MESA PUBLIC SCHOOLS
MESA, ARIZONA

Science

7-8 Curriculum Guides

including

Standards, Three Dimensional Foundations, and Evidence of Learning Specifications

Board Approved February 2020

Table of Contents

Introduction 2
Coding of the K-8 Science Standards 6
Standards v. Curriculum v. Instruction 7
Time Allotment 8
A Look at the Arizona Science Standards for Mesa Public Schools 9
Seventh Grade SC07 131
Eighth Grade SC08 154
Bibliography 181

mesa
PUBLIC SCHOOLS
MESA, ARIZONA

Introduction

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

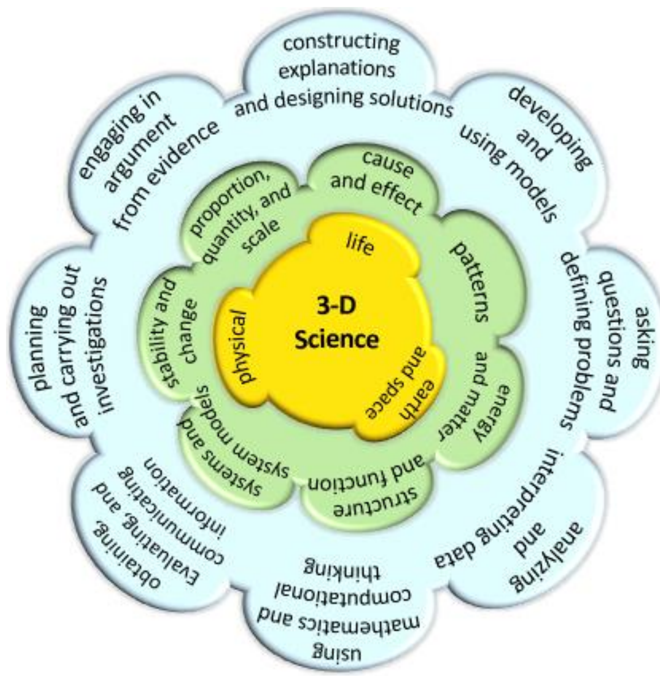


Figure 1: Three Dimensions of Science Instruction

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.

Three Dimensions of Science

Sense-making in science occurs with the integration of three essential dimensions:

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

Science and Engineering Practices

For decades teachers have utilized the scientific method as a methodology to engage in scientific inquiry. How it has been implemented in classrooms describes a set of prescribed steps used to engage in science teaching and to learn in a rather linear process. The new vision calls for students to engage in multifaceted science and engineering practices in more complex, relevant, and authentic ways. The science and engineering practices describe a robust process for how scientists investigate and build models and theories of the natural world or how engineers design and build

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

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

While the scientific method is still being widely used, and a part of academics, the science and engineering practices are expected to be integrated with the core ideas and crosscutting concepts across all grade levels and disciplines.

Crosscutting Concepts

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

- patterns
- cause and effect
- structure and function
- systems and system models
- stability and change

- scale, proportion, and quantity
- energy and matter

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

The use of crosscutting concepts can be demonstrated within cause and effect relationships. For example, researchers investigate cause and effect mechanisms in the motion of a single object, specific chemical reactions, population changes in an ecosystem, and the development of holes in the polar ozone layers. Patterns are present in all science disciplines, and much of science is about explaining observed patterns. Using data, graphs, charts,

maps, and statistics in combination with the science and engineering practices, students can use their knowledge of cause and effect relationships to formulate investigations, answer questions, and make informed predictions about observed phenomena.

Core Ideas

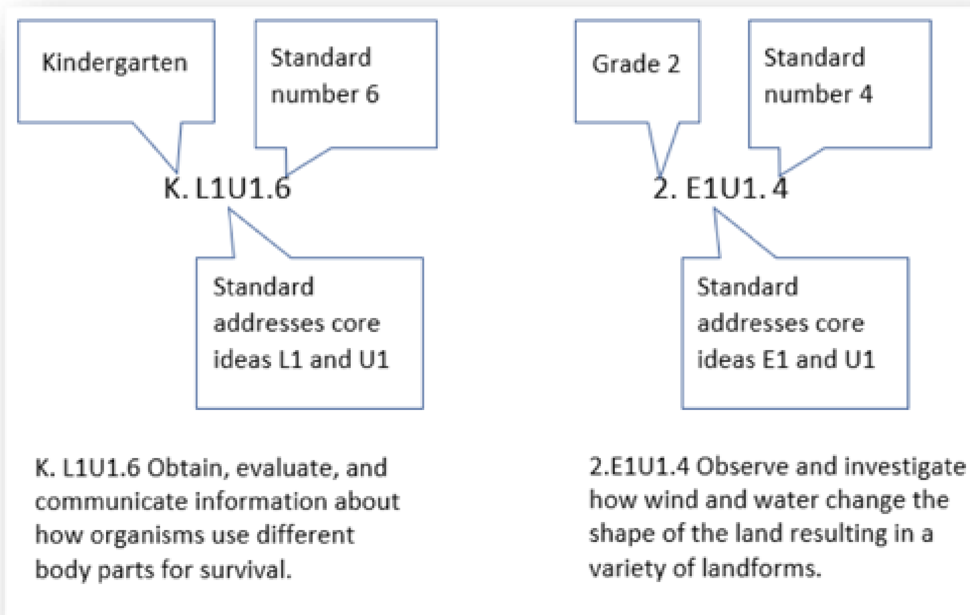
The Arizona Science Standards focus on thirteen core ideas in science and engineering, adapted from *Working with Big Ideas of Science Education*. The ten core ideas for **Knowing Science** center on understanding the causes of phenomena in physical, Earth and space, and life science. The three core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

Core Ideas for Knowing Science	Core Ideas for Using Science
Physical Science P1: All matter in the Universe is made of very small particles. P2: Objects can affect other objects at a distance. P3: Changing the movement of an object requires a net force to be acting on it.	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

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. <u>Earth and Space Science</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. E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe. <u>Life Science</u> 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. *Adapted from *Working with Big Ideas in Science Education*[2]	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.

Coding of the K-8 Science Standards

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



Standards v. Curriculum v. Instruction

Standards:

Standards are what a student needs to know, understand, and be able to do by the end of each grade. They build across grade levels in a progression of increasing understanding and through a range of cognitive demand levels. Standards are adopted at the state level by the Arizona State Board of Education.

Curriculum:

Curriculum refers to resources used for teaching and learning the standards. Curricula are adopted at the local level.

Instruction:

Instruction refers to the methods, or methodologies, used by teachers to teach their students. Instructional techniques are employed by individual teachers in response to the needs of the students in their classes to help them progress through the curriculum to master the standards. Decisions about instructional practice and techniques are made at a local level.

Time Allotment

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

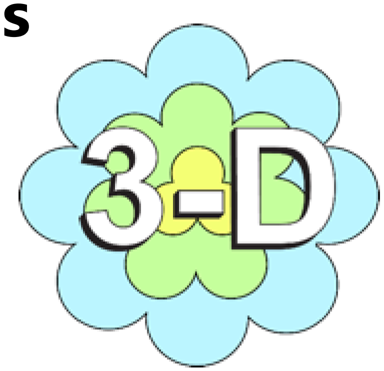
The Arizona Science Standards have been designed so that these time suggestions provide adequate time to actively engage in all 3 dimensions of science instruction to master the standards for each grade level. Depending on local factors, schools may allocate more or less time when determining curriculum programming within a specific context. Instruction on the Arizona Science Standards may be a dedicated time in the school schedule or may be integrated with the instruction of other subjects.

