plan and carry out an investigation to explore how sound waves affect objects at varying distances.
3.P4U1.3	Develop and use models to describe how light and sound waves transfer energy.

Earth and Space Science Standards

Students develop an understanding of how the Sun provides light and energy for Earth systems.

3.E1U1.4	Construct an explanation describing how the Sun is the primary source of energy impacting Earth systems.

Life Science Standards

Students develop an understanding of the flow of energy in a system beginning with the Sun to and among organisms They also understand that plants and animals (including humans) have specialized internal and external structures and can respond to stimuli to increase survival.

3.L1U1.5	Develop and use models to explain that plants and animals (including humans) have internal and external structures that serve various functions that aid in growth, survival, behavior, and reproduction.
3.L1U1.6	Plan and carry out investigations to demonstrate ways plants and animals react to stimuli.
3.L2U1.7	Develop and use system models to describe the flow of energy from the Sun to and among living organisms.
3.L2U1.8	Construct an argument from evidence that organisms are interdependent.

Phenomena are observable events that can be explained or explored. Science aims to explain the causes of these events, or phenomena, using scientific ideas, concepts, and practices (3-dimensions).

Key Crosscutting Concepts in 3rd Grade

Patterns; Cause and Effect; Scale, Proportion and Quantity; ***Systems and System Models****; Energy and Matter;* ***Structure and Function****; Stability and Change*

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Arizona Science Standards - 3rd Grade

Core Ideas for Knowing Science: Elements for Physical, Earth & Space, and Life Science Standards

Elements of Physical Science Standards

3.P2U1.1 Ask questions and investigate the relationship between light, objects, and the human eye.
- An object can be seen when light reflected from its surface enters the eyes; the color people see depends on the color of the available light sources as well as the properties of the surface.

Clarification Statement: This phenomenon is observed, but no attempt is made to discuss what confers the color reflection and absorption properties on a surface. The stress is on understanding that light traveling from the object to the eye determines what is seen.

3.P2U1.2 Plan and carry out an investigation to explore how sound waves affect objects at varying distances.
- Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).
- Sound comes from things that vibrate and can be detected at a distance from the source because the air or other material around is made to vibrate. Sounds are heard when the vibrations in the air enter our ears.

3.P4U1.3 Develop and use models to describe how light and sound waves transfer energy.
- Energy can be moved from place to place by moving objects or through sound or light.

Boundary: At this grade level, no attempt is made to give a precise or complete definition of energy.

Elements of Earth and Space Science Standards

3.E1U1.4 Construct an explanation describing how the Sun is the primary source of energy impacting Earth systems.
- Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans).
- Radiation from the Sun heats the Earth's surface.
- Energy radiated from the sun is transferred to Earth by light. When this light is absorbed, it warms Earth's land, air, and water and facilitates plant growth.

Elements of Life Science Standards

3.L1U1.5 Develop and use models to explain that plants and animals (including humans) have internal and external structures that serve various functions that aid in growth, survival, behavior, and reproduction.
- Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

3.L1U1.6 Plan and carry out investigations to demonstrate ways plants and animals react to stimuli.
- Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions.

3.L2U1.7 Develop and use system models to describe the flow of energy from the Sun to and among living organisms.
- The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants. Either way, they are "consumers."
- Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil for plants to use. (3.L2U1.8)
- Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life.

3.L2U1.8 Construct an argument from evidence that organisms are interdependent.
- Animals need food that they can break down, which comes either directly by eating plants (herbivores) or by eating animals (carnivores) which have eaten plants or other animals.
- Animals are ultimately dependent on plants for their survival. The relationships among organisms can be represented as food chains and food webs. Some animals are dependent on plants in other ways as well as for food. Plants also depend on animals in various ways. (3.L2U1.8)

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

Arizona Science Standards - 4th Grade

Three Dimensions of Science

Sensemaking in science occurs with the integration of three essential dimensions.

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
- Obtain, Evaluate, and Communicate Information

Crosscutting Concepts

- Patterns
- Cause and Effect
- Structure and Function
- Systems and System Models
- Stability and Change
- Scale, Proportion, and Quantity
- Energy and Matter

Core Ideas

Core Ideas for Knowing Science

Physical Science

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

P2: Objects can affect other objects at a distance.

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

P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event.

Earth and Space Science

E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.

E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe.

Life Science

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

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

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

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

Core Ideas for Using Science

U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

Physical Science Standards

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.

4.P4U1.1	Develop and use a model to demonstrate how a system transfers energy from one object to another even when the objects are not touching.
4.P4U1.2	Develop and use a model that explains how energy is moved from place to place through electric currents.
4.P2U1.3	Develop and use a model to demonstrate magnetic forces.
4.P4U3.4	Engage in argument from evidence on the use and impact of renewable and nonrenewable resources to generate electricity.

Life Science Standards

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

4.L4U1.11	Analyze and interpret environmental data to demonstrate that species either adapt and survive or go extinct over time.

Phenomena are observable events that can be explained or explored. Science aims to explain the causes of these events, or phenomena, using scientific ideas, concepts, and practices (3-dimensions).

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Earth and Space Science Standards

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

4.E1U1.5	Use models to explain seismic waves and their effect on the Earth.
4.E1U1.6	Plan and carry out an investigation to explore and explain the interactions between Earth's major systems and the impact on Earth's surface materials and processes.
4.E1U1.7	Develop and/or revise a model using various rock types, fossil location, and landforms to show evidence that Earth's surface has changed over time.
4.E1U1.8	Collect, analyze, and interpret data to explain weather and climate patterns.
4.E1U3.9	Construct and support an evidence-based argument about the availability of water and its impact on life.
4.E1U2.10	Define problem(s) and design solution(s) to minimize the effects of natural hazards.

Key Crosscutting Concepts in 4th Grade

Patterns; Cause and Effect; Scale, Proportion and Quantity; ***Systems and System Models****;* ***Energy and Matter****; Structure and Function;* ***Stability and Change***

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Arizona Science Standards - 4th Grade

Core Ideas for Knowing Science: Elements for Physical, Earth & Space, and Life Science Standards

Elements of Physical Science Standards

4.P4U1.1 Develop and use a model to demonstrate how a system transfers energy from one object to another even when the objects are not touching.
- Energy is transferred from one object, which is an energy source or resource, to another.
- Energy is present whenever there are moving objects, sound, light, or heat. (4.P4U1.2)

4.P4U1.2 Develop and use a model that explains how energy is moved from place to place through electric currents.
- Energy is present whenever there are moving objects, sound, light, or heat. (4.P4U1.1)
- Energy can be moved from place to place by moving objects or through sound or light, or electric currents.

Boundary: At this grade level, no attempt is made to give a precise or complete definition of energy.
- Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.
- Light also transfers energy from place to place through electric currents.

4.P2U1.3 Develop and use a model to demonstrate magnetic forces.
- Magnetic forces between a pair of objects do not require that the objects be in contact. The size of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.

4.P4U3.4 Engage in argument from evidence on the use and impact of renewable and nonrenewable resources to generate electricity.
- The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use.
- Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.

Elements of Life Science Standards

4.L4U1.11 Analyze and interpret environmental data to demonstrate that species either adapt and survive or go extinct over time.
- When the environment changes in ways that affect a place’s physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die.
- Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments.
- For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

Elements of Earth and Space Science Standards

4.E1U1.5 Use models to explain seismic waves and their effect on the Earth.
- Earthquakes cause seismic waves, which are waves of motion in Earth’s crust.
- Energy originates from the sun and from Earth’s interior. Transfers of energy and the movements of matter can cause physical changes among Earth’s materials and living organisms.
- Local, regional, and global patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. (4.E1U1.7)

4.E1U1.6 Plan and carry out an investigation to explore and explain the interactions between Earth’s major systems and the impact on Earth’s surface materials and processes.
- Earth’s major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth’s surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.
- The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans.
- Rainfall helps shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4.E1U1.7)

4.E1U1.7 Develop and/or revise a model using various rock types, fossil location, and landforms to show evidence that Earth’s surface has changed over time.
- Local, regional, and global patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. (4.E1U1.5)
- Rainfall helps shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4.E1U1.6)
- Earth has changed over time. Understanding how landforms develop, are weathered (broken down into smaller pieces), and erode (get transported elsewhere) can help infer the history of the current landscape.

4.E1U1.8 Collect, analyze, and interpret data to explain weather and climate patterns.
- Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.
- Climate describes the ranges of an area’s typical weather conditions and the extent to which those conditions vary over years.

4.E1U3.9 Construct and support an evidence-based argument about the availability of water and its impact on life.
- Nearly all of Earth's available water is in the ocean. Most freshwater is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.
- About two-thirds of the surface of the Earth is covered by liquid water, which is essential to life.

4.E1U2.10 Define problem(s) and design solution(s) to minimize the effects of natural hazards.
- A variety of hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.

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Arizona Science Standards - 5th Grade

Three Dimensions of Science

Sensemaking in science occurs with the integration of three essential dimensions.

Science and Engineering Practices

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Crosscutting Concepts

- Patterns
- Cause and Effect
- Structure and Function
- Systems and System Models
- Stability and Change
- Scale, Proportion, and Quantity
- Energy and Matter

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Core Ideas for Knowing Science

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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.

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Life Science

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

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Core Ideas for Using Science

U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

Physical Science Standards

Students develop an understanding that changes can occur to matter/objects on Earth or in space, but both energy and matter follow the pattern of being conserved during those changes.

5.P1U1.1	Analyze and interpret data to explain that matter of any type can be subdivided into particles too small to see and, in a closed system, if properties change or chemical reactions occur, the amount of matter stays the same.
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.
5.P2U1.3	Construct an explanation using evidence to demonstrate that objects can affect other objects even when they are not touching.
5.P3U1.4	Obtain, analyze, and communicate evidence of the effects that balanced and unbalanced forces have on the motion of objects.
5.P3U2.5	Define problems and design solutions pertaining to force and motion.
5.P4U1.6	Analyze and interpret data to determine how and where energy is transferred when objects move.

Key Crosscutting Concepts in 5th Grade

***Patterns**; Cause and Effect; **Scale, Proportion and Quantity**; Systems and System Models; Energy and Matter; Structure and Function; Stability and Change*

Phenomena are observable events that can be explained or explored. Science aims to explain the causes of these events, or phenomena, using scientific ideas, concepts, and practices (3-dimensions).

