March 2018 Draft Science Standards Review

As you read through this parent and teacher review of the March 2018 Draft Science Standards, please keep in mind the research of a well-known developmental psychologist, Jean Piaget. Before he studied the minds of children, it was thought that children have the capability to think and reason like adults. However, after his studies on epistemology (the nature of knowledge) and how people gradually acquire it, he formed the Piaget theory –which is used by child psychologists around the world. Below is a basic chart explaining the cognitive development of children and what type of demands their minds can accept in their corresponding ages:

Piaget's Theory

Stage	Age Range	Description
Sensorimotor	0-2 years	Coordination of senses with motor response, sensory curiosity about the world. Language used for demands and cataloguing. Object permanence developed
Preoperational	2-7 years	Symbolic thinking, use of proper syntax and grammar to express full concepts. Imagination and intuition are strong, but complex abstract thought still difficult. Conservation developed.
Concrete Operational	7-11 years	Concepts attached to concrete situations. Time, space, and quantity are understood and can be applied, but not as independent concepts
Formal Operations	11+	Theoretical, hypothetical, and counterfactual thinking. Abstract logic and reasoning. Strategy and planning become possible. Concepts learned in one context can be applied to another.

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A large number of the March 2018 Draft Science Standards do not meet the criteria for clarity and appropriate cognitive demand. These same problems were called out throughout in the 2016 Mathematics Standards Comments document- especially in the Standards for Mathematical Practice- which *still* remain in the 2018 March draft Science Standards. These "Standards for Mathematical practice" are referenced in the "Connection to the Arizona Mathematics Standards" in the March 2018 draft Science Standards, by grade level. These standards need to be removed in grades where they are developmentally inappropriate especially below 11 years old as referenced in "Piaget's Theory" table above. Children under 11 years old cannot think "abstractly, persevere when solving problems, or analyze strategically."

Science has not changed! What *has* changed is the progressives in this country, and around the world, and *how* they want all of us to "teach science" in the classroom. These supposed "big ideas" that were the basis for these Science Standards, and the Next Generation Science Standards, are "bad ideas," and are nothing more than the progressives push to change *how* our children are being taught and it is *adding* to the "deliberate dumbing down of America" that we continue to see with Common Core in English Language Arts and Mathematics through our current Arizona K-12 Standards.

The same documents the working groups used to develop the March 2018 draft Science Standards, "Working with Big Ideas of Science Education" and "A Framework for K-12 Science Education," were the basis for

developing the Next Generation Science Standards (NGSS). So, saying these standards do not resemble NGSS is just a false statement. Twenty-six states rallied together to review these 2 documents, and Arizona was one of them under former Superintendent John Huppenthal, and these states were told to review the draft NGSS science standards that were primarily written by Achieve, Inc. This is eerily familiar to what happened with Common Core in 2010 but under the National Governor's Association. The "Three Dimensions" you call out in in the "Introduction"- Science & Engineering Practice, Crosscutting Concepts and Core Ideas- are the same three ideas called out in NGSS (same verbiage!). There is no hiding or denying that these ideas are the same in this March 2018 draft Science Standards as NGSS! What developmental psychologist(s) were used in developing the March 2018 draft Science Standards? Was this developmental psychologist(s) consulted on the "assumed minutes per week" of instructional time necessary for students to learn these standards by grade level from K-8 and High School?

Two experts were called by California and Massachusetts to review their Science Standards in 2012 when they adopted NGSS- Ze'ev Wurman and Paul R. Gross. This is what they had to say about NGSS: "The [NGSS] standards are so generic. They often lack actual content that has been in the past standards," said Ze'ev Wurman in a Boston Herald article. Paul R. Gross stated, "The new standards leave out much important science that has worked perfectly for our students in the recent past….to follow the newest wrinkle in school pedagogy, every standard becomes a performance test, not necessarily on the history, the facts, and *big ideas* of science, but primarily on the students' ability to satisfy somebody's idea of *their* 'explanation,' or 'modeling,' or 'collecting evidence' skills and the like." Fordham Institute rated NGSS a "C" rating and Arizona's 2005 Science Standards a "D" rating, BTW. We continue to see the same problem with the Common Core Standards today in our state- "primarily [asking] students to prove their ability to satisfy somebody's idea of *their* 'explanation,' or 'modeling,' or 'collecting evidence' skills and the like." These March 2018 draft Science Standards are *very* generic and lack the "big ideas of science" which have been successful for decades. "According to the National Science Foundation's (NSF) Science and Engineering Indicators 2018 report released [in January], the United States is the global leader in science and technology (S&T)" So, *why* do we need to teach science in a new way using these supposed "Big Ideas" like eliminating the Scientific Method which has been rigorous in Science application for decades? Science *has not* changed, just the way progressives in this country want to "teach science."

The 2006 Massachusetts Science/Technology Standards were rated #1 in the nation before NGSS standards were developed in 2010! We would suggest the working groups use these standards to fill in the gaps in the March 2018 Science Standards where standards are missing or delayed. Massachusetts continues to outperform the states on NAEP assessments scores year-after-year. The 2006 Massachusetts Science/Technology Standards are referenced throughout this document in PreK-2nd grade, 3rd-6th grade, 6th-8th grade and in the High School grade sections.

Introduction

This is where a development psychologist is needed to review the standards in their entirety: "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." See "Piaget's Theory" table on what children can cognitively do from 0-11 years of age- page 1 of this document. Children cannot think abstractly, strategize, persevere or apply one concept to another until at least 11 years old!