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

Grade	K	1	2	3	4	5	6	7	8	HS
Suggested Minutes per Week	90	150	150	200	225	225	250	250	250	275
Suggested Average Minutes per Day	18	30	30	40	45	45	50	50	50	55

mesa
PUBLIC SCHOOLS
MESA, ARIZONA

A Look at the Arizona Science Standards for Mesa Public Schools



The 2018 Arizona Science Standards (AzSS) differ from prior science standards in that they integrate three dimensions (Core Ideas, Science and Engineering Practices, and Crosscutting Concepts) into a single standard document and have intentional connections between standards across all disciplines. The Mesa Public Schools Science Curriculum Guide highlights the Arizona Science Standards as well as each of the three integral dimensions and connections to other grade bands and subjects. This guide includes a table with three main sections.

What is Assessed (The Standard)	**3D Foundations Box**	**Evidence of Learning Specifications Box (EoLS)**
A standard describes what students should be able to do at the end of instruction and incorporates a Science and Engineering Practice and Core Idea. Standards are not instructional strategies or objectives for a lesson. Instead, they are intended to guide the development of assessments and are 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.	The three dimensions foundation boxes contain the learning goals that students should achieve. It is critical that science educators consider the foundations boxes an essential component when reading the AzSS and developing curricula. There are four foundation boxes: Core Ideas, Science and Engineering Practices, Crosscutting Concepts, and Using Science, all of which are derived from *A Framework for Science Education* and *Working with Big Ideas of Science Education*. During instruction, teachers guide students to use multiple practices to help them understand the Core Ideas. Most groupings of standards emphasize only a few practices or Crosscutting Concepts; however, all are emphasized within a grade band. The foundation boxes also contains Using Science (unique to AzSS) that connect scientific principles, theories, and models;	The Evidence of Learning Specification box uses the standards and 3D foundations to develop EoLS, which describe what qualifies as evidence for students' proficiency. High quality assessment practices are critical to the success of the AzSS. The Evidence of Learning Specifications represent learning at the nexus of the 3-dimensions of the AzSS while engaged in AzSS phenomena.

	engineering and technological applications; and societal implications to the content knowledge to support scientific understanding.	

Navigating the Science Curriculum

Core Ideas for the Unit
Core Ideas as described below that will appear in the unit.

What is Assessed
A collection of one or more standards describing what students should be able to do at the end of instruction

Core Ideas
Concepts in science that that have broad importance within and across disciplines as well as relevance in people's lives

Science & Engineering Practices
Skills and knowledge that scientists and engineers engage in to either understand the world or solve a problem

Crosscutting Concepts
Ideas that are not specific to one discipline but cut across all disciplines

Using Science
Concepts that connect scientific principles, theories, and models; engineering and technological applications; and societal implications to the content knowledge to support scientific understanding.

Kindergarten Unit 2: Earth and Space Science

Kindergarten Unit 2

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.

Instructional Sequence 1

Az Science Standard K.E1U1.3

Observe, record, and ask questions about temperature, precipitation, and other weather data to identify patterns or changes in local weather.

CI E1 The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate

- Weather is determined by the conditions and movement of the air.
- The temperature, pressure, direction, speed of movement and the amount of water vapor in the air combine to create the weather.

Science and Engineering Practices

Asking Questions and Defining Problems:

- Ask questions based on observations of the natural and/or designed world.

Mathematical and Computational Thinking:

- 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.

Crosscutting Concepts

Patterns:

- Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.

Cause and Effect:

- Events have causes that generate observable patterns.

Using Science – U1

- Science is about finding explanations for why things happen as they do or why they take a particular form.
- Every event or phenomenon has a cause or causes and that there is a reason for the form things take.

Big Ideas Sequence 1

Weather is a result of the condition and movement of their air. Patterns found in weather help us make predictions and identify seasons.

Evidence of Learning Specifications

Ask questions:

1. and investigate why changes in weather patterns take place.

MPS Science Curriculum Guide 12

Standard
A statement that Combines Science and Engineering Practices and Core Ideas to describe how students can show what they have learned

3D Foundations
The Practices, Core Ideas, and Crosscutting Concepts from *A Framework for K-12 Science Education* that were used to form the standards

Evidence of Learning Specifications (EoLS)
Standards and the 3-dimensions are used to develop EoLS, which describe what qualifies as evidence for students' proficiency.

Seventh Grade
SC07

Scope and Sequence

Seventh Grade

By the end of seventh grade, students will explore how forces cause changes in motion and how energy is transferred in geologic, atmospheric, and environmental processes. Students investigate force and motion in a wide variety of systems, model how heat energy drives cycles in weather and climate, and explain the structure and function of cells. Student investigations focus on collecting and making sense of observational data and measurements using the science and engineering practices:

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

While individual lessons may include connections to any of the crosscutting concepts, the standards in seventh grade focus on helping students understand phenomena though patterns, cause and effect, and structure and function.

Unit #	Title	Content
1	Forces at a Distance	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 Earth.
2	Newton's Laws	
3	Earth Systems	Students develop an understanding of the patterns of energy flow along with matter cycling within and among Earth's systems.
4	Cells: Structure and Function	Students develop an understanding of the structure (organization) and function (need for and obtaining energy) of cells.
5	Body Systems	

Seventh Grade Unit 1: Forces at a Distance

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.

Instructional Sequence 1

Az Science Standard 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.

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

- 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] can be explained by force fields that extend through space and can be mapped by their effect on a test object (e.g., a ball).
- On Earth, it [gravity] results in everything being pulled down towards the center of the Earth. This downward attraction is called the weight of an object.
- The object pulls the Earth as much as the Earth pulls the object, but because the Earth's mass is much bigger, people observe the resulting motion of the object, not of the Earth.

Science and Engineering Practices

Planning and Carrying Out Investigations:

- 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.
- 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.

Constructing Explanations and Designing Solutions:

- Construct explanations for either qualitative or quantitative relationships between variables.
- 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.
- Apply scientific knowledge and evidence to explain real-world phenomena, examples, or events.
- Construct explanations from models or representations.

Crosscutting Concepts

Cause and Effect:

- 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.

Patterns:

- 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.

Using Science – U1

- Careful and systematic observations and accurate descriptions of what is observed are fundamental to scientific investigation.
- What people expect to happen can influence what they observe, so it is good practice for observations to be made by several people independently and for results to be reported clearly enough to be checked by others.
- Different kinds of natural phenomena are explained in different ways. In some cases a possible explanation (hypothesis) indicates the variable factor thought to cause a phenomenon. To test a hypothesis it is used to predict what will happen when the variable identified as a possible cause is changed and then see if what happens fits the prediction. If the outcome agrees with the prediction, and no other changes are found to produce the same result, then the factor is accepted as being the cause that explains the observation.

Big Ideas Sequence 1

Gravitational forces are proportional to mass and distance.