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Earth and Space Science Standards

Students develop an understanding of the how gravitational forces in space cause observable patterns due to the position of Earth, Sun, Moon, and stars.

5.E2U1.7	Develop, revise, and use models based on evidence to construct explanations about the movement of the Earth and Moon within our solar system.
5.E2U1.8	Obtain, analyze, and communicate evidence to support an explanation that the gravitational force of Earth on objects is directed toward the planet's center.

Life Science Standards

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

5.L3U1.9	Obtain, evaluate, and communicate information about patterns between the offspring of plants, and the offspring of animals (including humans); construct an explanation of how genetic information is passed from one generation to the next.
5.L3U1.10	Construct an explanation based on evidence that the changes in an environment can affect the development of the traits in a population of organisms.
5.L4U3.11	Obtain, evaluate, and communicate evidence about how natural and human-caused changes to habitats or climate can impact populations.
5.L4U3.12	Construct an argument based on evidence that inherited characteristics can be affected by behavior and/or environmental conditions.

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Arizona Science Standards - 5th Grade

Core Ideas for Knowing Science: Elements for Physical, Earth & Space, and Life Science Standards

Elements of Physical Science Standards

5.P1U1.1 Analyze and interpret data to explain that matter of any type can be subdivided into particles too small to see and, in a closed system, if properties change or chemical reactions occur, the amount of matter stays the same.
- Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means.
- The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish.
- No matter what reaction or change in properties occurs, the amount of matter does not change. (5.P1U1.2)

Boundary: At this grade level, mass and weight are not distinguished and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.

5.P1U1.2 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.
- When two or more different substances are mixed, a new substance with different properties may be formed. Other substances simply mix without changing permanently and can often be separated again.

Boundary: At this grade level, mass and weight are not distinguished and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.

5.P2U1.3 Construct an explanation using evidence to demonstrate that objects can affect other objects even when they are not touching.
- 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 (e.g. visible light).
- Electric, magnetic, and gravitational forces between a pair of objects do not require that the objects be in contact.
- The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5.E2U1.8)

5.P3U1.4 Obtain, analyze, and communicate evidence of the effects that balanced and unbalanced forces have on the motion of objects.
- Each force acts on one particular object and has both a strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (5.P3U2.5)

Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.
- Objects in contact exert forces on each other.
- How quickly an object's motion is changed depends on the force acting and the object's mass. The greater the mass of an object, the longer it takes to speed it up or slow it down. (5.P3U2.5)

Boundary: At this grade level, mass and weight are not distinguished and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.

5.P3U2.5 Define problems and design solutions pertaining to force and motion.
- Each force acts on one particular object and has both a strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (5.P3U1.4)

Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.
- The patterns of an object's motion in various situations can be observed and measured; when past motion exhibits a regular pattern, future motion can be predicted from it.

Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.
- How quickly an object's motion is changed depends on the force acting and the object's mass. The greater the mass of an object, the longer it takes to speed it up or slow it down. (5.P3U1.4)

5.P4U1.6 Analyze and interpret data to determine how and where energy is transferred when objects move.
- The faster a given object is moving, the more energy it possesses.
- Energy can be moved from place to place by moving objects.
- When objects collide, the contact forces transfer energy so as to change the objects' motions.
- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.

Elements of Earth and Space Science Standards

5.E2U1.7 Develop, revise, and use models based on evidence to construct explanations about the movement of the Earth and Moon within our solar system.
- The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the Sun and Moon at different times of the day, month, and year.

5.E2U1.8 Obtain, analyze, and communicate evidence to support an explanation that the gravitational force of Earth on objects is directed toward the planet's center.
- Gravity is the universal attraction between all objects, however large or small, although it is only apparent when one of the objects is very large.
- The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5.P2U1.3)

Elements of Life Science Standards

5.L3U1.9 Obtain, evaluate, and communicate information about patterns between the offspring of plants, and the offspring of animals (including humans); construct an explanation of how genetic information is passed from one generation to the next.
- Many characteristics of organisms are inherited from their parents.
- Different organisms vary in how they look and function because they have different inherited information.

5.L3U1.10 Construct an explanation based on evidence that the changes in an environment can affect the development of the traits in a population of organisms.
- Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (5.L4U3.12)
- The environment also affects the traits that an organism develops. Differences in where they grow or in the food they consume may cause organisms that are related to end up looking or behaving differently.

5.L4U3.11 Obtain, evaluate, and communicate evidence about how natural and human-caused changes to habitats or climate can impact populations.
- Populations of organisms live in a variety of habitats and change in those habitats affects the organisms living there.
- Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful. For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.

5.L4U3.12 Construct an argument based on evidence that inherited characteristics can be affected by behavior and/or environmental conditions.
- Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.
- Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (5.L3U1.10)

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

ARIZONA DEPARTMENT OF EDUCATION

Arizona Science Standards Science and Engineering Practices for 6-8 | For use with Arizona Science Standards

Asking Questions and Defining Problems

A science practice is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested.

- Ask questions that arise from careful observation of phenomena, models, or unexpected results.
- Ask questions to clarify or identify evidence and the premise(s) of an argument.
- Ask questions to determine relationships between independent and dependent variables.
- Ask questions that challenge the interpretation of a data set.
- Ask questions to clarify and refine a model, an explanation, or an engineering problem.
- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
- Formulate a question that can be investigated within the scope of the classroom, school laboratory, or field with available resources and, when appropriate, frame a hypothesis (a possible explanation that predicts a particular and stable outcome) based on a model or theory.

Using Mathematics and Computational Thinking

Mathematics and computation are fundamental tools for representing physical variables and their relationships in both science and engineering.

- Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.
- Create algorithms (a series of ordered steps) to solve a problem.
- Apply concepts of ratio, rate, percent, basic operations, and simple algebra to scientific and engineering questions and problems.
- Use mathematical arguments to describe and support scientific conclusions and design solutions.
- Use digital tools, mathematical concepts, and arguments to test and compare proposed solutions to an engineering design problem.

Obtaining, Evaluating, and Communicating Information

Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate.

- Communicate scientific information and/or technical information (e.g. about a proposed object, tool, process, system) in different formats (e.g., verbally, graphically, textually, and mathematically).
- Gather, read, and communicate information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used.
- Read critically using scientific knowledge and reasoning to evaluate data, hypotheses, conclusions that appear in scientific and technical texts in light of competing information or accounts; provide an accurate summary of the text distinct from prior knowledge or opinions.
- Critically evaluate whether or not technical information on a device, tool or process is relevant to its suitability to solve a specific design problem.

Constructing Explanations and Designing Solutions

The end-products of science are explanations and the end products of engineering are solutions. The goal of science is the construction of theories that provide explanatory accounts of the world. The goal of engineering design is to find a systematic solution to problems that is based on scientific knowledge and models of the material world.

- Construct explanations for either qualitative or quantitative relationships between variables.
- Apply scientific reasoning to show why the data are adequate for the explanation or conclusion.
- Base explanations on evidence obtained from sources (including their own experiments) and the assumption that natural laws operate today as they did in the past and will continue to do so in the future.
- Undertake design projects, engaging in the design cycle, to construct and implement a solution that meets specific design criteria and constraints.
- Apply scientific knowledge and evidence to explain real-world phenomena, examples, or events.
- Construct explanations from models or representations.
- Apply scientific knowledge to design, construct, and test a design of an object, tool, process or system.
- Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and retesting.

Engaging in Argument from Evidence

Argumentation is the process by which explanations and solutions are reached. Reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem in science and engineering.

- Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation for a phenomenon or a solution to a problem.
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.
- Respectfully provide and receive critiques on scientific arguments by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.
- Compare two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.
- Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system, based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

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Analyzing and Interpreting Data

Scientific investigations produce data that must be analyzed in order to derive meaning. Engineering investigations include analysis of data collected in the tests of designs.

- Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.
- Construct, analyze, and interpret graphical displays of data to identify linear and nonlinear relationships.
- Consider limitations of data analysis (e.g., measurement error), and seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).
- Analyze and interpret data in order to determine similarities and differences in findings.
- Distinguish between causal and correlational relationships.
- Use graphical displays (e.g., maps) of large data sets to identify temporal and spatial relationships.
- Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success.

Developing and Using Models

A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations.

- Use and/or develop models to predict, describe, support explanations, and/or collect data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.
- Develop models to describe unobservable mechanisms.
- Modify models—based on their limitations—to increase detail or clarity, or to explore what will happen if a component is changed.
- Use and develop models of simple systems with uncertain and less predictable factors.
- Develop a model that allows for manipulation and testing of a proposed object, tool, process or system.
- Evaluate limitations of a model for a proposed object or tool.

Planning and Carrying Out Investigations

Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually.

- Conduct an investigation and evaluate and revise the experimental design to ensure that the data generated can meet the goals of the experiment.
- Design an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how much data are needed to support their claim.
- Evaluate the accuracy of various methods for collecting data.
- Collect data and generate evidence to answer scientific questions or test design solutions under a range of conditions.
- Collect data about the performance of a proposed object, tool, process or system under a range of conditions.

Arizona Science Standards Crosscutting Concepts for 6-8 | For use with Arizona Science Standards

Patterns

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Macroscopic patterns are related to the nature of microscopic and atomic-level structure.
- Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems.
- Patterns can be used to identify cause and effect relationships.
- Graphs, charts, and images can be used to identify patterns in data.
  - *How do you describe the pattern?*
  - *How can you use this pattern in an explanation?*
  - *Is there a way to use mathematics to describe the pattern?*
  - *What predictions are possible based on the pattern?*
  - *The pattern I notice is _____ because _____.*
  - *I can use this pattern in an explanation by _____.*
  - *From the pattern _____ I predict that _____ because _____.*

Structure and Function

The way an object is shaped or structured determines many of its properties and functions.

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.
- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
  - *How are the structures related to the functions in this scenario or investigation?*
  - *What structures are important in this scenario or investigation?*
  - *Describe a different structure that might be able to perform the same function?*
  - *The important structures are _____.*
  - *The _____ (structure) performs _____ (function).*
  - *I think that _____ (structure) could perform the same function because _____.*

Cause and Effect

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
- Cause and effect relationships may be used to predict phenomena in natural or designed systems.
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
  - *Does the effect have more than one cause?*
  - *What predictions are possible from the cause-effect relationship?*
  - *How have you used the cause-effect relationship in a scientific argument?*
  - *One cause of _____ (effect) might be _____.*
  - *From the cause-effect relationship, I would claim that _____.*
  - *I tested what I thought was the cause-effect relationship by _____ .*

Energy and Matter

Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.