Safety Expectations do not need to be called out in the Science standards document- Occupational Health and Safety Administration (OSHA) or the Environmental Protection Agency (EPA). These are class specific for each school and should be handled in their own school safety plan. Students are already required to sign safety agreements when using lab equipment and chemicals for Chemistry Class or a microscope safety agreement in a Biology class, for example.

Kindergarten

Kindergarteners cannot collect and make sense of observational data using science and engineering practices: "ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematical and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate and communicate information." This are developmentally inappropriate according to "Piaget Theory" on what children can cognitively due in ages 0-11 years old!

A review of the March 2018 draft Science Standards compared to the 2013 Next Generation Science Standards (NGSS) written by Achieve, Inc.

Arizona Earth and Space Science Standards vs. NGSS

K.E1U1.3	**K-ESS2-1**
Observe, records and ask questions about temperature precipitation, and other weather data to identify patterns or changes in local weather.	**Weather and Climate-** Weather is the combination of sunlight, wind snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather to notice patterns over time (K-ESS2.D)
K.E1U1.4	**K-ESS2-2**
Observe, describe, ask questions, and predict seasonal weather patterns; understand how those patterns influence plans and animals (including humans)	**Construct an argument supported by evidence for how plans and animals (including humans) can change the environment to meet their needs.** Plants and animals can change their environment (K-ESS2.C and E)

Arizona Life Sciences Standards vs. NGSS

K.L2U.6	**K-ESS3-1**
Ask questions about and explain the difference between the properties of living and nonliving things.	**Use a model to represent the relationship between the needs of different plants or animals (including humans and the places they live.** Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. (K-ESS3.A)
K.L4U2.7	**K-ESS3-3**
Ask questions about and explain how specialized structures found on a variety of plants and animals (including humans) help them sense and respond to their environment.	**Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.** Things that people do to live comfortably can affect the world around them. But they can make choices to

	reduce their impacts on the land, water, air and other living things (K-ESS3.C)

Kindergarten Connections to Other Academic Disciplines

Connection to the Arizona English Language Arts (ELA) Standards for Kindergarten- "Use age-appropriate scientific text and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards." Who determines this when the current Arizona K-12 ELA standards are already developmentally inappropriate?

Connection to the Arizona Mathematics Standards for Mathematical Standards for Kindergarten

- Standards for Mathematical Practice- Developmentally inappropriate for this age!

First Grade

First graders cannot collect and make sense of observational data using science and engineering practices: "ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematical and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate and communicate information." This are developmentally inappropriate according to "Piaget Theory" on what children can cognitively due in ages 0-11 years old!

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Arizona Physical Science Standards vs. NGSS

1.P2U1.1	**1-PS4-3**
Plan and carry out investigations demonstrating the effect of placing objects made with different material in the path of a beam of light and **predict** how objects with similar properties with affect the beam of light.	**Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.** Some materials allow light to pass through them, others allow only some light through and other block all the light and create a dark shadow on any surface beyond them, where the light cannot reach... (1-PS4.B)

Arizona Life Sciences Standards vs. NGSS

1.L3U2.9	**1-LS1-2**
Obtain, evaluate, and communicate information to support an evidence-based explanation that plants and animals produce offspring of the same kind, but offspring are generally no identical to each other or their parents.	**Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.** Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive (1-LS1.B)

First Grade Connections to Other Academic Disciplines

Connection to the Arizona English Language Arts (ELA) Standards for First Grade- "Use age-appropriate scientific text and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards." Who determines this when the current K-12 ELA standards are already developmentally inappropriate?

Connection to the Arizona Mathematics Standards for Mathematical Standards for First Grade

- Standards for Mathematical Practice- Developmentally inappropriate for this age!

Second Grade

Second graders cannot collect and make sense of observational data using science and engineering practices: "ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematical and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate and communicate information." This are developmentally inappropriate according to "Piaget Theory" on what children can cognitively due in ages 0-11 years old!

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Arizona Physical Science Standards vs. NGSS

2.P1U2.1	**2-PS1-1**
Plan and carry out investigation to determine that matter has mass, takes up space, and is recognized by its observable properties; use the collected evidence to **develop and support and explanation.**	**Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.** Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties (1-PS1.A)
2.P1U2.2	**2-PS1-4**
Plan and carry out investigations to gather evidence to support an explanation on how heating or cooling can cause a transformation (solid, liquid, gas).	**Construct an argument with evidence that some changes cause by heating or cooling can be reversed and some cannot.** Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not. (2-PS1.B)
2.P4U1.3	**2-PS1-4 (Chemical reactions)**
Gather, reason, and communicate information about ways heat energy can cause change in objects or materials.	**Heating or cooling a substance may cause changes that can be observed.** Sometimes these changes are reversible, and sometimes they are not. (2-PS1.B)

Arizona Earth and Space Science Standards vs. NGSS

2.E1U1.4	**2-ESS2-1**
Observe, describe, and predict how wind and water change the shape of the land resulting in a variety of landforms.	**Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.** (2-ESS2.A)

K.E1U2.5	2-ESS2-3
Develop and use models to represent that water can exist in different states and is found in oceans, glaciers, lakes, rivers, ponds, and the atmosphere (water cycle).	**The Roles of Water in Earth's Surface Processes. Water is found in the ocean, rivers, lakes, and ponds**. Water exists as solid ice and in liquid form. (2-ESS2.C)