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Plan and carry out an investigation that:

1. provides evidence that objects on Earth are pulled towards Earth's center by gravitational force.
2. identifies patterns including multiple variables (i.e., distance, mass) and gravity.

Construct an explanation that:

1. shows the cause and effect relationship between gravitational forces depending on distance and mass.
2. that anything with mass has a gravitational pull and gravity is always attractive.

Instructional Sequence 2
Unit 1: Forces at a Distance

Az Science Standard 7.P2U1.1

Collect and analyze data demonstrating how electromagnetic forces can be attractive or repulsive and can vary in strength.

Az Science Standard 7.P2U1.2

Develop and use a model to predict how forces act on objects at a distance.

CI P2 Objects can affect other objects at a distance.

- Electric and magnetic 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.
- Forces that act at a distance can be explained by force fields that extend through space and can be mapped by their effect on a test object
- Gravitational forces are always attractive.

Science and Engineering Practices

Analyzing and Interpreting Data:

- 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:

- 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.
- Modify models—based on their limitations—to increase detail or clarity, or to explore what will happen if a component is changed.
- Develop a model that allows for manipulation and testing of a proposed object, tool, process or system.

Obtaining, Evaluating, and Communicating Information:

- 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).
- 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.

Crosscutting Concepts

Patterns:

- 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.

Cause and Effect:

- 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.

System and System Models:

- 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.

Using Science – U1

- To help explain observations, scientists create models to represent what they think may be happening.
- Sometimes these are physical models, such as an orrery – a model of the solar system where various objects are used to represent the Sun, Moon, Earth and other planets – or a ball and stick model of how atoms are thought to be arranged in a substance.
- Other models are theoretical, more abstract, such as in representing light as a wave motion, or representing relationships as mathematical formulae.
- Some models are firmly established in theories which have been shown to work without contradiction in all contexts so far encountered.
- Careful and systematic observations and accurate descriptions of what is observed are fundamental to scientific investigation.

Big Ideas Sequence 2

Objects are affected by a force at varying distances. Electromagnetic forces can be attractive or repulsive depending on their charges (electrons), and the strength of the attraction/repulsion depends both on the magnitudes of the charges and currents involved and on the distances between the interacting objects.

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Analyzing and interpreting data:

1. to find the relationship between the distance of objects and their effects on magnetic fields.
2. to identify cause and effect relationships between variables in an electromagnetic system.

Develop models that:

1. show the strength of electric and magnetic forces due to cause and effect relationships.
2. predict patterns present as forces act on objects (i.e., a magnet or a charged object) at a distance.

Obtain, evaluate, and communicate information:

1. about cause and effect relationships that affect magnetic forces and their impact on an electric current.
2. about the cause and effect relationship that affects electric forces, like magnitude, signs of charges, and distance.
3. on how forces are repulsive and attractive and vary in strength.

Seventh Grade Unit 2: Newton's Laws

Instructional Sequence 1

Az Science Standard 7.P3U1.4

Use non-algebraic mathematics and computational thinking to explain Newton's laws of motion.

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

- 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 achieve the same change in motion.
- For any given object, a larger force causes a larger change in motion. Forces on an object can also change its shape or orientation.

Science and Engineering Practices

Planning and Carrying Out Investigations:

- 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.
- Collect data about the performance of a proposed object, tool, process or system under a range of conditions.

Using Mathematics and Computational Thinking:

- Create algorithms (a series of ordered steps) to solve a problem.
- Use mathematical arguments to describe and support scientific conclusions and design solutions.

Crosscutting Concepts

Cause and Effect:

- 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.

Patterns:

- 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.

Using Science – U1

- Careful and systematic observations and accurate descriptions of what is observed are fundamental to scientific investigation.
- What people expect to happen can influence what they observe, so it is good practice for observations to be made by several people independently and for results to be reported clearly enough to be checked by others.
- To help explain observations, scientists create models to represent what they think may be happening.

Big Ideas Sequence 1
Newton's three laws (inertia, acceleration, action/reaction forces) describe the relationship between an object's motion and the forces acting on it.
Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning. Plan and carry out an investigation that: 1. provides evidence that the changes in an object's motion are due to balanced or unbalanced forces acting on an object and the mass of the object. 2. demonstrate inertia and its relationship to mass. Use non-algebraic mathematics and computational thinking: 1. with data, to diagram the cause and effect relationships between total forces (balanced and unbalanced) acting on an object. 2. to explain the patterns in proportional relationships between force, mass and acceleration. 3. to explain action and reaction force pairs and represent them using force diagrams.

Seventh Grade Unit 3: Earth Systems

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

Instructional Sequence 1

Az Science Standard 7.E1U1.5

Construct a model that shows the cycling of matter and flow of energy in the atmosphere, hydrosphere, and geosphere.

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

- 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 and living organisms.
- Radioactive decay of material inside the Earth since it was formed is its internal source of energy.

Science and Engineering Practices

Asking Questions and Defining Problems:

- Ask questions that arise from careful observation of phenomena, models, or unexpected results.
- Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Developing and Using Models:

- 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.

Crosscutting Concepts

Energy and Matter:

- 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.

Systems and System Models:

- 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.

Cause and Effect:

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Using Science – U1

- To help explain observations, scientists create models to represent what they think may be happening.

- Sometimes these are physical models, such as an orrery – a model of the solar system where various objects are used to represent the Sun, Moon, Earth and other planets – or a ball and stick model of how atoms are thought to be arranged in a substance.
- Other models are theoretical, more abstract, such as in representing light as a wave motion, or representing relationships as mathematical formulae.
- Some models are firmly established in theories which have been shown to work without contradiction in all contexts so far encountered.
- There may be more than one possible model and the evidence of which works best is not conclusive; and in other cases scientists do not yet have a satisfactory explanatory model.

Big Ideas Sequence 1

The Sun and Earth's hot interior are the sources of energy in the cycling of matter on Earth. Earth materials and energy flow through the atmosphere, hydrosphere, geosphere and biosphere through physical and chemical processes.

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Ask questions and define problems:

1. about the general types of Earth materials that can be found in different locations (i.e., those located at the surface and/or the interior of the Earth).
2. about the cycling of matter between the atmosphere, hydrosphere, geosphere, and biosphere.
3. about how Earth's processes cycle matter through chemical and physical changes.
4. about how the movement of energy originates from the Sun and Earth's hot interior (caused by radioactive decay of material inside the Earth) and causes the cycling of matter through Earth.
5. that occur in systems when one or more of the spheres is impacted by a catastrophic event.

Develop and use models that:

1. show the cycling of energy from the Sun through Earth's spheres drives Earth's processes (i.e., the movement of wind and water, which causes erosion, weathering, and sedimentation of weathered Earth materials).

Instructional Sequence 2
Unit 3: Earth Systems

Az Science Standard 7.E1U1.6

Construct a model to explain how the distribution of fossils and rocks, continental shapes, and seafloor structures provide evidence of past plate motions.

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

- 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.
- Plate movements are responsible for most continental and ocean floor features and for the distribution of most rocks and minerals within Earth's crust.
- 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.

Science and Engineering Practices

Developing and Using Models:

- 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.