- Matter is conserved because atoms are conserved in physical and chemical processes.
- Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.
- Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).
- The transfer of energy can be tracked as energy flows through a designed or natural system.
  - *How do energy changes appear in this scenario or investigation?*
  - *Describe the cycles of matter represented in this scenario or investigation.*
  - *How do energy and matter interact in this scenario or investigation?*
  - *I think energy changed because _____.*
  - *Matter in this system went from _____ to _____.*
  - *The evidence I have for matter being conserved in this system is _____.*
  - *The interaction of energy and matter in this system is observed when _____.*

Systems and System Models

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.
- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.
- Models are limited in that they only represent certain aspects of the system under study.
  - *What are the parts of the system?*
  - *Describe how the parts of the system interact.*
  - *What are the interactions of the system?*
  - *How does the model represent the system?*
  - *The parts of the system are _____ , _____ , _____...*
  - *In this system _____ interacts with _____ to cause _____.*
  - *The model I used to describe the system we studied was ____ because it ___.*

Stability and Change

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
- Small changes in one part of a system might cause large changes in another part.
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
- Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms
  - *How does the system display stability?*
  - *What changes were occurring while the system was stable?*
  - *Describe how the system is able to remain stable.*
  - *Where else have you seen this type of stability (or change)?*
  - *The system displays stability by _____.*
  - *Even though the system appears stable, I know that _____ (changes) were happening.*
  - *The reason this system can remain stable is _____.*

Scale, Proportion, and Quantity

It is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change when considering phenomena.

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
- The observed function of natural and designed systems may change with scale.
- Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.
- Scientific relationships can be represented through the use of algebraic expressions and equations.
- Phenomena that can be observed at one scale may not be observable at another scale.
  - *How does proportion fit into this scenario or investigation?*
  - *How does scale fit into this scenario or investigation?*
  - *How does quantity fit into this scenario or investigation?*
  - *Is this phenomenon visible at other scales? Explain your thinking.*
  - *In this science idea, scale is important because _____.*
  - *In this science idea, proportion is important because _____.*
  - *In this science idea, quantity is important because _____.*

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

ARIZONA DEPARTMENT OF EDUCATION

Adapted from: REGIONAL EDUCATIONAL SERVICE AGENCY www.sccresa.org to support K-12 Crosscutting Concepts

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Arizona Science Standards - 6th Grade

Three Dimensions of Science

Sensemaking in science occurs with the integration of three essential dimensions.

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
- Obtain, Evaluate, and Communicate Information

Crosscutting Concepts

- Patterns
- Cause and Effect
- Structure and Function
- Systems and System Models
- Stability and Change
- Scale, Proportion, and Quantity
- Energy and Matter

Core Ideas

Core Ideas for Knowing Science

Physical Science

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

P2: Objects can affect other objects at a distance.

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

P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event.

Earth and Space Science

E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.

E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe.

Life Science

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

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

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

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

Core Ideas for Using Science

U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

Physical Science Standards

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.

6.P1U1.1	Analyze and interpret data to show that changes in states of matter are caused by different rates of movement of atoms in solids, liquids, and gases (Kinetic Theory).
6.P1U1.2	Plan and carry out an investigation to demonstrate that variations in temperature and/or pressure affect changes in state of matter.
6.P1U1.3	Develop and use models to represent that matter is made up of smaller particles called atoms.
6.P2U1.4	Develop and use a model to predict how forces act on objects at a distance.
6.P4U2.5	Analyze how humans use technology to store (potential) and/or use (kinetic) energy.

Key Crosscutting Concepts in 6th Grade

Patterns; *Cause and Effect;* ***Scale, Proportion and Quantity***; ***Systems and System Models; Energy and Matter***; *Structure and Function; Stability and Change*

Phenomena are observable events that can be explained or explored. Science aims to explain the causes of these events, or phenomena, using scientific ideas, concepts, and practices (3-dimensions).

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ARIZONA DEPARTMENT OF EDUCATION

Earth and Space Science Standards

Students develop an understanding of how the Sun provides light and energy for Earth systems.

6.E1U1.6	Investigate and construct an explanation demonstrating that radiation from the Sun provides energy and is absorbed to warm the Earth's surface and atmosphere.
6.E2U1.7	Use ratios and proportions to analyze and interpret data related to scale, properties, and relationships among objects in our solar system.
6.E2U1.8	Develop and use models to explain how constellations and other night sky patterns appear to move due to Earth's rotation and revolution.
6.E2U1.9	Develop and use models to construct an explanation of how eclipses, moon phases, and tides occur within the Sun-Earth-Moon system.
6.E2U1.10	Use a model to show how the tilt of Earth's axis causes variations in the length of the day and gives rise to seasons.

Life Science Standards

Students develop an understanding of the flow of energy in a system beginning with the Sun to and among organisms They also understand that plants and animals (including humans) have specialized internal and external structures and can respond to stimuli to increase survival.

6.L2U3.11	Use evidence to construct an argument regarding the impact of human activities on the environment and how they positively and negatively affect the competition for energy and resources in ecosystems.
6.L2U3.12	Engage in argument from evidence to support a claim about the factors that cause species to change and how humans can impact those factors.
6.L2U1.13	Develop and use models to demonstrate the interdependence of organisms and their environment including biotic and abiotic factors.
6.L2U1.14	Construct a model that shows the cycling of matter and flow of energy in ecosystems.

Arizona Science Standards - 6th Grade

Core Ideas for Knowing Science: Elements for Physical, Earth & Space, and Life Science Standards

Elements of Physical Science Standards

6.P1U1.1 Analyze and interpret data to show that changes in states of matter are caused by different rates of movement of atoms in solids, liquids, and gases (Kinetic Theory).
- The particles are not static but move in random directions. The speed at which they move is experienced as the temperature of the material.
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with each other; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and vibrate in position but do not change relative locations.

6.P1U1.2 Plan and carry out an investigation to demonstrate that variations in temperature and/or pressure affect changes in state of matter.
- The changes of state that occur with variations in temperature or pressure can be described and predicted using models of matter.

Boundary: Predictions here are qualitative, not quantitative.

6.P1U1.3 Develop and use models to represent that matter is made up of smaller particles called atoms.
- All materials, anywhere in the universe, living and nonliving, are made of a very large numbers of basic "building blocks" called atoms, of which there are about 100 different kinds.
- The behavior and arrangement of the atoms explains the properties of different materials.

6.P2U1.4 Develop and use a model to predict how forces act on objects at a distance.
- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass.
- Forces that act at a distance (gravitational, electric, and magnetic) can be explained by force fields that extend through space and can be mapped by their effect on a test object (a ball, a charged object, or a magnet, respectively). (7.P2U1.2)

Note: Gravitational force is a suggested focus for 6th grade; It is suggested that all 3 forces be focused on in 7th grade.

6.P4U2.5 Analyze how humans use technology to store (potential) and/or use (kinetic) energy.
- Objects can have stored energy (that is, the ability to make things change) either because of their chemical composition, their movement, their temperature, their position in a gravitational or other field.
- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- A system of objects may also contain stored (potential) energy, depending on their relative positions.

Elements of Earth and Space Science Standards

6.E1U1.6 Investigate and construct an explanation demonstrating that radiation from the Sun provides energy and is absorbed to warm the Earth's surface and atmosphere.
- The radiation from the Sun absorbed by the Earth warms the surface which then emits radiation of longer wavelength (infrared) that does not pass through the atmosphere but is absorbed by it, keeping the Earth warm.
- Greenhouse gases in the atmosphere absorb and retain the energy radiated from land and ocean surfaces, thereby regulating Earth's average surface temperature and keeping it habitable.

6.E2U1.7 Use ratios and proportions to analyze and interpret data related to scale, properties, and relationships among objects in our solar system.
- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.

Note: Utilize the Crosscutting Concept Scale, Proportion, and Quantity 6-8 elements when teaching this standard.

6.E2U1.8 Develop and use models to explain how constellations and other night sky patterns appear to move due to Earth's rotation and revolution.
- Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, and explained with models. (6.E2U1.9) (6.E2U1.10)

6.E2U1.9 Develop and use models to construct an explanation of how eclipses, moon phases, and tides occur within the Sun-Earth-Moon system.
- Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, and explained with models. (6.E2U1.8) (6.E2U1.10)
- A model of the solar system can explain tides and eclipses of the sun and the moon.

6.E2U1.10 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.
- Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, and explained with models. (6.E2U1.8) (6.E2U1.9)
- Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

Elements of Life Science Standards

6.L2U3.11 Use evidence to construct an argument regarding the impact of human activities on the environment and how they positively and negatively affect the competition for energy and resources in ecosystems.
- Human activity which controls the growth of certain plants and animal changes an ecosystem.
- In any given ecosystem there is competition among species for the energy resources and the materials they need to live. The persistence of an ecosystem depends on the continued availability in the environment of these energy resources and materials.
- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of many other species. (6.L2U3.12) *Note: Supports the 8th grade standard, 8.E1U3.8.*
- Changes to Earth's environments can have different impacts (negative and positive) for different living things. *Note: Supports the 8th grade standard, 8.E1U3.8.*

6.L2U3.12 Engage in argument from evidence to support a claim about the factors that cause species to change and how humans can impact those factors.
- Ecosystems are dynamic in nature, their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.
- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of many other species. (6.L2U3.11) *Note: Supports the 8th grade standard, 8.E1U3.8.*

6.L2U1.13 Develop and use models to demonstrate the interdependence of organisms and their environment including biotic and abiotic factors.
- Predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

6.L2U1.14 Construct a model that shows the cycling of matter and flow of energy in ecosystems.
- Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, water, and minerals from the environment and release waste matter (gas, liquid, or solid) back into the environment.
- Energy resources pass through the ecosystem. When food is used by organisms for life processes some energy is dissipated as heat but is replaced in the ecosystem by radiation from the Sun being used to produce plant food.
- Food webs are models that demonstrate how matter and energy are transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycles repeatedly between the living and nonliving parts of the ecosystem.

ARIZONA DEPARTMENT OF EDUCATION

Arizona Science Standards - 7th Grade

Three Dimensions of Science

Sensemaking in science occurs with the integration of three essential dimensions.