Arizona Physical Science Standards vs. NGSS

2.P1U2.1	2-PS1-1
Plan and carry out an investigation to determine that matter has mass, takes up space, and is recognized by its observable properties; use the collected evidence to **develop and support and explanation.**	**Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.** Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties. (2-PS1.A)
2.P1U2.2	**2-PS1-4**
Plan and carry out investigations to gather evidence to support and explanation on how heating or cooling can cause a transformation (solid, liquid, gas).	**Construct and argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.** Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not (2-PS1.B)
2.P4U1.3	**2-PS1-4 (Chemical Reactions)**
Gather, reason, and communicate information about ways heat energy can cause change in objects or materials.	**Construct and argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.** Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not (2-PS1.B)

Distribution of K-2 Standards

L4- "The theory of evolution seeks to make clear the unity and diversity of living and extinct organisms." (K.L4U2.7, 1.L4U2.10 and 1.L4U4.11) Students should hear about the controversy in the highest levels of science over neo-Darwinian evolution. By examining both sides, asking questions and analyzing concepts, students will learn science more effectively. In 2017, Texas' streamlined biology standards on evolution and these standards provide a wonderful model of this.

Second Grade Connections to Other Academic Disciplines

Connection to the Arizona English Language Arts (ELA) Standards for Second Grade- "Use age-appropriate scientific text and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards." Who determines this when the current K-12 ELA standards are already developmentally inappropriate?

Connection to the Arizona Mathematics Standards for Mathematical Standards for Second Grade

- Standards for Mathematical Practice- Developmentally inappropriate for this age!

From the 2006 Massachusetts Science/Technology Standards (PreK-2nd grade):

- "**In grades PreK–2**, scientific investigations can center on student questions, observations, and communication about what they observe. For example, students might plant a bean seed following simple directions written on a chart. Then they can write down what happens over time in their own words."

Grades PreK–2

- Ask questions about objects, organisms, and events in the environment.
- Tell about *why and what would happen if*?
- Make predictions based on observed patterns.
- Name and use simple equipment and tools (e.g., rulers, meter sticks, thermometers, hand lenses, and balances) to gather data and extend the senses.
- Record observations and data with pictures, numbers, or written statements.
- Discuss observations with others.

Earth and Space Science

- "In **grades PreK–2**, students are naturally interested in everything around them. This curiosity leads them to observe, collect, and record information about the earth and about objects visible in the sky. Teachers should encourage their students' observations without feeling compelled to offer precise scientific reasons for these phenomena. Young children bring these experiences to school and learn to extend and focus their explorations. In the process, they learn to work with tools like magnifiers and simple measuring devices."

  "Learning standards for grades PreK–2 fall under the following four subtopics: *Earth's Materials; The Weather; The Sun as a Source of Light and Heat;* and *Periodic Phenomena."*

Life Science (Biology)

- "As Piaget noted, young children tend to describe anything that moves as *alive.* For purposes of working with students in **grades PreK–2**, who do not yet understand the continuity of life (e.g., from seed to seedling to tree to log), *living* can be defined as anything that is alive or has ever been alive (e.g., muskrat, flower, roadkill, log) and *nonliving* can be defined as anything that is not now and has never been alive (e.g., rock, mountain, glass, wristwatch). Over time, students refine their intuitive understanding. They begin to include in their definition of *living* such behaviors as eating, growing, and reproducing. They learn to use their senses to observe and then describe the natural world. Noticing differences and similarities, and grouping organisms based on common features are skills developed in the life science curriculum at this grade span. For a more in-depth discussion of this issue, please refer to the *National Science Education Standards*."

  "Learning standards for PreK–2 fall under the following four subtopics: *Characteristics of Living Things; Heredity; Evolution and Biodiversity;* and *Living Things and Their Environment."*

Physical Sciences (Chemistry and Physics)

- "In **grades PreK–2**, students' curiosity is engaged when they observe physical processes and sort objects by different criteria. During these activities, students learn basic concepts about how things are alike or different. As they push, pull, and transform objects by acting upon them, the students see the results of their actions and begin to understand how part of their world works. They continue to build understanding by telling stories about what they did and what they found out."

  "Learning standards for PreK–2 fall under the following three subtopics: *Observable Properties of Objects; States of Matter;* and *Position and Motion of Objects."*

Technology/Engineering

- "Even before entering **grades PreK–2**, students are experienced technology users. Their natural curiosity about how things work is clear to any adult who has ever watched a child doggedly work to improve the design of a paper airplane, or to take apart a toy to explore its insides. They are also natural engineers and inventors, builders of sandcastles at the beach and forts under furniture. Most students in grades PreK–2 are fascinated with technology. While learning the safe uses of tools and materials that underlie engineering solutions, PreK–2 students are encouraged to manipulate materials that enhance their three-dimensional visualization skills–an essential component of the ability to design. They identify and describe characteristics of natural and humanmade materials and their possible uses and identify uses of basic tools and materials (e.g., glue, scissors, tape, ruler, paper, toothpicks, straws, spools). In addition, PreK–2 students learn to identify tools and simple machines used for specific purposes (e.g., ramp, wheel, pulley, lever). They also learn to describe how human beings use parts of the body as tools."

  "Learning standards for PreK–2 fall under the following two subtopics: *Materials and Tools;* and *Engineering Design."*

Third Grade

Third graders cannot collect and make sense of observational data using science and engineering practices: "ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematical and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate and communicate information." This are developmentally inappropriate according to "Piaget Theory" on what children can cognitively due in ages 0-11 years old!