Constructing Explanations and Designing Solutions:

- 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.
- Apply scientific knowledge and evidence to explain real-world phenomena, examples, or events.
- Construct explanations from models or representations.

Crosscutting Concepts

Cause and Effect:

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Patterns:

- Patterns can be used to identify cause and effect relationships.
- Graphs, charts, and images can be used to identify patterns in data.

Energy and Matter:

- 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.

Using Science – U1

- To help explain observations, scientists create models to represent what they think may be happening.
- Sometimes these are physical models, such as an orrery – a model of the solar system where various objects are used to represent the Sun, Moon, Earth and other planets – or a ball and stick model of how atoms are thought to be arranged in a substance.
- Other models are theoretical, more abstract, such as in representing light as a wave motion, or representing relationships as mathematical formulae.
- Computer-based models enable phenomena to be simulated and variables easily changed to investigate their effect.
- Some models are firmly established in theories which have been shown to work without contradiction in all contexts so far encountered.

Big Ideas Sequence 2

Heat energy from Earth's core causes convection currents which move Earth's tectonic plates. The movement of these plates is known as the Theory of Continental Drift and is evidenced in the fossil record, continental shapes, seafloor structures (i.e., volcanic ridges at the center of the oceans, trenches at the edges of continents) and the ages of rocks (i.e., youngest rocks found at ridges, and oldest rocks found at trenches).

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Develop and use models that:

1. show how the energy from Earth's hot interior causes convection in the mantle, that is, hot plates rise and the colder rock sinks.
2. the distribution of seafloor structures (i.e., trenches, ridges, and changes in magnetization of the seafloor)and rock ages provide evidence of seafloor spreading.
3. show patterns in qualitative data, like continental shape and distribution of fossils.

Construct an explanation:

1. from evidence (i.e., shares similar fossils and rocks) that supports that the continents were once attached and have since separated (Continental Drift).

Instructional Sequence 3
Unit 3: Earth Systems

Az Science Standard 7.E1U2.7

Analyze and interpret data to construct an explanation for how advances in technology have improved weather prediction.

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

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things.
- The ocean exerts a major influence on weather and climate by absorbing energy from the Sun, releasing it over time, and globally redistributing it through ocean currents.
- 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.
- 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.

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information:

- 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.

Analyzing and Interpreting Data:

- Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize date, 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.

Constructing Explanations and Designing Solutions:

- 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.

- Apply scientific knowledge and evidence to explain real-world phenomena, examples, or events.
- Construct explanations from models or representations.

Crosscutting Concepts

Stability and Change:

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
- Small changes in one part of a system might cause large changes in another part.
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

Patterns:

- 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.

Using Science – U2

- There are usually many factors to be considered in optimizing a solution, such as cost, availability of materials and impact on users and on the environment, which may constrain choices.

Big Ideas Sequence 3

Over time, advancements in technology improve weather prediction, which results in better preparedness during extreme weather.

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Obtain, evaluate, and communicate information:

1. and record observations, either firsthand and/or from professional weather monitoring services, patterns in weather conditions in a specific area (e.g., temperature, air pressure, humidity, wind speed) over time.
2. about how motions and complex interactions of air masses result in changes in weather conditions (i.e., temperature, air pressure, humidity, windspeed).
3. describing what happens when light energy from the Sun reaches Earth's atmosphere and some of it is reflected back to space while some of it is absorbed and reradiated by greenhouse gases that regulate temperatures on Earth.
4. to describe how scientists use patterns to improve weather prediction and that past technologies and methods of monitoring weather have changed and improved over time.

Analyze and interpret data to:

1. determine the relationship between the distribution and movement of air masses and landforms, ocean temperatures, and currents.
2. the correlation between improvement in technology and improvement in forecast accuracy.

Construct an explanation for:

1. the relationship between observed, large-scale weather patterns and the location or movement of air masses, including patterns that develop between air masses (e.g., cold fronts may be characterized by thunderstorms).
2. weather patterns being so complex and having multiple causes, that weather can be predicted only probabilistically using current technological tools and methods.

MESA PUBLIC SCHOOLS
MESA, ARIZONA

Seventh Grade Unit 4:
Cells: Structure and Function

L1: Organisms are organized on a cellular basis and have a finite lifespan.
L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.

Instructional Sequence 1

Az Science Standard 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.

Az Science Standard 7.L1U1.9

Construct an explanation to demonstrate the relationship between major cell structures and cell functions (plant and animal).

Note: in this grade level, the major cell structures will be identified as the nucleus, chloroplasts, mitochondria, cell membrane and cell wall.

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

- All living organisms are made of one or more cells, which can be seen only through a microscope.
- All the basic processes of life are the results of what happens inside cells.
- Cells are often aggregated into tissues, tissues into organs, and organs into organ systems.

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information:

- 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).
- 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.
- Use models to share findings or solutions in oral and/or written presentations, and/or extended discussions.

Developing and Using Models:

- 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.
- Use and develop models of simple systems with uncertain and less predictable factors.
- Evaluate limitations of a model for a proposed object or tool.

Constructing Explanations and Designing Solutions:

- Apply scientific knowledge and evidence to explain real-world phenomena, examples, or events.

- Construct explanations from models or representations.

Crosscutting Concepts

Systems and System Models:

- 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.

Structure and Function:

- 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.

Using Science – U1

- Careful and systematic observations and accurate descriptions of what is observed are fundamental to scientific investigation.
- To help explain observations, scientists create models to represent what they think may be happening.
- Sometimes these are physical models, such as an orrery – a model of the solar system where various objects are used to represent the Sun, Moon, Earth and other planets – or a ball and stick model of how atoms are thought to be arranged in a substance.
- What people expect to happen can influence what they observe, so it is good practice for observations to be made by several people independently and for results to be reported clearly enough to be checked by others. *(Note: if using the E.coli lesson, this can be part of a debrief after students predict how plants were infected.)*

Big Ideas Sequence 1

Cells are the basic building blocks of life. The cell theory was developed over time with the input of many scientists. The cell functions as a whole system and the primary roles of the identified parts (organelles), specifically the nucleus, chloroplasts, mitochondria, cell membrane and cell wall, is the focus of this grade level. Cells are too small to be seen with the human eye, so a model designed for understanding cellular processes can be a useful tool.

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Obtain, evaluate, and communicate information that explains:

1. cells come from existing cells, all living things are made of cells, life processes are determined by cell processes, the cell is the smallest unit (microscopic) that can be said to be alive, and cells form larger biological systems.

Develop and use a model:

1. to identify the organelles of a cell (i.e., nucleus, chloroplasts, mitochondria, cell membrane, cell wall) and their functions.

Construct an explanation:

1. with the model, about how each of the organelles function individually.
2. with the model, about how the organelles together maintain a cell's internal system.

Instructional Sequence 2
Unit 4: Cells: Structure and Function

Az Science Standard 7.L2U1.12

Construct an explanation for how some plant cells convert light energy into food energy.

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

- In most cases, the energy needed for life is ultimately derived from the Sun through photosynthesis (although in some ecologically important cases, energy is derived from reactions involving inorganic chemicals in the absence of sunlight e.g. chemosynthesis).
- Plants, algae (including phytoplankton), and other energy-fixing microorganisms use sunlight, water and carbon dioxide to facilitate photosynthesis, which stores energy (sugar), forms plant matter, releases oxygen, and maintains plants' activities.
- These sugars can be used immediately or stored for growth or later use.
- Food is the energy source they need in order to carry out these and other functions [cellular, homeostasis].