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
- Obtain, Evaluate, and Communicate Information

Crosscutting Concepts

- Patterns
- Cause and Effect
- Structure and Function
- Systems and System Models
- Stability and Change
- Scale, Proportion, and Quantity
- Energy and Matter

Core Ideas

Core Ideas for Knowing Science

Physical Science

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

P2: Objects can affect other objects at a distance.

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

P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event.

Earth and Space Science

E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.

E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe.

Life Science

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

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

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

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

Core Ideas for Using Science

U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

Physical Science Standards

Students will explore how cause and effect take place within and between a wide variety of force and motion systems from forces on individual objects to the forces that shape our Earth.

7.P2U1.1	Collect and analyze data demonstrating how electromagnetic forces can be attractive or repulsive and can vary in strength.
7.P2U1.2	Develop and use a model to predict how forces act on objects at a distance.
7.P3U1.3	Plan and carry out an investigation that can support an evidence-based explanation of how objects on Earth are affected by gravitational force.
7.P3U1.4	Use non-algebraic mathematics and computational thinking to explain Newton's laws of motion.

Earth and Space Science Standards

Students develop an understanding of the patterns of energy flow along with matter cycling within and among Earth's systems.

7.E1U1.5	Construct a model that shows the cycling of matter and flow of energy in the atmosphere, hydrosphere, and geosphere.
7.E1U1.6	Construct a model to explain how the distribution of fossils and rocks, continental shapes, and seafloor structures provides evidence of the past plate motions.
7.E1U2.7	Analyze and interpret data to construct an explanation for how advances in technology has improved weather prediction.

Life Science Standards

Students develop an understanding of the structure and function of cells.

7.L1U1.8	Obtain, evaluate, and communicate information 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.
7.L1U1.9	Construct an explanation to demonstrate the relationship between major cell structures and cell functions (plant and animal).
7.L1U1.10	Develop and use a model to explain how cells, tissues, and organ systems maintain life (animals).
7.L1U1.11	Construct an explanation for how organisms maintain internal stability and evaluate the effect of the external factors on organisms' internal stability.
7.L2U1.12	Construct an explanation for how some plant cells convert light energy into food energy.

Key Crosscutting Concepts in 7th Grade

Patterns; Cause and Effect*; Scale, Proportion and Quantity; Systems and System Models; Energy and Matter;* ***Structure and Function****; Stability and Change*

Phenomena are observable events that can be explained or explored. Science aims to explain the causes of these events, or phenomena, using scientific ideas, concepts, and practices (3-dimensions).

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Arizona Science Standards - 7th Grade

Core Ideas for Knowing Science: Elements for Physical, Earth & Space, and Life Science Standards

Elements of Physical Science Standards

7.P2U1.1 Collect and analyze data demonstrating how electromagnetic forces can be attractive or repulsive and can vary in strength.
- Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.

7.P2U1.2 Develop and use a model to predict how forces act on objects at a distance.
- Forces that act at a distance (gravitational, electric, and magnetic) can be explained by force fields that extend through space and can be mapped by their effect on a test object (a ball, a charged object, or a magnet, respectively). (6.P2U1.4).

Note: Gravitational force is a suggested focus for 6th grade; It is suggested that all 3 forces be focused on in 7th grade.

7.P3U1.3 Plan and carry out an investigation that can support an evidence-based explanation of how objects on Earth are affected by gravitational force.
- All objects on the Earth are affected by gravitational forces. An object which stays at rest on the surface of the Earth has one or more forces acting on it counter balancing the force of gravity.

7.P3U1.4 Use non-algebraic mathematics and computational thinking to explain Newton's laws of motion.
- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first but in the opposite direction.
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to change the object's motion. For any given object, a larger force causes a larger change in motion.
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

Elements of Earth and Space Science Standards

7.E1U1.5 Construct a model that shows the cycling of matter and flow of energy in the atmosphere, hydrosphere, and geosphere.
- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.
- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
- The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials. This does not include the identification and naming of minerals. Emphasis is also on the ways that water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.

7.E1U1.6 Construct a model to explain how the distribution of fossils and rocks, continental shapes, and seafloor structures provides evidence of the past plate motions.
- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geological history.
- Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.
- Tectonic processes continually generate new ocean seafloor at ridges and destroy old seafloor at trenches.

7.E1U2.7 Analyze and interpret data to construct an explanation for how advances in technology has improved weather prediction.
- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. Because these patterns are so complex, weather can be predicted only probabilistically.

Elements of Life Science Standards

7.L1U1.8 Obtain, evaluate, and communicate information 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.
- All living things are made up of cells, which is the smallest unit that can be said to be alive. All the basic processes of life are the results of what happens inside cells. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).
- Cells divide to replace aging cells and to make more cells in growth and in reproduction.

7.L1U1.9 Construct an explanation to demonstrate the relationship between major cell structures and cell functions (plant and animal).
- Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.

Boundary: At this grade level, only a few major cell structures should be introduced.

7.L1U1.10 Develop and use a model to explain how cells, tissues, and organ systems maintain life (animals).
- In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions, such as respiration, digestion, elimination of waste and temperature control.

7.L1U1.11 Construct an explanation for how organisms maintain internal stability and evaluate the effect of the external factors on organisms' internal stability.
- Organisms respond to stimuli from their environment and actively maintain their internal environment.

7.L2U1.12 Construct an explanation for how some plant cells convert light energy into food energy.
- Plants, algae (including phytoplankton) and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

Arizona Science Standards - 8th Grade

Three Dimensions of Science

Sensemaking in science occurs with the integration of three essential dimensions.

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
- Obtain, Evaluate, and Communicate Information

Crosscutting Concepts

- Patterns
- Cause and Effect
- Structure and Function
- Systems and System Models
- Stability and Change
- Scale, Proportion, and Quantity
- Energy and Matter

Core Ideas

Core Ideas for Knowing Science

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

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

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U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

Physical Science Standards

Students apply stability and change to explore chemical properties of matter and chemical reactions to further understand energy and matter.

8.P1U1.1	Develop and use a model to demonstrate that 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.
8.P1U1.2	Obtain and evaluate information regarding how scientists identify substances based on unique physical and chemical properties.
8.P4U1.3	Construct an explanation on how energy can be transferred from one energy store to another.
8.P4U1.4	Develop and use mathematical models to explain wave characteristics and interactions.
8.P4U2.5	Develop a solution to increase efficiency when transferring energy from one source to another.

Earth and Space Science Standards

Students explore natural and human-induced cause-and-effect changes in Earth systems over time.

8.E1U1.6	Analyze and interpret data about the Earth's geological column to communicate relative ages of rock layers and fossils.
8.E1U3.7	Obtain, evaluate, and communicate information about data and historical patterns to predict natural hazards and other geological events.
8.E1U3.8	Construct and support an argument about how human consumption of limited resources impacts the biosphere.

Life Science Standards

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.

8.L3U1.9	Construct an explanation of how genetic variations occur in offspring through the inheritance of traits or through mutations.
8.L3U3.10	Communicate how advancements in technology have furthered the field of genetic research and use evidence to support an argument about the positive and negative effects of genetic research on human lives.
8.L4U1.11	Develop and use a model to explain how natural selection may lead to increases and decreases of specific traits in populations over time.
8.L4U1.12	Gather and communicate evidence on how the process of natural selection provides an explanation of how new species can evolve.

Key Crosscutting Concepts in 8th Grade

*Patterns**; Cause and Effect**; Scale, Proportion and Quantity; Systems and System Models; **Energy and Matter**; Structure and Function; **Stability and Change***

Phenomena are observable events that can be explained or explored. Science aims to explain the causes of these events, or phenomena, using scientific ideas, concepts, and practices (3-dimensions).

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Arizona Science Standards - 8th Grade

Core Ideas for Knowing Science: Elements for Physical, Earth & Space, and Life Science Standards

Elements of Physical Science Standards

8.P1U1.1 Develop and use a model to demonstrate that 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.
- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- The total number of each type of atom is conserved, and thus the mass does not change.

8.P1U1.2 Obtain and evaluate information regarding how scientists identify substances based on unique physical and chemical properties.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

8.P4U1.3 Construct an explanation on how energy can be transferred from one energy store to another.
- Energy is transferred out of hotter regions or objects and into colder ones by the processes of conduction, convection, and radiation.

8.P4U1.4 Develop and use mathematical models to explain wave characteristics and interactions.
- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.
- A sound wave needs a medium through which it is transmitted.
- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials where the light bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
- Since light can travel through space, it cannot be a matter wave, like sound or water waves.

Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking. Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.

8.P4U2.5 Develop a solution to increase efficiency when transferring energy from one source to another.
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

Elements of Earth and Space Science Standards

8.E1U1.6 Analyze and interpret data about the Earth's geological column to communicate relative ages of rock layers and fossils.
- The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analysis of rock strata and the fossil record provide only relative dates, not an absolute scale.

8.E1U3.7 Obtain, evaluate, and communicate information about data and historical patterns to predict natural hazards and other geological events.
- Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events.

8.E1U3.8 Construct and support an argument about how human consumption of limited resources impacts the biosphere.
- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing extinction of many other species. But changes to Earth's environment can have different impacts (negative and positive) for different living things.
- Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Elements of Life Science Standards

8.L3U1.9 Construct an explanation of how genetic variations occur in offspring through the inheritance of traits or through mutations.
- Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of a specific protein, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.
- Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited.
- In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.
- In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. (8.L3U3.10)

Elements of Life Science Standards (continued)

8.L3U3.10 Communicate how advancements in technology have furthered the field of genetic research and use evidence to support an argument about the positive and negative effects of genetic research on human lives.
- In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. (8.L3U1.9)
- In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed onto offspring.

8.L4U1.11 Develop and use a model to explain how natural selection may lead to increases and decreases of specific traits in populations over time.
- Natural selection leads to the predominance of certain traits in a population and the suppression of others.
- Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (8.L4U1.12)

8.L4U1.12 Gather and communicate evidence on how the process of natural selection provides an explanation of how new species can evolve.
- The natural selection of organisms with certain features that enable them to survive in particular environmental conditions has been going since the first form of life appeared on Earth.
- Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (8.L4U1.11)
- In separated populations with different conditions, the changes can be large enough that the populations, provided they remain separated (a process called reproductive isolation), evolve to become separate species.