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Arizona Physical Science Standards vs. NGSS

3.P2U2.2	**1-PS4-1 (In 1st grade!)**
Collect data and construct arguments based on evidence to explain how sound waves affect objects at varying distances and parts of the human ear.	**Plan and conduct investigation to provide evidence that vibrating materials can make sound and that sounds can make materials vibrate.** Sounds can make matter vibrate, and vibrating matter can make sound. (1-PS4.A)

Arizona Earth and Space Science Standards vs. NGSS

3.E1U1.4	**K-PS3-1 (In Kindergarten!)**
Construct an explanation describing how the Sun is the primary source of energy for the Earth.	**Make observations to determine the effect of sunlight on Earth's surface.**

Arizona Life Science Standards vs. NGSS

3.L1U2.6	**1-LS1-1 (In 1st grade!)**
Develop and use models to explain that plants and animals have internal and external structures that serve various functions that aid in growth, survival, behavior, and reproduction.	**Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.** All organisms have

	external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. (1-LS1.A)
3.L2U1.8	**2-LS2-1**
Use food chains as **system models** to describe the exchange of energy between the Sun, plants, and animals.	**Plan and conduct an investigation to determine if plants need sunlight and water to grow.** Interdependent Relationships in Ecosystems (2-LS2.A)

Third Grade Connections to Other Academic Disciplines

Connection to the Arizona English Language Arts (ELA) Standards for Third Grade- "Use age-appropriate scientific text and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards." Who determines this when the current ELA standards are already developmentally inappropriate?

Connection to the Arizona Mathematics Standards for Mathematical Standards for Third Grade

- Standards for Mathematical Practice- Developmentally inappropriate for this age!

Fourth Grade

Fourth graders cannot collect and make sense of observational data using science and engineering practices: "ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematical and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate and communicate information." This are developmentally inappropriate according to "Piaget Theory" on what children can cognitively due in ages 0-11 years old!

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Arizona Physical Science Standards vs. NGSS

4.P4U2.2	**3-PS2-3 (In 3rd grade!)**
Develop and use a model that demonstrates how energy is moved from place to place through electric and magnetic currents.	**Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other**. Electric, and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. (3-PS2.B)
4.P4U4.3	**4-ESS3-2**

Construct an explanation and engage in argument from evidence on the use of renewable and nonrenewable resources to provide energy. (Indoctrination here- manmade global warming proven false!)	**Generate and compare multiple solutions to reduce the impacts of natural Earth process on humans.** Energy and fuels that humans use is derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. (4-ESS3.A)

Arizona Earth and Space Science Standards vs. NGSS

4.E1U2.4	**4-ESS2-2**
Use models to explain seismic waves and their effect on the Earth.	**Analyze and interpret data from maps to describe patterns of Earth's features.** The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water feature area of Earth. (4-ESS2.B)
4.E1U4.8	**No NGSS standard match- NOAA chemtrail worksheets will be taught for cloud types!** This is indoctrination and chemtrails caused by man and not natural!
Collect, analyze, and interpret data to explain weather and climate patterns. (Indoctrination here- manmade global warming proven false!)	Concepts taught in 2.E1U3.6 and weather, climate, fronts, forecasting, barometric pressure, cloud types.
4.E1U3.10	
Identify the causes and effect of natural disasters, **define the problem(s),** and **design solution(s)** to minimize those effect on humans.	Cannot minimize natural disasters- just be prepared! (Grab and Go kits, extra water, family/community evacuation plan, etc.)

Fourth Grade Connections to Other Academic Disciplines

Connection to the Arizona English Language Arts (ELA) Standards for Fourth Grade- "Use age-appropriate scientific text and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards." Who determines this when the current ELA standards are already developmentally inappropriate?

Connection to the Arizona Mathematics Standards for Mathematical Standards for Fourth Grade

- Standards for Mathematical Practice- Developmentally inappropriate for this age!

Fifth Grade

Fifth graders cannot collect and make sense of observational data using science and engineering practices: "ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematical and computational thinking, construct explanations and design solutions, engage in

argument from evidence, and obtain, evaluate and communicate information." This are developmentally inappropriate according to "Piaget Theory" on what children can cognitively due in ages 0-11 years old!

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Arizona Physical Science Standards vs. NGSS

5.P1U1.1	**5-PS1-1**
Analyze and interpret data to explain that matter of any type can be subdivided into particles too small to see (atom) and, in a closed system, if properties change or reactions occur, the amount of matter stays the same.	**Develop a model to describe that matter is made of particles too small to be seen.** Matter of any type can be subdivided into particles that are too small to see, but even than the matter still exists and can be detected by other means. A model showing that gases are made freely from matter particles that are too small to see and are moving freely can explain man observations... (5-PS1.A)
5.P2U1.3	**5-PS1-4**
Construct an explanation using evidence of the effect that balanced and unbalanced forces have on the motion of objects	**Conduct an investigation to determine whether the mixing of two or more substances results in new substances.** When two or different substances are mixed, a new substance with different properties may be formed. (5-PS1.B)
5.P3U1.4	**3-PS2-1**
Obtain, analyze, and communicate evidence of the effects that balanced and unbalanced forces have on the motion of objects	**Support and argument that the gravitational force exerted by Earth on objects is directed down.** The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the plant's center. (5-PS2.B)
5.P3U3.5	**3-PS2-1**
Apply scientific ideas to **define problems** and **design solutions** pertaining to force and motion- **Scientific Method or NGSS way?**	**Support and argument that the gravitational force exerted by Earth on objects is directed down.** The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the plant's center. (5-PS2.B)
5.P4U1.6	**3-PS2-3 (In 3rd grade!)**
Analyze and interpret data to determine whether energy is present and can be transferred whenever there are moving objects.	**Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.** Electric, and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. (3-PS2.B)