Science and Engineering Practices

Constructing Explanations and Designing Solution:

- 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.
- Apply scientific knowledge and evidence to explain real-world phenomena, examples, or events.

Crosscutting Concepts

Energy and Matter:

- 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.

Structure and Function:

- 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.

Using Science – U1

- Careful and systematic observations and accurate descriptions of what is observed are fundamental to scientific investigation.
- What people expect to happen can influence what they observe, so it is good practice for observations to be made by several people independently and for results to be reported clearly enough to be checked by others.
- To help explain observations, scientists create models to represent what they think may be happening.

Big Ideas Sequence 2
Plant cells convert sunlight to food using chloroplasts in a process called photosynthesis.
Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning. Construct an explanation to: 1. describe how plants have specific structures called chloroplasts that convert light energy (sunlight), carbon dioxide, and water into food energy (sugar) and oxygen via photosynthesis. 2. describe how plants use the food they have made for energy, growth, and other necessary functions (i.e., repair, seed production).

Seventh Grade Unit 5: Body Systems

Instructional Sequence 1

Az Science Standard 7.L1U1.10

Develop and use a model to explain how cells, tissues, and organ systems maintain life (animals).

Az Science Standard 7.L1U1.11

Construct an explanation for how organisms maintain internal stability and evaluate the effect of the external factors on organisms' internal stability.

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

- Cells divide to replace aging cells and to make more cells in growth and in reproduction.
- Cells are often aggregated into tissues, tissues into organs, and organs into organ systems.
- Organisms range in composition from a single cell (unicellular microorganisms) to multicellular organisms, in which different groups of large number of cells work together to form systems of tissues and organs (e.g. circulatory, respiratory, nervous, musculoskeletal, digestive), that are specialized for particular functions.
- Some cells in multicellular organisms, as well as carrying out the functions that all cells do, are specialized; for example, muscle, blood and nerve cells carry out specific functions within the organism.
- In the human body, systems carry out such key functions as respiration, digestion, elimination of waste and temperature control.
- Both single cell and multi-cellular organisms have mechanisms to maintain temperature and acidity within certain limits that enable the organism to survive.
- Organisms respond to stimuli from their environment and actively maintain their internal environment through homeostasis.

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information:

- 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).
- 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.

Develop and Using Models:

- 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.

Constructing Explanations and Designing Solutions:

- 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.

Crosscutting Concepts

Structure and Function:

- 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.

Systems and System Models:

- 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.

Stability and Change:

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
- Small changes in one part of a system might cause large changes in another part.
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
- Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.

Using Science – U1

- Careful and systematic observations and accurate descriptions of what is observed are fundamental to scientific investigation.
- To help explain observations, scientists create models to represent what they think may be happening.
- Sometimes these are physical models, such as an orrery – a model of the solar system where various objects are used to represent the Sun, Moon, Earth and other planets – or a ball and stick model of how atoms are thought to be arranged in a substance.
- Some models are firmly established in theories which have been shown to work without contradiction in all contexts so far encountered.

Big Ideas Sequence 1

The body is a system of interacting subsystems composed of groups of cells. Cells work together to form tissues, and tissues form organs. Organs function to maintain life through homeostasis. For example, the heart is made of muscle, connective, and other tissues that allow the heart to receive and pump blood, and the heart and blood vessels work together make up the circulatory system to transport blood and materials throughout the body.

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Obtain, evaluate, and communicate information:

1. to explain why cells divide (i.e., aging, cell replacement, and cell reproduction).

2. about various cell types found in different body systems and the cell's function within that system.

Develop and use a model:

1. that demonstrates that cells comprise tissues, and specialized tissues comprise each organ, enabling the specific organ functions to be carried out.
2. that demonstrates that different organs can work together as subsystems to form organ system that carry out complex functions to maintain life.

Construct an explanation:

1. that supports how the body stabilizes its internal systems within the external environment (i.e., surroundings, sweat on a hot day).
2. about how other external factors (i.e., disease, bacteria, virus, extreme temperature, drought) can impact an organism's ability to maintain homeostasis.

Eighth Grade
SC08

Scope and Sequence

Eighth Grade

By the end of eighth grade, students will describe how stability and change and the process of cause and effect influence changes in the natural world. Students will apply energy principles to chemical reactions, explore changes within Earth and understand how genetic information is passed down to produce variation among the populations. Student investigations focus on collecting and making sense of observational data and measurements using the science and engineering practices:

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

While individual lessons may include connections to any of the crosscutting concepts, the standards in eighth-grade focus on helping students understand phenomena through cause and effect, energy and matter, and stability and change.

Unit #	Title	Content
1	Genetics and Traits	Students develop an understanding of patterns and how genetic information is passed from one generation of organisms to another. They also develop an understanding of how traits within populations change over time.
2	Life Over Geologic Time	Students explore natural and human-induced cause-and-effect changes in life because of Earth systems over time.
3	Energy Transfer	Students apply stability and change to explore both chemical properties of matter and chemical reactions to further understand energy and matter.

Eighth Grade Unit 1: Genetics and Traits

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.

Instructional Sequence 1

Az Science Standard 8.L3U1.9

Construct an explanation of how genetic variations occur in offspring through the inheritance of traits or through mutations.

Note: Emphasis is on using data to support explanations for the way variation occurs. At this grade level, do not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

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

- 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 or (more rarely) from mutations. (Note: The stress here is on the impact of gene transmission in reproduction, not the mechanism.)
- Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent, randomly. These versions may be identical or may differ from each other.
- Though rare, mutations may result in changes to the structure and function.

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information:

- 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.

Constructing Explanations and Designing Solutions:

- 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.
- Apply scientific knowledge and evidence to explain real-world phenomena, examples, or events.

Crosscutting Concepts

Patterns:

- 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.

Stability and Change:

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
- Small changes in one part of a system might cause large changes in another part.
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

Structure and Function:

- 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.

Cause and Effect:

- Relationships can be classified as casual 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.

Using Science – U1

- Careful and systematic observations and accurate descriptions of what is observed are fundamental to scientific investigation.
- What people expect to happen can influence what they observe, so it is good practice for observations to be made by several people independently and for results to be reported clearly enough to be checked by others.
- To help explain observations, scientists create models to represent what they think may be happening.

Big Ideas Sequence 1

Genetic variation occurs in organisms that reproduce sexually. This is because both parents contribute different genes that are passed onto the resulting offspring in random combinations. This results in gradual trait changes over time, but sometimes mutations can cause sudden changes.

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Obtain, evaluate, and communicate information:

1. about how genes are located in chromosomes of cells, which determine the structure of a specific set of proteins.
2. about how protein structure influences protein function (i.e., pigment molecules in human skin color or PTC tasting.)
3. observable organism traits (skin color, hair color, eye color) result from the activity of proteins.

Construct an explanation:

1. describing how both parents contribute different genetic information and the resulting offspring's chromosomes contain new combinations of genes (genetic variations) which make their chromosomes distinct from either parent.