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

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Arizona Science Standards - High School Essential Standards

Physical Science Standards

HS.P1U1.1	Develop and use models to explain the relationship of the structure of atoms to patterns and properties observed within the Periodic Table and describe how these models are revised with new evidence.
HS.P1U1.2	Develop and use models for the transfer or sharing of electrons to predict the formation of ions, molecules, and compounds in both natural and synthetic processes.
HS.P1U1.3	Ask questions, plan, and carry out investigations to explore the cause and effect relationship between reaction rate factors.
HS.P1U3.4	Obtain, evaluate, and communicate information about how the use of chemistry related technologies have had positive and negative ethical, social, economic, and/or political implications.
HS.P2U1.5	Construct an explanation for a field's strength and influence on an object (electric, gravitational, magnetic).
HS.P3U1.6	Collect, analyze, and interpret data regarding the change in motion of an object or system in one dimension, to construct an explanation using Newton's Laws.
HS.P3U2.7	Use mathematics and computational thinking to explain how Newton's laws are used in engineering and technologies to create products to serve human ends.
HS.P4U1.8	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.
HS.P4U3.9	Engage in argument from evidence regarding the ethical, social, economic, and/or political benefits and liabilities of energy usage and transfer.
HS.P4U1.10	Construct an explanation about the relationships among the frequency, wavelength, and speed of waves traveling in various media, and their applications to modern technology.

Earth and Space Science Standards

HS.E1U1.11	Analyze and interpret data to determine how energy from the Sun affects weather patterns and climate.
HS.E1U1.12	Develop and use models of the Earth that explains the role of energy and matter in Earth's constantly changing internal and external systems (geosphere, hydrosphere, atmosphere, biosphere).
HS.E1U1.13	Evaluate explanations and theories about the role of energy and matter in geologic changes over time.
HS.E1U3.14	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.
HS.E2U1.15	Construct an explanation based on evidence to illustrate the role of nuclear fusion in the life cycle of a star.
HS.E2U1.16	Construct an explanation of how gravitational forces impact the evolution of planetary motion, structure, surfaces, atmospheres, moons, and rings.
HS.E2U1.17	Construct an explanation of the origin, expansion, and scale of the universe based on astronomical evidence.

Essential standards are standards that will be assessed on the state exam and are intended for all students to have learned by the end of 3 credits of high school science courses.

Life Science Standards

HS.L2U3.18	Obtain, evaluate, and communicate about the positive and negative ethical, social, economic, and political implications of human activity on the biodiversity of an ecosystem.
HS.L2U1.19	Develop and use models that show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment.
HS.L1U1.20	Ask questions and/or make predictions based on observations and evidence to demonstrate how cellular organization, structure, and function allow organisms to maintain homeostasis.
HS.L2U1.21	Obtain, evaluate, and communicate data showing the relationship of photosynthesis and cellular respiration; flow of energy and cycling of matter.
HS.L1U1.22	Construct an explanation for how cellular division (mitosis) is the process by which organisms grow and maintain complex, interconnected systems.
HS.L1U3.23	Obtain, evaluate, and communicate the ethical, social, economic and/or political implications of the detection and treatment of abnormal cell function.
HS.L3U1.24	Construct an explanation of how the process of sexual reproduction contributes to genetic variation.
HS.L3U1.25	Obtain, evaluate, and communicate information about the causes and implications of DNA mutation.
HS.L3U3.26	Engage in argument from evidence regarding the ethical, social, economic, and/or political implications of a current genetic technology.
HS.L4U1.27	Obtain, evaluate, and communicate evidence that describes how changes in frequency of inherited traits in a population can lead to biological diversity.
HS.L4U1.28	Gather, evaluate, and communicate multiple lines of empirical evidence to explain the mechanisms of biological evolution.

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Arizona Science Standards - Three-Dimensional Learning in Science

Dimension 1: Science and Engineering Practices
The actions students perform in science.

DO

1. Asking Questions and Defining Problems (p. 54)*
2. Developing and Using Models (p. 56)*
3. Planning and Carrying Out Investigations (p. 59)*
4. Analyzing and Interpreting Data (p. 61)*
5. Using Mathematics and Computational Thinking (p. 64)*
6. Constructing Explanations and Designing Solutions (p. 67)*
7. Engaging in Argument from Evidence (p. 71)*
8. Obtaining, Evaluating, and Communicating Information (p. 74)*

Phenomena are observable events that can be explained or explored. Science aims to explain the causes of these events, or phenomena, using scientific ideas, concepts, and practices (3-dimensions).

Dimension 2: Crosscutting Concepts
The unifying ideas across science disciplines.

THINK

1. Patterns (p. 85)*
2. Cause and Effect (p. 87)*
3. Scale, Proportion, and Quantity (p. 89)*
4. Systems and System Models (p. 91)*
5. Energy and Matter (p. 94)*
6. Structure and Function (p. 96)*
7. Stability and Change (p. 98)*

Dimension 3: Core Ideas of Knowing Science and Core Ideas of Using Science

Knowing Science
The fundamental ideas within science disciplines.

KNOW

Physical Science (p. 105)*

P1: All matter in the Universe is made of very small particles. (p. 20)**

P2: Objects can affect other objects at a distance. (p. 21)**

P3: Changing the movement of an object requires a net force to be acting on it. (p. 22)**

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. (p. 23)**

Earth and Space Science (p. 171)*

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. (p. 24)**

E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe. (p. 25)**

Life Science (p. 142)*

L1: Organisms are organized on a cellular basis and have a finite life span. (p. 26)**

L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms. (p. 27)**

L3: Genetic information is passed down from one generation of organisms to another. (p. 28)**

L4: The unity and diversity of organisms, living and extinct, is the result of evolution. (p. 29)*

Using Science
The application of science and engineering.

USE

U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised. (p.30 & 31)**

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products. (p.32)**

U3: Applications of science often have ethical, social, economic, and/or political implications. (p. 23)**

**A Framework for K-12 Science Education*, 2011 ***Working with Big Ideas of Science Education*, 2015

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Arizona Science Standards Science and Engineering Practices for HS | For use with Arizona Science Standards

Developing and Using Models

A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations.

- Use multiple types of models to represent and support explanations of phenomena, and move flexibly between model types based on merits and limitations.
- Develop, revise, and use models to predict and support explanations of relationships between systems or between components of a system.
- Use models (including mathematical and computational) to generate data to support explanations and predict phenomena, analyze systems, and solve problems.
- Design a test of a model to ascertain its reliability.
- Develop a complex model that allows for manipulation and testing of a proposed process or system.
- Evaluate merits and limitations of two different models of the same proposed tool, process, or system in order to select or revise a model that best fits the evidence. or design criteria.

Obtaining, Evaluating, and Communicating Information

Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate.

- Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- Synthesize, communicate, and evaluate the validity and reliability of claims, methods, and designs that appear in scientific and technical texts or media reports, verifying the data when possible.
- Produce scientific and/or technical writing and/or oral presentations that communicate scientific ideas and/or the process of development and the design and performance of a proposed process or system.
- Compare, integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) in order to address a scientific question or solve a problem.

Asking Questions and Defining Problems

A science practice is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and can be empirically tested.

- Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results.
- Ask questions that require relevant empirical evidence to answer.
- Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.
- Ask and evaluate questions that challenge the premise of an argument, the interpretation of a data set, or the suitability of a design.
- Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Planning and Carrying Out Investigations

Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually.

- Design an investigation individually and collaboratively and test designs as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems.
- Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.
- Design and conduct an investigation individually and collaboratively, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.
- Select appropriate tools to collect,record, analyze, and evaluate data.
- Design and conduct investigations and test design solutions in a safe and ethical manner including considerations of environmental, social, and personal impacts.
- Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.
- Use investigations to gather evidence to support explanations or concepts.

Constructing Explanations and Designing Solutions

The end-products of science are explanations and the end products of engineering are solutions. The goal of science is the construction of theories that provide explanatory accounts of the world. The goal of engineering design is to find a systematic solution to problems that is based on scientific knowledge and models of the material world.

- Make quantitative and qualitative claims regarding the relationship between dependent and independent variables.
- Apply scientific reasoning, theory, and models to link evidence to claims to assess the extent to which the reasoning and data support the explanation or conclusion.
- Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review.
- Base causal explanations on valid and reliable empirical evidence from multiple sources and the assumption that natural laws operate today as they did in the past and will continue to do so in the future.
- Apply scientific knowledge and evidence to explain phenomena and solve design problems, taking into account possible unanticipated effects.
- Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations.

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

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Analyzing and Interpreting Data

Scientific investigations produce data that must be analyzed in order to derive meaning. Engineering investigations include analysis of data collected in the tests of designs.

- Use tools, technologies, and/or models (e.g., computational, mathematical) to generate and analyze data in order to make valid and reliable scientific claims or determine an optimal design solution.
- Consider limitations (e.g., measurement error, sample selection) when analyzing and interpreting data.
- Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.
- Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
- Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.
- Evaluate the impact of new data on a working explanation of a proposed process or system.

Engaging in Argument from Evidence

Argumentation is the process by which explanations and solutions are reached. Reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem in science and engineering.

- Critique and evaluate competing arguments, models, and/or design solutions in light of new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.
- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
- Construct a counter-argument that is based on data and evidence that challenges another proposed argument.
- Make and defend a claim about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.
- Evaluate a claim for a design solution to a real-world problem based on scientific knowledge, empirical evidence, and logical arguments regarding relevant factors (e.g.economic, societal, environmental, ethical considerations).

Using Mathematics and Computational Thinking

Mathematics and computation are fundamental tools for representing physical variables and their relationships in both science and engineering.

- Use mathematical or algorithmic representations of phenomena or design solutions to describe and support claims and explanations,and create computational models or simulations.
- Apply techniques of algebra and functions to represent and solve scientific and engineering problems.
- Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world.
- Create a simple computational model or simulation of a designed device, process, or system.