Arizona Life Science Standards vs. NGSS

5.L4U4.11- Genetic Information	M-LS3-1 (Middle School- Heredity!)
Obtain, evaluate, and communicate evidence about how natural and human cause changes to habitats or climate can impact populations.	**Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.** In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. (MS-LS3.B)

Distribution of 3-5 Standards

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." Indoctrination throughout this "distribution of standards" in 3-5th grade. Manmade global warming proven false! **(**4.E1U4.9- "Applications of science have often had both positive and negative, ethical, social economic, and political implications." Too subjective and cannot be measured. Politics should be left out of the classroom which is the law!**)**

Fifth Grade Connections to Other Academic Disciplines

Connection to the Arizona English Language Arts (ELA) Standards for Fifth Grade**-** "Use age-appropriate scientific text and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards." Who determines this when the current ELA standards are already developmentally inappropriate?

Connection to the Arizona Mathematics Standards for Mathematical Standards for Fifth Grade

- Standards for Mathematical Practice- Developmentally inappropriate for this age!

From the 2006 Massachusetts Science/Technology Standards (3rd-5th grade):

- "**In grades 3–5**, students can plan and carry out investigations as a class, in small groups, or independently, often over a period of several class lessons. The teacher should first model the process of selecting a question that can be answered, formulating a hypothesis, planning the steps of an experiment, and determining the most objective way to test the hypothesis. Students should incorporate mathematical skills of measuring and graphing to communicate their findings."

Grades 3–5

- Ask questions and make predictions that can be tested.
- Select and use appropriate tools and technology (e.g., calculators, computers, balances, scales, meter sticks, graduated cylinders) in order to extend observations.
- Keep accurate records while conducting simple investigations or experiments.
- Conduct multiple trials to test a prediction. Compare the result of an investigation or experiment with the prediction.
- Recognize simple patterns in data and use data to create a reasonable explanation for the results of an investigation or experiment.
- Record data and communicate findings to others using graphs, charts, maps, models, and oral and written reports.

Earth and Space Science

- "In **grades 3–5**, students explore properties of geological materials and how they change. They conduct tests to classify materials by observed properties, make and record sequential observations, note patterns and variations, and look for factors that cause change. Students observe weather phenomena and describe them quantitatively using simple tools. They study the water cycle, including the forms and locations of water. The focus is on having students generate questions, investigate possible solutions, make predictions, and evaluate their conclusions."

  "Learning standards for grades 3–5 fall under the following six subtopics: *Rocks and Their Properties; Soil; Weather; The Water Cycle; Earth's History;* and *The Earth in the Solar System."*

Life Science (Biology)

- "In **grades 3–5**, students expand the range of observations they make of the living world. In particular, students in these grades record details of the life cycles of plants and animals and explore how organisms are adapted to their habitats. Students move beyond using their senses to gather information. They begin to use measuring devices to gather quantitative data that they record, examine, interpret, and communicate. They are introduced to the power of empirical evidence as they design ways of exploring questions that arise from their observations. "

  "Learning standards for grades 3–5 fall under the following four subtopics: *Characteristics of Plants and Animals; Structures and Functions; Adaptations of Living Things;* and *Energy and Living Things."*

Physical Sciences (Chemistry and Physics)

- "In **grades 3–5**, students' growth in their understanding of ordinary things allows them to make the intellectual connections necessary to understand how the physical world works. Students are able to design simple comparative tests, carry out the tests, collect and record data, analyze results, and communicate their findings to others."

  "Learning standards for grades 3–5 fall under the following three subtopics: *Properties of Objects and Materials; States of Matter;* and *Forms of Energy* (including electrical, magnetic, sound, and light)."

Technology/Engineering

- "Students in **grades 3–5** learn how appropriate materials, tools, and machines extend our ability to solve problems and invent. They identify materials used to accomplish a design task based on the materials' specific properties, and explain which materials and tools are appropriate to construct a given prototype. They achieve a higher level of engineering design skill by recognizing a need or problem, learning different ways that the problem can be represented, and working with a variety of materials and tools to create a product or system to address the problem."

  "Learning standards for grades 3–5 fall under the following two subtopics: *Materials and Tools;* and *Engineering Design."*

6th-8th Grade

Sixth through eighth grade is when children can start to collect and make sense of observational data using science and engineering practices: "ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematical and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate and communicate information." According to "Piaget Theory" starting at 11 years of age, students can handle "abstract logic and

learning, can strategize and compare concepts learned in one area of science and apply it to another area of science."

A review of the March 2018 draft Science Standards compared to the 2013 Next Generation Science Standards (NGSS) written by Achieve, Inc.