2. about how Mendel showed the passing of traits from parent to offspring and how Mendelian inheritance occurs in a predictable pattern.
3. about the cause and effect relationships between DNA, the proteins it codes for, and the resulting traits in an organism.
4. about how genetic mutations (sudden event) occur randomly without predictable pattern causing a gradual change between cells and organisms that can be inherited and accumulates over time.

Instructional Sequence 2
Unit 1: Genetics and Traits

Az Science Standard 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.

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

Note: there is no research in A Framework for K-12 Science Education *or* Working with Big Ideas in Science Education *supporting this standard.*

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information:

- 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.

Asking Questions and Defining Problems:

- Ask questions that arise from careful observation of phenomena, models, or unexpected results.
- Ask questions to clarify or identify evidence and the premise(s) of an argument.
- Ask questions that challenge the interpretation of a data set.
- Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Engaging in Argument from Evidence:

- 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.
- 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.

Crosscutting Concepts

Cause and Effect:

- 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.

Stability and Change:

- 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.

Using Science – U3

- There are generally both positive and negative consequences of the applications of science. Some negative impacts can be anticipated but others emerge from experience.
- Some negative impacts can be anticipated but others emerge from experience.
- There are many examples of how technological and engineering advances have unintended consequences.
- If the detrimental effects are known, the trade-off between the advantages and the disadvantages of the application of science needs careful consideration.

Big Ideas Sequence 2

Increased computing power and advancing technology has influenced society and improved the field of genetics.

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Obtain, communicate, and use evidence to support an argument:

1. that technology in the field of genetics affects society both positively and negatively.

Instructional Sequence 3
Unit 1: Genetics and Traits

Az Science Standard 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.

Az Science Standard 8.L4U1.12

Gather and communicate evidence of how the process of natural selection provides an explanation of how new species can evolve.

Note: Focus how natural selection and other factors leads to speciation and therefore an increase in biodiversity.

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

- Genetic variations among individuals in a population give some individuals an advantage in surviving and reproducing in their environment. This is known as natural selection.
- It [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.
- In artificial selection, people have the capacity to influence certain characteristics of organisms by selective breeding.
- One can choose desired parental traits determined by genes, which are then passed on to offspring.
- 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.
- Biodiversity is the wide range of existing life forms that have adapted to the variety of conditions on Earth, from terrestrial to marine ecosystems.
- Biodiversity includes genetic variation within a species, in addition to species variation in different habitats and ecosystem types (e.g., forests, grasslands, wetlands).
- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.

Science and Engineering Practices

Developing and Using Models:

- 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.
- Develop a model that allows for manipulation and testing of a proposed object, tool, process or system.

Obtaining, Evaluating, and Communicating Information:

- 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.

Crosscutting Concepts:

Stability and Change:

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
- Small changes in one part of a system might cause large changes in another part. [In regards to natural selection]
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time. [In regards to natural selection]

Patterns:

- 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.

Using Science – U1

- Careful and systematic observations and accurate descriptions of what is observed are fundamental to scientific investigation.
- What people expect to happen can influence what they observe, so it is good practice for observations to be made by several people independently and for results to be reported clearly enough to be checked by others.
- To help explain observations, scientists create models to represent what they think may be happening.

Big Ideas Sequence 3

Natural selection is the mechanism that describes how genetic variations among individuals in a population can change a population over time. These changes can be brought about by either environmental impacts or by human interaction (i.e., changing the environment).

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Develop and use a model to obtain, evaluate, and communicate information:

1. about how new species evolve gradually over time (i.e., adaptations that have a positive effect on survival and reproduction), leading to a pattern of increase in biodiversity (i.e., Darwin's finches).
2. about how human interaction (i.e., deforestation) and natural selection will lead to a pattern decrease in biodiversity and resources over time.
3. to illustrate how artificial selection causes populations to change over time in designed ways (i.e., people selecting traits as in dog breeding and modern produce).
4. to predict a specific trait outcome of a population over a time period.
5. about how populations change over time (i.e., inheritable traits) in response to environmental changes (i.e., drought, temperature shift).

Eighth Grade Unit 2: Life Over Geologic Time

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.

Instructional Sequence 1

Az Science Standard 8.E1U1.6

Analyze and interpret data about the Earth's geological column to communicate relative ages of rock layers and fossils.

Note: Plate tectonics covered in depth in previous grade level. A basic understanding that the Earth moves is needed to understand rock layers.

CI E1: Earth and Space Sciences: Students explore natural and human-induced cause-and-effect changes in Earth systems over time.

- 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.
- Plate movement are responsible for most continental and ocean floor features and for the distribution of most rocks and minerals within Earth's crust.
- Evolution is shaped by Earth's varying geological conditions.
- Sudden changes in conditions (e.g., meteor impacts, major volcanic eruptions) have caused mass extinctions, but these changes, as well as more gradual ones, have ultimately allowed other life forms to flourish.
- The evolution and proliferation of living things over geological time have in turn changed the rates of weathering and erosion of land surfaces, altered the composition of Earth's soils and atmosphere, and affected the distribution of water in the hydrosphere.

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information:

- 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.

Analyzing and Interpreting Data:

- 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.

Crosscutting Concepts

Stability and Change:

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
- Small changes in one part of a system might cause large changes in another part.
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

Patterns:

- 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.

Using Science - U1

- Careful and systematic observations and accurate descriptions of what is observed are fundamental to scientific investigation.
- What people expect to happen can influence what they observe, so it is good practice for observations to be made by several people independently and for results to be reported clearly enough to be checked by others.
- Different kinds of natural phenomena are explained in different ways. In some cases a possible explanation (hypothesis) indicates the variable factor thought to cause a phenomenon. To test a hypothesis it is used to predict what will happen when the variable identified as a possible cause is changed and then see if what happens fits the prediction. If the outcome agrees with the prediction, and no other changes are found to produce the same result, then the factor is accepted as being the cause that explains the observation.
- To help explain observations, scientists create models to represent what they think may be happening.
- Sometimes these are physical models, such as an orrery – a model of the solar system where various objects are used to represent the Sun, Moon, Earth and other planets – or a ball and stick model of how atoms are thought to be arranged in a substance.
- Computer-based models enable phenomena to be simulated and variables easily changed to investigate their effect.

Big Ideas Sequence 1

The fossil record can provide relative dates based on the appearance or disappearance of organisms. Fossil layers that contain only extinct plant and animals groups are usually older than fossil layers that contain plant and animal groups that are still alive today. This geologic time scale is used to construct a timeline of Earth's history including major events like volcanic eruptions, meteor impacts, and mass extinctions of life.

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Obtain, evaluate, and communicate information:

1. about specific features and patterns from plate movements within the layers of rock (i.e., rock strata and rock ages) to correlate relevant events that impacted life (i.e., formations of mountain chains and ocean basins, volcanic eruptions, glaciations, meteor impacts, extinctions of groups of organisms) during each appropriate time frame.

2. to identify the different geological time frames and patterns of geological events that have changed species (i.e., microbial life increased soil formation, allowing for the evolution of land plants).

Analyze and interpret data:

1. from multiple valid and reliable sources of evidence to predict fossil age by the superposition of the rock layer.