Arizona Science Standards Crosscutting Concepts for HS | For use with Arizona Science Standards

Stability and Change

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Much of science deals with constructing explanations of how things change and how they remain stable.
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
- Feedback (negative or positive) can stabilize or destabilize a system.
- Systems can be designed for greater or lesser stability.
  - *How does the system display stability?*
  - *What changes were occurring while the system was stable?*
  - *Describe how the system is able to remain stable.*
  - *Where else have you seen this type of stability (or change)?*
  - *The system displays stability by _____.*
  - *Even though the system appears stable, I know that _____ (changes) were happening.*
  - *The reason this system can remain stable is _____.*

Cause and Effect

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.
- Systems can be designed to cause a desired effect.
- Changes in systems may have various causes that may not have equal effects.
  - *Does the effect have more than one cause?*
  - *What predictions are possible from the cause-effect relationship?*
  - *How have you used the cause-effect relationship in a scientific argument?*
  - *One cause of _____ (effect) might be _____.*
  - *From the cause-effect relationship, I would claim that _____.*
  - *I tested what I thought was the cause-effect relationship by _____.*

Structure and Function

The way an object is shaped or structured determines many of its properties and functions.

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.
- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.
  - *What structures are important in this scenario or investigation?*
  - *How are the structures related to the functions in this scenario or investigation?*
  - *Describe a different structure that might be able to perform the same function.*
  - *The important structures are _____.*
  - *The _____ (structure) performs _____ (function).*
  - *I think that _____ (structure) could perform the same function because _____.*

Energy and Matter

Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.

- The total amount of energy and matter in closed systems is conserved.
- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.
- Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.
- Energy drives the cycling of matter within and between systems.
- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.
  - *How do energy changes appear in this scenario or investigation?*
  - *Describe the cycles of matter represented in this scenario or investigation.*
  - *How do energy and matter interact in this scenario or investigation?*
  - *I think energy changed because _____.*
  - *Matter in this system went from _____ to _____.*
  - *The evidence I have for matter being conserved in this system is _____.*
  - *The interaction of energy and matter in this system is observed when _____.*

Systems and System Models

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Systems can be designed to do specific tasks.
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.
- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
  - *What are the parts of the system?*
  - *Describe how the parts of the system interact.*
  - *What are the interactions of the system?*
  - *How does the model represent the system?*
  - *The parts of the system are _____ , _____ , _____...*
  - *In this system _____ interacts with _____ to cause _____.*
  - *The model I used to describe the system we studied was ____ because it ____.*

Patterns

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
- Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments.
- Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.
- Mathematical representations are needed to identify some patterns.
- Empirical evidence is needed to identify patterns.
  - *How do you describe the pattern?*
  - *How can you use this pattern in an explanation?*
  - *Is there a way to use mathematics to describe the pattern?*
  - *What predictions are possible based on the pattern?*

Scale, Proportion, and Quantity

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
- Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.
- Patterns observable at one scale may not be observable or exist at other scales.
- Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.
- Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).
  - *How does proportion fit into this scenario or investigation?*
  - *How does scale fit into this scenario or investigation?*
  - *How does quantity fit into this scenario or investigation?*
  - *Is this phenomenon visible at other scales? Explain your thinking.*
  - *In this science idea, scale is important because _____.*
  - *In this science idea, proportion is important because _____.*
  - *In this science idea, quantity is important because _____.*

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

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Arizona Science Standards - High School Physical Science Essential and Plus Standards

Physical Science Standards: Chemistry	
HS.P1U1.1	Develop and use models to explain the relationship of the structure of atoms to patterns and properties observed within the Periodic Table and describe how these models are revised with new evidence.
HS+C.P1U1.1	Develop and use models to demonstrate how changes in the number of subatomic particles (protons, neutrons, electrons) affect the identity, stability, and properties of the element.
HS+C.P1U1.2	Obtain, evaluate, and communicate the qualitative evidence supporting claims about how atoms absorb and emit energy in the form of electromagnetic radiation.
HS+C.P1U1.3	Analyze and interpret data to develop and support an explanation for the relationships between kinetic molecular theory and gas laws.
HS.P1U1.2	Develop and use models for the transfer or sharing of electrons to predict the formation of ions, molecules, and compounds in both natural and synthetic processes.
HS.P1U1.3	Ask questions, plan, and carry out investigations to explore the cause and effect relationship between reaction rate factors.
HS+C.P1U1.4	Develop and use models to predict and explain forces within and between molecules.
HS+C.P1U1.5	Plan and carry out investigations to test predictions of the outcomes of various reactions, based on patterns of physical and chemical properties.
HS+C.P1U1.6	Construct an explanation, design a solution, or refine the design of a chemical system in equilibrium to maximize production.
HS+C.P1U1.7	Use mathematics and computational thinking to determine stoichiometric relationships between reactants and products in chemical reactions.

Physical Science Standards: Chemistry (continued)	
HS.P1U3.4	Obtain, evaluate, and communicate information about how the use of chemistry related technologies have had positive and negative ethical, social, economic, and/or political implications.
HS+C.P1U3.8	Engage in argument from evidence regarding the ethical, social, economic, and/or political benefits and liabilities of fission, fusion, and radioactive decay.

Physical Science Standards: Physics	
HS.P2U1.5	Construct an explanation for a field's strength and influence on an object (electric, gravitational, magnetic).
HS+Phy.P2U1.1	Plan and carry out investigations to 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.
HS.P3U1.6	Collect, analyze, and interpret data regarding the change in motion of an object or system in one dimension, to construct an explanation using Newton's Laws.
HS+Phy.P3U1.2	Develop and use mathematical models of Newton's law of gravitation and Coulomb's law to describe and predict the gravitational and electrostatic forces between objects.
HS+Phy.P3U1.3	Develop a mathematical model, using Newton's laws, to predict the motion of an object or system in two dimensions (projectile and circular motion).
HS+Phy.P3U1.4	Engage in argument from evidence regarding the claim that the total momentum of a system is conserved when there is no net force on the system.

Physical Science Standards: Physics (continued)	
HS.P3U2.7	Use mathematics and computational thinking to explain how Newton's laws are used in engineering and technologies to create products to serve human ends.
HS+Phy.P3U2.5	Design, evaluate, and refine a device that minimizes or maximizes the force on a macroscopic object during a collision.
HS.P4U1.8	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.
HS.P4U3.9	Engage in argument from evidence regarding the ethical, social, economic, and/or political benefits and liabilities of energy usage and transfer.
HS+Phy.P4U1.6	Analyze and interpret data to quantitatively describe changes in energy within a system and/or energy flows in and out of a system.
HS+Phy.P4U2.7	Design, evaluate, and refine a device that works within given constraints to transfer energy within a system.
HS+Phy.P4U1.8	Use mathematics and computational thinking to explain the relationships between power, current, voltage, and resistance.
HS.P4U1.10	Construct an explanation about the relationships among the frequency, wavelength, and speed of waves traveling in various media, and their applications to modern technology.

Essential standards are standards that will be assessed on the state exam and are intended for all students to have learned by the end of 3 credits of high school science courses.

Physical Science Plus (+) Standards HS+P are supporting standards designed to be used with the essential standards for students taking a high school physics (P) course. Standards HS+C are supporting standards designed to be used with the essential standards for students taking a high school chemistry (C) course.

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ARIZONA DEPARTMENT OF EDUCATION

Arizona Science Standards - High School Physical Science Essential Standards and Elements

Core Ideas for Knowing Science: Elements for Physical Science Standards

Physical Science Standards: Chemistry

HS.P1U1.1 Develop and use models to explain the relationship of the structure of atoms to patterns and properties observed within the Periodic Table and describe how these models are revised with new evidence.

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

HS.P1U1.2 Develop and use models for the transfer or sharing of electrons to predict the formation of ions, molecules, and compounds in both natural and synthetic processes.

- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
- The opposite electric charges of protons and electrons attract each other, keeping atoms together and accounting for the formation of some compounds.

HS.P1U1.3 Ask questions, plan, and carry out investigations to explore the cause and effect relationship between reaction rate factors.

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, that are matched by changes in kinetic energy.

HS.P1U3.4 Obtain, evaluate, and communicate information about how the use of chemistry related technologies have had positive and negative ethical, social, economic, and/or political implications.

- There are disadvantages as well as advantages to some technological products. Although the use of some artificial materials may mean less demand on scarce natural ones, many new materials do not degrade as do natural materials, presenting a waste disposal problem when discarded.

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

Physical Science Standards: Physics

HS.P2U1.5 Construct an explanation for a field's strength and influence on an object (electric, gravitational, magnetic).

- Gravity, electric and magnetic interactions can be described in terms of fields.
- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.
- Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.

HS.P3U1.6 Collect, analyze, and interpret data regarding the change in motion of an object or system in one dimension, to construct an explanation using Newton's Laws.

- Newton's second law accurately predicts changes in the motion of macroscopic objects.
- Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.
- Within an isolated system of interacting objects, any change in momentum of one object is balanced by an equal and oppositely directed change in the total momentum of the other objects. Thus total momentum is a conserved quantity.
- If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.

Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, and object rolling down a ramp, or a moving object being pulled by a constant force. Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.

HS.P3U2.7 Use mathematics and computational thinking to explain how Newton's laws are used in engineering and technologies to create products to serve human ends.

- Interactions between any two objects can cause changes in one or both of them. An understanding of the forces between objects is important for describing how their motions change, as well as for predicting stability or instability in systems at any scale.

Physical Science Standards: Physics

HS.P4U1.8 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.

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system.
- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed. When energy is transferred from one object to others the total amount of energy in the universe remains the same; the amount that one object loses is the same as the other objects gain.

HS.P4U3.9 Engage in argument from evidence regarding the ethical, social, economic, and/or political benefits and liabilities of energy usage and transfer.

- The availability of energy limits what can occur in any system.
- Although energy cannot be destroyed, it can be converted to less useful forms - for example, to thermal energy in the surrounding environment.
- Across the world, the demand for energy increases as human populations grow and because modern lifestyles require more energy, particularly in the convenient form of electrical energy. Ways of generating electricity have to be sought, while reducing demand and improving the efficiency of the processes in which we use it.

HS.P4U1.10 Construct an explanation about the relationships among the frequency, wavelength, and speed of waves traveling in various media, and their applications to modern technology.

- The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.
- Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.

Arizona Science Standards - High School Earth & Space Science Essential and Plus Standards

Earth and Space Science Standards	
HS.E1U1.11	Analyze and interpret data to determine how energy from the Sun affects weather patterns and climate.
HS+E.E1U1.1	Construct an explanation based on evidence for how the Sun's energy transfers between Earth's systems.
HS+E.E1U1.2	Develop and use models to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
HS+E.E1U1.3	Analyze geoscience data and the results from global climate models to make evidence-based predictions of current rate and scale of global or regional climate changes.
HS.E1U1.12	Develop and use models of the Earth that explains the role of energy and matter in Earth's constantly changing internal and external systems (geosphere, hydrosphere, atmosphere, biosphere).
HS+E.E1U1.4	Analyze and interpret geoscience data to make the claim that dynamic interactions with Earth's surface can create feedbacks that cause changes to other Earth systems.
HS+E.E1U1.5	Obtain, evaluate, and communicate information on the effect of water on Earth's materials, surface processes, and groundwater systems.