Arizona Physical Science Standards vs. NGSS

6.P1U1.1	**MS-PS3-1 & MS-PS-3-2**
Analyze and interpret data to show how changes in state od matter are caused by different rates of movement of atoms in solids, liquids, and gases (Kinetic Theory)	**Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. (MS-PS3-1)** **Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer (MS-PS-3-2)**
6.P1U1.2	**MS-PS3-3**
Plan and carry out an investigation to demonstrate how variations of temperature and/or pressure affect changes in state of matter.	**Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.** Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (Ms-PS3.B)
6.P1U2.3	**MP-PS1-1**
Develop and use models to demonstrate that matters is made up of smaller particles called atoms.	**Develop models to describe the atomic composition of simple molecules and extended structures.** Substance are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1.A)
6.P3U2.4	**5-PS2-1 (5th grade)**
Plan and carry out an investigation that can support and evidence-based explanation of how objects on Earth are affected by gravitational forces.	**Support an argument that the gravitational force exerted by Earth on objects is directed down.** The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2.B)
6.P4U3.5	**MS-PS3-2**
Analyze how humans use technology to store (potential) and/or use (kinetic) energy.	**Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amount of potential energy are stored in the system.** A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3.A)

Arizona Earth and Space Science vs. NGSS

6.E2U1.7	**MS-ESS1-2**
Evaluate how gravitational forces affect the motion of objects in our Solar System.	**Develop and use a model to describe the role of gravity in the motion within galaxies and the solar system.** Earth and its solar system are part of the

	Milky Way galaxy, which is one of many galaxies in the universe (MS-ESS1.A)
6.E2U2.9	**MS-ESS1-2**
Develop and use models to explain how constellations and other night sky patterns appear to move due Earth's rotation and revolution.	**Develop and use a model to describe the role of gravity in the motion within galaxies and the solar system.** Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models (MS-ESS1.A)
6.E2U2.11	**MS-EES1-1**
Develop and use models to construct an explanation of how eclipses, moon phases, and tides occur within the Sun-Earth-Moon system.	**Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.**

Arizona Life Sciences vs. NGSS

6.L1U2.13	**MS-LS1-1**
Carry out an investigation to provide evidence that all living things are made of cells, cells come from existing cells, and cells are the basic structural and functional unit of all living things.	**Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers of types of cells.** All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and typed of cells (multicellular). {Ms-LS1.A}
6.L1U1.14	**MS-LS1-3**
Develop and use a model to explain the organizational levels of structure in multicellular organisms consisting of organ systems, organs, tissues, and cells.	**Use arguments supported by evidence for how the body is a system of interacting subsystems composed of a group of cells. In multicellular organisms, the body is a system of multiple interacting subsystems.** These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.
6.L1U2.15	**MS-LS1-2**
Construct an explanation to demonstrate the relationship between major cell structures and cell functions (plant and animal)	**Develop and use a model to describe the function of a cell as a whole and ways the parts of the cells contribute to the function.** Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.
6.L2U1.16	**MS-LS1-6**
Construct and explanation for how some cells use light energy through the process of photosynthesis.	**Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy.** Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the

	atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1.C)

Sixth Grade Connections to Other Academic Disciplines

Connection to the Arizona English Language Arts (ELA) Standards for Sixth Grade- "Use age-appropriate scientific text and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards." Who determines what is developmentally appropriate at this age?

Connection to the Arizona Mathematics Standards for Mathematical Standards for Sixth Grade

Standards for Mathematical Practice- Developmentally appropriate for this age! According to "Piaget Theory" starting at 11 years of age, students can handle "abstract logic and learning, can strategize and compare concepts learned in one area of science and apply it to another area of science."

7th Grade

A review of the March 2018 draft Science Standards compared to the 2013 Next Generation Science Standards (NGSS) written by Achieve, Inc.

Arizona Physical Science Standards vs. NGSS

7P2U1.1	**MS-PS2-3**
Collect and analyze data demonstrating how electric and magnetic forces can be attractive or repulsive and can vary in strength.	**Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.** Electric and magnetics (electromagnetic) forces can be attractive or repulsive, and their sixes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between interacting objects. (MS-PS2.B)
7.P2U2.2	**MS-PS2-5**
Develop and use a model to predict how forces act on objects at a distance.	**Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other though the objects are not in contact.** Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively) (MS-PS2.B)
7.P3U2.3	**MS-PS2-1**
Use non-algebraic **mathematics and computational thinking** to explain Newton's laws of Motion	**Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.** 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 (Newton's Third Law) {MS-PS2.A}

Arizona Earth and Space Science Standards vs. NGSS

7.E1U2.4	**MS-ESS2-1**
Construct a model that shows the cycling of mater and flow of energy in the atmosphere, hydrosphere and geosphere.	**Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.** All Earth's 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. (MS-ESS2.A)
7.E1U2.5	**MS-ESS2-3**
Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structure to provide evidence of the past plate motions.	**Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.** 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. (MS-ESS2.B)
7.E1U3.6	**MS-ESS2-2**
Construct an explanation for how the technology scientists use to predict weather and to explore Earth has evolved over time.	**Construct and explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.** The plant's systems interact over scales that range from microscope to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2.A)

Arizona Life Science Standards vs. NGSS

7.L1U1.7	**MS-LS2-4**
Explain how organisms maintain internal stability and evaluate the effect of the external factors on organisms' internal stability.	**Construct an argument supported by empirical evidence that changes to physical and biological components of an ecosystem affect populations.** Ecosystems are dynamic in nature; their characteristic can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations (MS-LS2.C)
7.L2U2.9	**MS-LS2-2**
Develop and use models to demonstrate the interdependence of organisms and their environment including biotic and abiotic factors.	**Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.** In an ecosystem, organisms and

	populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, across to which consequently constrains their growth and reproduction. (MS-LS2.A)
7.L2U2.10	**MS-LS1-6**
Construct an explanation of how organisms use energy sources in ecosystems.	**Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.** Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1.C)

Seventh Grade Connections to Other Academic Disciplines

Connection to the Arizona English Language Arts (ELA) Standards for Seventh Grade- "Use age-appropriate scientific text and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards." Who determines what is developmentally appropriate at this age?