Instructional Sequence 2
Unit 2: Life Over Geologic Time

Az Science Standard 8.E1U3.7

Obtain, evaluate, and communicate information about data and historical patterns to predict natural hazards and other geological events.

CI E1: Earth and Space Sciences: Students explore natural and human-induced cause-and-effect changes in Earth systems over time.

- By tracking the upward movement of magma, for example, volcanic eruptions can often be predicted with enough advance warning to allow neighboring regions to be evacuated.
- Earthquakes, in contrast, occur suddenly; the specific time, day, or year cannot be predicted.
- However, the history of earthquakes in a region and the mapping of fault lines can help forecast the likelihood of future events.
- Finally, satellite monitoring of weather patterns, along with measurements from land, sea, and air, usually can identify developing severe weather and lead to its reliable forecast.

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information:

- 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.

Crosscutting Concepts

Patterns:

- 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.

Cause and Effect:

- 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.

Using Science - U3

- There are generally both positive and negative consequences of the applications of science. Some negative impacts can be anticipated but others emerge from experience.
- Some negative impacts can be anticipated but others emerge from experience.
- Improved ease and speed of transport, particularly by air, burns fuel that produces carbon dioxide, one of several gases in the atmosphere that keep the Earth warm through the greenhouse effect. Increase in these gases in the atmosphere raises the Earth's temperature.
- Even a small increase in temperature of the Earth can have widespread effects through changes in the polar ice, sea levels and weather patterns.
- If the detrimental effects are known, the trade-off between the advantages and the disadvantages of the application of science needs careful consideration.

Big Ideas Sequence 2

Some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions. Others, such as earthquakes, occur suddenly with no notice, and thus are not predictable. Technology and the study of historical data has helped to mitigate their effects (i.e., satellite systems).

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Obtain, evaluate, and communicate information:

1. about historical data that represents the type of natural hazard event and features associated with that type of event (i.e., location, magnitude, frequency, and precursors).
2. using patterns in the data (i.e., upward movement of magma in volcanoes, mapping fault lines of earthquakes) to forecast the potential for a natural hazard to affect an area in the future (i.e., probability of occurrence, severity of event, event location).
3. about examples of technology engineers have developed to mitigate the effects of natural hazards (i.e., satellite monitoring of weather patterns, designs of building and bridges to resist earthquakes, warning sirens for tsunamis, storm shelters for tornados, levees to prevent flooding).
    a. natural disasters cannot be predicted with absolute certainty.

Instructional Sequence 3
Unit 2: Life Over Geologic Time

Az Science Standard 8.E1U3.8

Construct and support an argument about how human consumption of limited resources impacts the biosphere.

CI E1: Earth and Space Sciences: Students explore natural and human-induced cause-and-effect changes in Earth systems over time.

- 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.

Science and Engineering Practices

Engaging in Argument from Evidence:

- 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.
- 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.

Constructing Explanations and Designing Solutions:

- 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.
- Apply scientific knowledge and evidence to explain real-world phenomena, examples, or events.

Crosscutting Concepts

Stability and Change:

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
- Small changes in one part of a system might cause large changes in another part.
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
- Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.

Cause and Effect:

- 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.

Systems and System Models:

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

Using Science - U3

- There are generally both positive and negative consequences of the applications of science. Some negative impacts can be anticipated but others emerge from experience.
- Some negative impacts can be anticipated but others emerge from experience.
- Clean water, adequate food and improved medicines have increased human life expectancy but at the same time the resulting population growth has increased demands on resources and on space on the Earth's surface for increased food production, housing and disposal of waste. This has often been detrimental to those in developing countries and resulted in the destruction of habitats of other living things, causing some to become extinct.
- There are many examples of how technological and engineering advances have unintended consequences.
- Improved ease and speed of transport, particularly by air, burns fuel that produces carbon dioxide, one of several gases in the atmosphere that keep the Earth warm through the greenhouse effect. Increase in these gases in the atmosphere raises the Earth's temperature. Even a small increase in temperature of the Earth can have widespread effects through changes in the polar ice, sea levels and weather patterns.
- If the detrimental effects are known, the trade-off between the advantages and the disadvantages of the application of science needs careful consideration.

Big Ideas Sequence 3

As the global human population increases, the desire for better living conditions requires more and more resources. The draw on these natural resources impact Earth's natural systems.

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Engage in an argument from evidence to:

1. support a claim that the increase in the size of the human population causes an increase in the consumption of natural resources, benefitting some organisms and harming others.
2. support a claim that natural resource consumption causes changes in the Earth's systems (biosphere, atmosphere, hydrosphere, geosphere).

Eighth Grade Unit 3: Energy Transfer

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

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.

Instructional Sequence 1

Az Science Standard 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.

Az Science Standard 8.P1U1.2

Obtain and evaluate information regarding how scientists identify substances based on unique physical and chemical properties.

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

- All materials, anywhere in the universe, living and non-living, are made of a very large numbers of basic ‘building blocks’ called atoms, of which there are about 100 different kinds.
- Substances made of only one kind of atom are called elements.
- Atoms of different elements can combine together to form a very large number of compounds.
- A chemical reaction involves a rearrangement of the atoms in the reacting substances to form new substances, while the total amount of matter remains the same.
- The properties of different materials can be explained in terms of the behavior of the atoms and groups of atoms of which they are made.
- 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.

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information:

- 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.
- 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).

Developing and Using Models:

- 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:

- 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.
- 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.

Crosscutting Concepts

Energy and Matter:

- 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.
- The transfer of energy can be tracked as energy flows through a designed or natural system.

Patterns:

- Microscopic patterns are related to the nature of microscopic and atomic level structure.

Scale, Proportion, and Quantity:

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
- 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.

Using Science - U1

- Different kinds of natural phenomena are explained in different ways. In some cases a possible explanation (hypothesis) indicates the variable factor thought to cause a phenomenon. To test a hypothesis it is used to predict what will happen when the variable identified as a possible cause is changed and then see if what happens fits the prediction. If the outcome agrees with the prediction, and no other changes are found to produce the same result, then the factor is accepted as being the cause that explains the observation.
- To help explain observations, scientists create models to represent what they think may be happening.
- Sometimes these are physical models, such as an orrery – a model of the solar system where various objects are used to represent the Sun, Moon, Earth and other planets – or a ball and stick model of how atoms are thought to be arranged in a substance.
- Other models are theoretical, more abstract, such as in representing light as a wave motion, or representing relationships as mathematical formulae.
- Computer-based models enable phenomena to be simulated and variables easily changed to investigate their effect.
- Some models are firmly established in theories which have been shown to work without contradiction in all contexts so far encountered.
- Others (models) are more tentative and are likely to be changed in future.

Big Ideas Sequence 1

Models can be used to illustrate that mass is conserved during chemical reactions because the number and types of atoms in the reactants equal the number and types of atoms in the products. A change in the property of a substance is related to the rearrangement of atoms in the reactants of a chemical reaction. The behavior of substances depends on their structures at atomic and molecular levels.

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Obtain, evaluate, and communicate information:

1. that all of matter is comprised of atoms, there are over 100 kinds of atoms, and each "kind" is an element differentiated by its properties.
2. about the characteristic physical and chemical properties (i.e., density, melting point, boiling point, solubility, flammability, odor) of pure substances before and after they react.
3. investigate and identify patterns when atoms rearrange in a chemical reaction to form new compounds (i.e., before the interaction, a substance burns, but after the interaction, the resulting substance does not burn).