Essential standards are standards that will be assessed on the state exam and are intended for all students to have learned by the end of 3 credits of high school science courses.

Earth and space Plus (+) Standards HS+E are supporting standards designed to be used with the essential standards for students taking a high school Earth and space (E) course.

Earth and Space Science Standards	
HS.E1U1.13	Evaluate explanations and theories about the role of energy and matter in geologic changes over time.
HS+E.E1U1.6	Obtain, evaluate, and communicate information of the theory of plate tectonics to explain the differences in age, structure, and composition of Earth's crust.
HS+E.E1U1.7	Engage in argument from evidence of ancient Earth materials, meteorites, and other planetary surfaces to explain Earth's formation and early history.
HS+E.E1U1.8	Develop and use models to illustrate how Earth's internal and surface processes operate over time to form, modify, and recycle continental and ocean floor features.
HS.E1U3.14	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.
HS+E.E1U3.9	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.E1U3.10	Ask questions, define problems, and 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.E1U3.11	Develop and use a quantitative model to illustrate the relationship among Earth systems and the degree to which those relationships are being modified due to human activity.

Earth and Space Science Standards	
HS.E2U1.15	Construct an explanation based on evidence to illustrate the role of nuclear fusion in the life cycle of a star.
HS+E.E2U1.12	Obtain, evaluate, and communicate scientific information about the way stars, throughout their stellar stages, produce elements and energy.
HS.E2U1.16	Construct an explanation of how gravitational forces impact the evolution of planetary motion, structure, surfaces, atmospheres, moons, and rings.
HS+E.E2U1.13	Analyze and interpret data showing how gravitational forces are influenced by mass, and the distance between objects.
HS+E.E2U1.14	Use mathematics and computational thinking to explain the movement of planets and objects in the solar system.
HS.E2U1.17	Construct an explanation of the origin, expansion, and scale of the universe based on astronomical evidence.
HS+E.E2U1.15	Obtain, evaluate, and communicate information on how the nebular theory explains solar system formation with distinct regions characterized by different types of planetary and other bodies.
HS+E.E2U1.16	Obtain, evaluate, and communicate information about patterns of size and scale of our solar system, our galaxy, and the universe.
HS+E.E2U2.17	Obtain, evaluate, and communicate the impact of technology on human understanding of the formation, scale, and composition of the universe.

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Arizona Science Standards - High School Earth & Space Science Essential Standards and Elements

Core Ideas for Knowing Science: Elements for Earth & Space Science Essential Standards

Earth and Space Science Standards

HS.E1U1.11 Analyze and interpret data to determine how energy from the Sun affects weather patterns and climate.

- The foundation for Earth's global climate system is the electromagnetic radiation from the Sun as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems and this energy's reradiation into space.

HS.E1U1.12 Develop and use models of the Earth that explains the role of energy and matter in Earth's constantly changing internal and external systems (geosphere, hydrosphere, atmosphere, biosphere).

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, and a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.
- The geologic record shows that changes to global and regional climate can be caused by interactions among changes in the Sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.

Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and seafloor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion). This does not include memorization of the details of the formation of specific geographic features of Earth's surface. Emphasis is also on both a one dimensional model of Earth, with radial layers determined by density, and a three dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high pressure laboratory experiments.

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Earth and Space Science Standards

HS.E1U1.13 Evaluate explanations and theories about the role of energy and matter in geologic changes over time.

- Continental rocks, which can be older than 4 billion years, are generally much older than rocks on the ocean floor, which are less than 200 million years old.
- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mangle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.

HS.E1U3.14 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.

- Resource availability has guided the development of human society.
- Global climate models are often used to understand the process of climate change because these changes are complex and can occur slowly over Earth's history. Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.
- Natural hazards and other geologic events have shaped the course of human history; they have significantly altered the sizes of human populations and have driven human migrations.
- The sustainability of human societies and biodiversity that supports them requires responsible management of natural resources.

HS.E2U1.15 Construct an explanation based on evidence to illustrate the role of nuclear fusion in the life cycle of a star.

- Our Sun is one of many stars that make up the Universe, essentially made of hydrogen. The source of energy that the Sun and all stars radiate comes from nuclear reactions in their central cores.
- Nuclear fusion processes in the center of the Sun release the energy that ultimately reaches Earth as radiation.
- Other than hydrogen and helium formed at the time of the big bang, nuclear fusion within stars produce all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

Earth and Space Science Standards

HS.E2U1.16 Construct an explanation of how gravitational forces impact the evolution of planetary motion, structure, surfaces, atmospheres, moons, and rings.

- Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the Sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.
- Cyclical changes in the shape of Earth's orbit around the Sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the Earth. These phenomena cause a cycle of ice ages and other gradual climate changes.

Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and Moons.

Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's laws of orbital motions should not deal with more than two bodies, nor involve calculus.

HS.E2U1.17 Construct an explanation of the origin, expansion, and scale of the universe based on astronomical evidence.

- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.
- The big bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe.

Clarification Statement: Emphasis is on the astronomical evidence of the redshift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the big bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the big bang theory (3/4 hydrogen and 1/4 helium).

ARIZONA DEPARTMENT OF EDUCATION

Arizona Science Standards - High School Life Science Essential and Plus Standards

Life Science Standards	
HS.L2U3.18	Obtain, evaluate, and communicate about the positive and negative ethical, social, economic, and political implications of human activity on the biodiversity of an ecosystem.
HS+B.L2U1.1	Develop a model showing the relationship between limiting factors and carrying capacity, and use the model to make predictions on how environmental changes impact biodiversity.
HS+B.L4U1.2	Engage in argument from evidence that changes in environmental conditions or human interventions may change species diversity in an ecosystem.
HS.L2U1.19	Develop and use models that show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment.
HS+B.L2U1.3	Use mathematics and computational thinking to support claims for the cycling of matter and flow of energy through trophic levels in an ecosystem.

Essential standards are standards that will be assessed on the state exam and are intended for all students to have learned by the end of 3 credits of high school science courses.

Life Science Plus (+) Standards HS+B are supporting standards designed to be used with the essential standards for students taking a high school biology (B) course.

ARIZONA DEPARTMENT OF EDUCATION

Life Science Standards	
HS.L1U1.20	Ask questions and/or make predictions based on observations and evidence to demonstrate how cellular organization, structure, and function allow organisms to maintain homeostasis.
HS+B.L1U1.4	Develop and use models to explain the interdependency and interactions between cellular organelles.
HS+B.L1U1.5	Analyze and interpret data that demonstrates the relationship between cellular function and the diversity of protein functions.
HS+B.L1U1.6	Develop and use models to show how transport mechanisms function in cells.
HS+B.L1U1.7	Develop and use models to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms (plant and animal).
HS.L2U1.21	Obtain, evaluate, and communicate data showing the relationship of photosynthesis and cellular respiration; flow of energy and cycling of matter.
HS+B.L2U1.8	Develop and use models to develop a scientific explanation that illustrates how photosynthesis transforms light energy into stored chemical energy and how cellular respiration breaks down macromolecules for use in metabolic processes.
HS.L1U1.22	Construct an explanation for how cellular division (mitosis) is the process by which organisms grow and maintain complex, interconnected systems.
HS.L1U3.23	Obtain, evaluate, and communicate the ethical, social, economic and/or political implications of the detection and treatment of abnormal cell function.
HS+B.L1U1.9	Develop and use a model to communicate how a cell copies genetic information to make new cells during asexual reproduction (mitosis).

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Life Science Standards	
HS.L3U1.24	Construct an explanation of how the process of sexual reproduction contributes to genetic variation.
HS.L3U1.25	Obtain, evaluate, and communicate information about the causes and implications of DNA mutation.
HS.L3U3.26	Engage in argument from evidence regarding the ethical, social, economic, and/or political implications of a current genetic technology.
HS+B.L3U1.10	Use mathematics and computational thinking to explain the variation that occurs through meiosis and calculate the distribution of expressed traits in a population.
HS+B.L3U1.11	Construct an explanation for how the structure of DNA and RNA determine the structure of proteins that perform essential life functions.
HS+B.L3U1.12	Analyze and interpret data on how mutations can lead to increased genetic variation in a population.
HS.L4U1.27	Obtain, evaluate, and communicate evidence that describes how changes in frequency of inherited traits in a population can lead to biological diversity.
HS.L4U1.28	Gather, evaluate, and communicate multiple lines of empirical evidence to explain the mechanisms of biological evolution.
HS+B.L4U1.13	Obtain, evaluate, and communicate multiple lines of empirical evidence to explain the change in genetic composition of a population over successive generations.
HS+B.L4U1.14	Construct an explanation based on scientific evidence that the process of natural selection can lead to adaptation.

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Arizona Science Standards - High School Life Science Essential Standards and Elements

Core Ideas for Knowing Science: Elements for Life Science Standards

Life Science Standards

HS.L2U3.18 Obtain, evaluate, and communicate about the positive and negative ethical, social, economic, and political implications of human activity on the biodiversity of an ecosystem.

- Anthropogenic changes (induced by human activity) in the environment - including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change - can disrupt an ecosystem and threaten the survival of some species.
- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e. the ecosystem is resilient) as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

HS.L2U1.19 Develop and use models that show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment.

- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.

HS.L1U1.20 Ask questions and/or make predictions based on observations and evidence to demonstrate how cellular organization, structure, and function allow organisms to maintain homeostasis.

- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.

HS.L2U1.21 Obtain, evaluate, and communicate data showing the relationship of photosynthesis and cellular respiration; flow of energy and cycling of matter.

- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
- Photosynthesis and cellular respiration are important components of the carbon cycle in which carbon is exchanged among the biosphere, atmosphere, and oceans, and geosphere through chemical, physical, geologic, and biological processes.

The elements are not to be used as a check-off list, but rather a useful tool to help educators identify the specific pieces of knowledge and skill that make up the practice, crosscutting concept, or core idea at that grade-band.