Connection to the Arizona Mathematics Standards for Mathematical Standards for Seventh Grade

Standards for Mathematical Practice- Developmentally appropriate for this age! According to "Piaget Theory" starting at 11 years of age, students can handle "abstract logic and learning, can strategize and compare concepts learned in one area of science and apply it to another area of science."

8th Grade

A review of the March 2018 draft Science Standards compared to the 2013 Next Generation Science Standards (NGSS) written by Achieve, Inc.

Arizona Physical Science Standards vs. NGSS

8.P1U2.1	**MS-PS1-1**
Develop and use a model to demonstrate how atoms and molecules can be combined or rearranged in chemical reactions to form new compounds with the total number of each type of atom conserved.	**Develop models to describe the atomic composition of simple molecules and extended structures.** Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms (MS-PS1.A)
8.P4U1.3	**MS-PS1-2 and MS-PS1-5**
Obtain and evaluate information regarding how scientists use technology to identify substances based on unique physical and chemical properties.	**Analyze and interpret data on the properties of substances before and after the substance interact to determine if a chemical reaction has occurred (MS-PS1-2)**

	Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved (MS-PS1-5)
8.P4U1.4	**MS-PS4-1**
Evaluate how energy affects wave characteristics and interactions **using mathematical models.**	**Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy of a wave.** A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude (MS-PS4.A)
8.P4U3.5	**MS-PS4-2**
Develop a solution to increase efficiency when transferring energy from one source to another.	**Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.** When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4.B)

Arizona Earth and Space Science Standards vs. NGSS

8.E1U1.6	**MS-ESS2-2**
Develop and use a model of Earth's geological column to **communicate** relative ages of rocks layers and fossils.	**Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying times and spatial scales.** The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. There interactions have shaped Earth's history and will determine its future. (MS-ESS2.A)
8.E1U3.7	**MS-ESS3-2**
Obtain, evaluate, and communicate information about technologies that use data and historical patterns to predict natural disasters.	**Analyze and interpret data on natural hazards to forecast catastrophic events and inform the development of technologies to mitigate their effects.** Mapping the history of natural hazards in a region, combined with understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3.B)
8.E1U4.8	**MS-ESS3-3**
Construct and support an argument about human consumption of limited resources impacts the geosphere. (Very subjective and up to interpretation of data- can be indoctrination that all human activity is harmful to environment which isn't true!)	**Apply scientific principles to design a method for monitoring and minimizing human impact to the environment.** Human activities have significantly altered the biosphere, sometimes damaging or destroying the natural habitats and causing extinction of other species. But changes in Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3.C)

Arizona Life Science Standards (Patterns and Genetic Information) vs. NGSS

8.L3.U1.9	**HS-LS3-1 (High School!)**
Explain how the transfer of genetic information from each parent produces variation in offspring.	**Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.** All cells contain genetic information in the form of DNA molecules. Genes are regions in DNA that contain the instructions that code for the formation of proteins. (HS-LS1.A)
8.L4U2.11	**HS-LS3-1 (High School!), HS-LS3-3 (High School!) and MS-LS3-2**
Develop and use a model to explain how natural selection may lead to increases and decreases of specific traits in populations over time.	**Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. (HS-LS3-1)** **Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population (HS-LS3-3)** **Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. (MS-LS3-2)**
8.L4U2.12	**HS-LS3-2**
Gather and communicate evidence on the processes by which a species may change over time in response to environmental conditions.	**Make and defend a claim based on evidence that inheritable genetic variation may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.** In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3.B)

Eighth Grade Connections to Other Academic Disciplines

Connection to the Arizona English Language Arts (ELA) Standards for Eighth Grade- "Use age-appropriate scientific text and biographies to develop instruction surrounding the Reading Standards for Informational Text, the Reading Standards for Foundational Skills, and the Writing Standards." Who determines what is developmentally appropriate at this age?

Connection to the Arizona Mathematics Standards for Mathematical Standards for Eighth Grade

Standards for Mathematical Practice- Developmentally appropriate for this age! According to "Piaget Theory" starting at 11 years of age, students can handle "abstract logic and learning, can strategize and compare concepts learned in one area of science and apply it to another area of science."

From the 2006 Massachusetts Science/Technology Standards (6th-8th grade):

- "**In grades 6–8**, teacher guidance remains important but allows for more variation in student approach. Students at this level are ready to formalize their understanding of what an experiment requires by controlling variables to ensure a fair test. Their work becomes more quantitative, and they learn the importance of carrying out several measurements to minimize sources of error. Because students at this level use a greater range of tools and equipment, they must learn safe laboratory practices (see Appendix IV). At the conclusion of their investigations, students in these grades can be expected to prepare reports of their questions, procedures, and conclusions."

Grades 6–8

- Formulate a testable hypothesis.
- Design and conduct an experiment specifying variables to be changed, controlled, and measured.
- Select appropriate tools and technology (e.g., calculators, computers, thermometers, meter sticks, balances, graduated cylinders, and microscopes), and make quantitative observations.
- Present and explain data and findings using multiple representations, including tables, graphs, mathematical and physical models, and demonstrations.
- Draw conclusions based on data or evidence presented in tables or graphs and make inferences based on patterns or trends in the data.
- Communicate procedures and results using appropriate science and technology terminology.
- Offer explanations of procedures, and critique and revise them.

Earth and Space Science

- "In **grades 6–8**, students gain sophistication and experience in using models, satellite images, and maps to represent and interpret processes and features. In the early part of this grade span, students continue to investigate geological materials' properties and methods of origin. As their experiments become more quantitative, students should begin to recognize that many of the earth's natural events occur because of processes such as heat transfer.