Develop and use an (atomic) model:

1. that varies in complexity (i.e., simple ammonia or methanol to sodium chloride) and identify relevant components (i.e., individual atoms, molecules, extended structures with repeating subunits).
2. that demonstrate scale, proportion, and quantity of the types and number of molecules that make of the reactants and products.
3. that demonstrate when a chemical reaction occurs, the atoms that make up molecules of reactants rearrange and form new molecules (products), and that these products are equal to the number and types of atoms that make up the reactants (conservation of matter).

Instructional Sequence 2
Unit 3: Energy Transfer

Az Science Standard 8.P4U1.3

Construct an explanation on how energy can be transferred from one energy store to another.

CI 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.

- Energy can be stored by lifting an object higher above the ground.
- When it is released and falls, this energy is stored in its motion.
- When an object is heated it has more energy than when it is cold.
- An object at a higher temperature heats the surroundings or cooler objects in contact with it until they are all at the same temperature.
- The chemicals in the cells of a battery store energy which is released when the battery is connected so that an electric current flows, transferring energy to other components in the circuit and on to the environment.

Science and Engineering Practices

Constructing Explanations and Designing Solutions:

- 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.

Analyzing and Interpreting Data:

- 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.
- Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success.

Planning and Carrying Out Investigations:

- 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.

Crosscutting Concepts

Energy and Matter:

- 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.

Stability and Change:

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
- Small changes in one part of a system might cause large changes in another part.
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

Scale, Proportion, and Quantity:

- 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.

Using Science - U1

- Careful and systematic observations and accurate descriptions of what is observed are fundamental to scientific investigation.
- Different kinds of natural phenomena are explained in different ways. In some cases a possible explanation (hypothesis) indicates the variable factor thought to cause a phenomenon. To test a hypothesis it is used to predict what will happen when the variable identified as a possible cause is changed and then see if what happens fits the prediction. If the outcome agrees with the prediction, and no other changes are found to produce the same result, then the factor is accepted as being the cause that explains the observation.
- To help explain observations, scientists create models to represent what they think may be happening.

Big Ideas Sequence 2

Energy cannot be created or destroyed but can change form. Some energy is stored (potential) and some is used in different ways (thermal, kinetic). The speed of the particles in matter determines the level of energy in a system.

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Plan and carry out an investigation that:

1. shows how energy is stored (potential, i.e., gravity or battery) and transferred from one type (i.e., kinetic, thermal, chemical) to another.
2. determines the relationship between the transfer of thermal energy, the type of matter, the mass of the matter, and the change in average kinetic energy of the

particles.

3. identifies thermal energy is transferred from hotter objects to colder objects.

Construct an explanation by analyzing data:

1. that provides evidence of proportional relationships between the changes in temperature and materials and the mass of those materials.
2. that connects the change of temperature of a material to the type of matter (i.e., conductor or insulator) and to the change in the average kinetic energy (speed) of the particles.

Instructional Sequence 3
Unit 3: Energy Transfer

Az Science Standard 8.P4U2. 5

Develop a solution to increase efficiency when transferring energy from one source to another.

CI 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.

- An object at a higher temperature heats the surroundings or cooler objects in contact with it until they are all at the same temperature.
- How quickly this happens depends on the kind of material which is heated and on the materials between them (the extent to which they are thermal insulators or conductors).
- The transfer of energy in making things happen almost always results in some energy being shared more widely, heating more atoms and molecules and spreading out by conduction or radiation.
- The process cannot be reversed and the energy of the random movement of particles cannot as easily be used. Thus, some energy is dissipated.

Science and Engineering Practices

Constructing Explanations and Designing Solutions:

- 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.

Crosscutting Concepts

Energy and Matter:

- 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.

Systems and System Models:

- 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.

Using Science - U2

- Designing a solution to a problem generally involves making a drawing or model.
- Physical, mathematical or computer models enable the effect of changes in materials or design to be tested and the solution improved.
- There are usually many factors to be considered in optimizing a solution, such as cost, availability of materials and impact on users and on the environment, which may constrain choices.

Big Ideas Sequence 3

Energy can be lost from a system through thermal (heat) transfer. Some processes are helped by heat loss (i.e., a motor) and some are helped by heat retention (i.e., Styrofoam cups). Materials are designed and made of different substances, some of which store thermal energy better than others.

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Construct an explanation:

1. that during an event that exchanges energy (i.e., plant growth, weather, combusting fuel), energy transfer cannot be reversed and the efficiency depends on the quantity of energy lost from the system.

Develop a solution:

1. to a given problem that requires either minimizing or maximizing thermal energy transfer.
2. that identifies that thermal energy is transferred from hotter objects to colder objects until both are the same temperature.
3. that describes different types of materials used in the solution and their properties (i.e., thickness, heat conductivity, reflectivity) and how these materials will be used to minimize or maximize energy transfer.

Instructional Sequence 4
Unit 3: Energy Transfer

Az Science Standard 8.P4U1. 4

Develop and use mathematical models to explain wave characteristics and interactions.

CI 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.

- A sound wave needs a medium through which it is transmitted.
- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.

Science and Engineering Practices

Mathematical and Computational Thinking:

- Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.
- 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.

Developing and Using Models:

- 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.

Crosscutting Concepts

Patterns:

- 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.
- Graphs, charts, and images can be used to identify patterns in data.

Using Science - U1

- To help explain observations, scientists create models to represent what they think may be happening.
- Sometimes these are physical models, such as an orrery – a model of the solar system where various objects are used to represent the Sun, Moon, Earth and other planets – or a ball and stick model of how atoms are thought to be arranged in a substance.
- Other models are theoretical, more abstract, such as in representing light as a wave motion, or representing relationships as mathematical formulae.
- Computer-based models enable phenomena to be simulated and variables easily changed to investigate their effect.
- Some models are firmly established in theories which have been shown to work without contradiction in all contexts so far encountered.
- Others (models) are more tentative and are likely to be changed in future.

Big Ideas Sequence 4

Waves represent repeating quantities. A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. It is possible to predict the change in the energy of the wave if any one of the parameters of the wave is changed.

Evidence of Learning Specifications: how students show proficiency in standards through engaging with phenomena and 3D learning.

Use mathematics and computational thinking:

1. to identify the characteristics of a simple wave model representing the repeating qualities of a wave (i.e., frequency, amplitude, wavelength).
    a. Frequency is defined as the number of times the pattern repeats in a given amount of time (i.e. beats per second).
    b. Amplitude is the difference between equilibrium to its maximum wave height (i.e., how high an ocean wave reaches compared to sea level).
    c. Wavelength is the length of a wave from one peak to the next (i.e., the distance between the tops of a series of water waves).

Design and use models to:

1. identify how the wave characteristics correspond with physical observations (i.e., frequency corresponds to sound pitch, amplitude corresponds to sound volume).

Bibliography

Harlen, Wynne, editor. *Working with Big Ideas of Science Education.* The Science Education Program (SEP) of IAP, 2015.

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

mesa
PUBLIC SCHOOLS