Life Science Standards

HS.L1U1.22 Construct an explanation for how cellular division (mitosis) is the process by which organisms grow and maintain complex, interconnected systems.

- In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a simple cell (fertilized egg) that divides successfully to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.
- Most cells are programmed for a limited number of cell divisions. Organisms die if their cells are incapable of further division.

HS.L1U3.23 Obtain, evaluate, and communicate the ethical, social, economic and/or political implications of the detection and treatment of abnormal cell function.

- Diseases, which may be caused by invading microorganisms, environmental conditions or defective cell programming, generally result in disturbed cell function.
- Given a suitable medium, cells from a variety of organisms can be grown in situ, that is, outside the organism. These cell cultures are used by scientists to investigate cell functions and have medical implications such as the production of vaccines, screening of drugs, and in vitro fertilization.

HS.L3U1.24 Construct an explanation of how the process of sexual reproduction contributes to genetic variation.

- In sexual reproduction, a specialized type of cell division called meiosis occurs and results in the production of sex cells, such as gametes (sperm and eggs) or spores, which contain only one member from each chromosome pair in the parent cell.
- In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS.L3U1.25)
- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors.

HS.L3U1.25 Obtain, evaluate, and communicate information about the causes and implications of DNA mutation.

- Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.
- In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS.L1U3.24)

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Life Science Standards

HS.L3U3.26 Engage in argument from evidence regarding the ethical, social, economic, and/or political implications of a current genetic technology.

- The overall sequence of genes of an organism is known as its genome. More is being learned all the time about genetic information by mapping the genomes of different kinds of organisms.
- When sequences of genes are known genetic material can be artificially changed to give organisms certain features.
- In gene therapy special techniques are used to deliver into human cells genes that are beginning to help in curing disease.
- Biotechnology has made possible the production of genetically identical organisms through artificial cloning in a range of species.

HS.L4U1.27 Obtain, evaluate, and communicate evidence that describes how changes in frequency of inherited traits in a population can lead to biological diversity.

- Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. The traits that positively affect survival are more likely to be reproduced and thus are more common in the population.
- Adaptation also means that the distribution of traits in a population can change when conditions change.
- Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' evolution is lost.
- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).

HS.L4U1.28 Gather, evaluate, and communicate multiple lines of empirical evidence to explain the mechanisms of biological evolution.

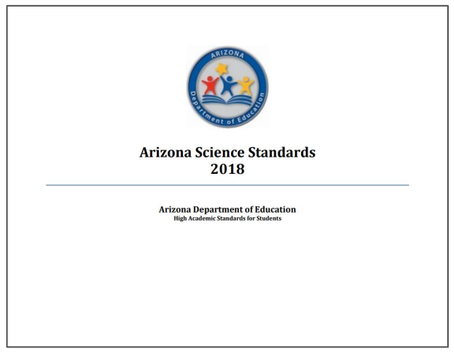
- Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.
- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline-and sometimes the extinction of some species.
- Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.

ARIZONA DEPARTMENT OF EDUCATION

Additional Resources to Support Implementation of Arizona Science Standards

Resources located on the Arizona Department of Education Science Standards Website

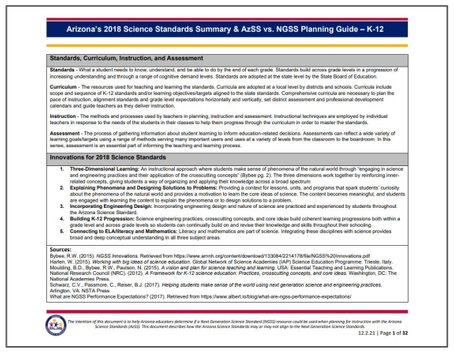
www.azed.gov/standards-practices/k-12standards/standards-science



Arizona Science Standards 2018

Arizona Department of Education
High Academic Standards for Students

K-12 Arizona Science Standards



Arizona's 2018 Science Standards Summary & AzSS vs. NGSS Planning Guide – K-12

Standards, Curriculum, Instruction, and Assessment

Standards - What a student needs to know, understand, and be able to do by the end of each grade. Standards 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 State Board of Education.

Curriculum - The resources used for teaching and learning the standards. Curricula are adopted at a local level by districts and schools. Curricula include scope and sequence of K-12 standards and/or learning objectives/targets aligned to the state standards. Comprehensive curricula are necessary to plan the pace of instruction, alignment standards and grade level expectations horizontally and vertically, set district assessment and professional development calendars and guide teachers as they deliver instruction.

Instruction - The methods and processes used by teachers in planning, instruction and assessment. 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 in order to master the standards.

Assessment - The process of gathering information about student learning to inform education-related decisions. Assessments can reflect a wide variety of learning goals/targets using a range of methods serving many important users and uses at a variety of levels from the classroom to the boardroom. In this sense, assessment is an essential part of informing the teaching and learning process.

Innovations for 2018 Science Standards

1. **Three-Dimensional Learning:** An instructional approach where students make sense of phenomena of the natural world through "engaging in science and engineering practices and their application of the crosscutting concepts" (Bybee pg. 2). The three dimensions work together by reinforcing inner-related concepts, giving students a way of organizing and applying their knowledge across a broad spectrum.
2. **Explaining Phenomena and Designing Solutions to Problems:** Providing a context for lessons, units, and programs that spark students' curiosity about the phenomena of the natural world and provides a motivation to learn the core ideas of science. The content becomes meaningful, and students are engaged with learning the content to explain the phenomena or to design solutions to a problem.
3. **Incorporating Engineering Design:** Incorporating engineering design and nature of science are practiced and experienced by students throughout the Arizona Science Standard.
4. **Building K-12 Progression:** Science engineering practices, crosscutting concepts, and core ideas build coherent learning progressions both within a grade level and across grade levels so students can continually build on and revise their knowledge and skills throughout their schooling.
5. **Connecting to ELA/literacy and Mathematics:** Literacy and mathematics are part of science. Integrating these disciplines with science provides broad and deep conceptual understanding in all three subject areas.

Sources:

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Schwarz, C.V., Passmore, C., Reiser, B.J. (2017). *Helping students make sense of the world using next generation science and engineering practices*. Arlington, VA: NSTA Press.

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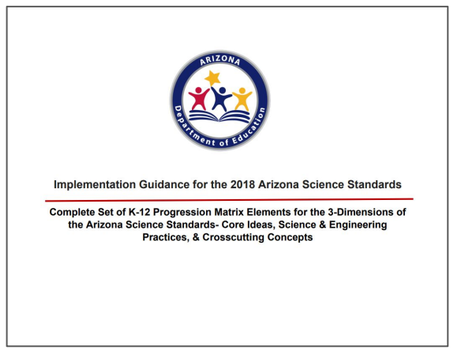
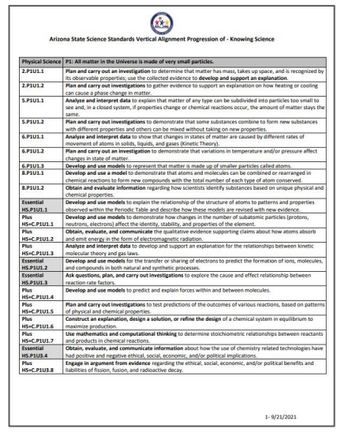
Arizona's 2018 Science Standards Summary & AZSS vs. NGSS Planning Guide K-12



Implementation Guidance for the 2018 Arizona Science Standards

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

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



Arizona State Science Standards Vertical Alignment Progression of - Knowing Science

Physical Science	**P1: All matter in the Universe is made of very small particles.**
7.P1U1.1	**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.**
7.P1U1.2	**Plan and carry out investigations** to gather evidence to support an explanation on how heating or cooling can cause a phase change in matter.
5.P1U1.1	**Analyze and interpret data** to explain that matter of any type can be subdivided into particles too small to see and, in a closed system, if properties change or chemical reactions occur, the amount of matter stays the same.
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.
6.P1U1.1	**Analyze and interpret data** to show that changes in states of matter are caused by different rates of movement of atoms in solids, liquids, and gases (Kinetic Theory).
6.P1U1.2	**Plan and carry out an investigation** to demonstrate that variations in temperature and/or pressure affect changes in state of matter.
6.P1U1.3	**Develop and use models** to represent that matter is made up of smaller particles called atoms.
8.P1U1.1	**Develop and use a model** to demonstrate that 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.
8.P1U1.2	**Obtain and evaluate information** regarding how scientists identify substances based on unique physical and chemical properties.
Essential HS.P1U1.1	**Develop and use models** to explain the relationship of the structure of atoms to patterns and properties observed within the Periodic Table and describe how these models are revised with new evidence.
Plus HS+C.P1U1.1	**Develop and use models** to demonstrate how changes in the number of subatomic particles (protons, neutrons, electrons) affect the identity, stability, and properties of the element.
Plus HS+C.P1U1.2	**Obtain, evaluate, and communicate** the qualitative evidence supporting claims about how atoms absorb and emit energy in the form of electromagnetic radiation.
Plus HS+C.P1U1.3	**Analyze and interpret data** to develop and support an explanation for the relationships between kinetic molecular theory and gas laws.
Essential HS.P1U1.2	**Develop and use models** for the transfer or sharing of electrons to predict the formation of ions, molecules, and compounds in both natural and synthetic processes.
Essential HS.P1U1.3	**Ask questions, plan, and carry out investigations** to explore the cause and effect relationship between reaction rate factors.
Plus HS+C.P1U1.4	**Develop and use models** to predict and explain forces within and between molecules.
Plus HS+C.P1U1.5	**Plan and carry out investigations** to test predictions of the outcomes of various reactions, based on patterns of physical and chemical properties.
Plus HS+C.P1U1.6	**Construct an explanation, design a solution, or refine the design** of a chemical system in equilibrium to maximize production.
Plus HS+C.P1U1.7	**Use mathematics and computational thinking** to determine stoichiometric relationships between reactants and products in chemical reactions.
Essential HS.P1U1.4	**Obtain, evaluate, and communicate information** about how the use of chemistry related technologies have had positive and negative ethical, social, economic, and/or political implications.
Plus HS+C.P1U1.8	**Engage in argument from evidence** regarding the ethical, social, economic, and/or political benefits and liabilities of fission, fusion, and radioactive decay.

1- 9/21/2021

Arizona State Science Standards Vertical Alignment Progression of Core Idea: Knowing Science