  Students in these grades should recognize the interacting nature of the earth's four major systems: the geosphere, hydrosphere, atmosphere, and biosphere. They should begin to see how the earth's movement affects both the living and nonliving components of the world. Attention shifts from the properties of particular objects toward an understanding of the place of the earth in the solar system and changes in the earth's composition and topography over time. Middle school students grapple with the importance and methods of obtaining direct and indirect evidence to support current thinking. They recognize that new technologies and observations change our explanations about how things in the natural world behave."

Life Science (Biology)

- "In **grades 6–8**, the emphasis changes from observation and description of individual organisms to the development of a more connected view of biological systems. Students in these grades begin to study biology at the microscopic level, without delving into the biochemistry of cells. They learn that organisms are composed of cells and that some organisms are unicellular and must therefore carry out all of the necessary processes for life within that single cell. Other organisms, including human beings, are multicellular, with cells working together. Students should observe that the cells of a multicellular organism can be physically very different from each other and should relate that fact to the specific role that each cell has in the organism (specialization). For example,

cells of the eye or the skin or the tongue look different and do different things. Students in these grades also examine the hierarchical organization of multicellular organisms and the roles and relationships that organisms occupy in an ecosystem. As is outlined in the *National Science Education Standards*, students in grades 6–8 should be exposed in a general way to the systems of the human body but are not expected to develop a detailed understanding at this grade level. They should develop the understanding that the human body has organs, each of which has a specific function of its own, and that these organs together create systems that interact with each other to maintain life."

"At the macroscopic level, students focus on the interactions that occur within ecosystems. They explore the interdependence of living things, specifically the dependence of life on photosynthetic organisms such as plants, which in turn depend upon the sun as their source of energy. Students use mathematics to calculate rates of growth, derive averages and ranges, and represent data graphically to describe and interpret ecological concepts.

Learning standards for grades 6–8 fall under the following eight subtopics: *Classification of Organisms; Structure and Function of Cells; Systems in Living Things; Reproduction and Heredity; Evolution and Biodiversity; Living Things and Their Environment; Energy and Living Things;* and *Changes in Ecosystems Over Time."*

Physical Sciences (Chemistry and Physics)

- "In **grades 6–8**, students still need concrete, physical-world experiences to help them develop concepts associated with motion, mass, volume, and energy. As they learn to make accurate measurements using a variety of instruments, their experiments become more quantitative and their physical models more precise. Students in these grades are able to graph one measurement in relation to another, such as temperature change over time. They may collect data by using microcomputer- or calculator-based laboratories (MBL or CBL) and can learn to make sense immediately of graphical and other abstract representations essential to scientific understanding."

  "Learning standards for grades 6–8 fall under the following five subtopics: *Properties of Matter; Elements, Compounds, and Mixtures; Motion of Objects; Forms of Energy;* and *Heat Energy."*

Technology/Engineering

- "In **grades 6–8**, students pursue engineering questions and technological solutions that emphasize research and problem solving. They identify and understand the five elements of a technology system (goal, inputs, processes, outputs, and feedback). They acquire basic safety skills in the use of hand tools, power tools, and machines. They explore engineering design; materials, tools, and machines; and communication, manufacturing, construction, transportation, and bioengineering technologies. Starting in grades 6–8 and extending through grade 10, the topics of power and energy are incorporated into the study of most areas of technology. Grades 6–8 students use knowledge acquired in their mathematics and science curricula to understand engineering. They achieve a more advanced level of skill in engineering design by learning to conceptualize a problem, design prototypes in three dimensions, and use hand and power tools to construct their prototypes, test their prototypes, and make modifications as necessary. The culmination of the engineering design experience is the development and delivery of an engineering presentation. Because of the hands-on, active nature of the technology/engineering environment, it is strongly recommended that it be taught by teachers who are certified in technology education, and who are very familiar with the safe use of tools and machines."

  "Learning standards for grades 6–8 fall under the following seven subtopics: *Materials, Tools, and Machines; Engineering Design; Communication Technologies; Manufacturing Technologies; Construction Technologies; Transportation Technologies;* and *Bioengineering Technologies."*

High School

A review of the March 2018 draft Science Standards compared to the 2013 Next Generation Science Standards (NGSS) written by Achieve, Inc.

Arizona Physical Science Standards (Chemistry) vs. NGSS

HS.P1U2.1 (Essential Standard)	**HS-PS1-1**
Use the structure of atoms and their properties to explain patterns in the Periodic Table and describe how these models are revised with new evidence.	**Use the periodic table as a model to predict the relative properties of elements based on the patters of electrons in the outermost energy level of atoms.** The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1.A)
HS+C.P1U1.1 (Plus Standard)	**HS-PS1-2**
Use the quantum mechanical model to explain how valence electrons can be used to predict properties and behaviors of elements and compounds.	**Construct and revise an explanation of the outcome of a simple chemical reaction based on the outermost electron states of atoms, rends in the periodic table, and know of the patterns of chemical properties.**
HS+C.P1U3.2 (Plus Standard)	**HS-PS1-2 and HS-PS1-8**
Engage in argument, from evidence, to explain how changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay have been used to positively and negatively serve human ends. Connection: 8.E1U1.6, HS.E1U2.13	**Construct and revise an explanation of the outcome of a simple chemical reaction based on the outermost electron states of atoms, rends in the periodic table, and know of the patterns of chemical properties. (HS-PS1-2)** **Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. (HS-PS1-8)**
HS+C.P1U2.3 (Plus Standard)	**HS-PS1-4**
Use a historical model of the atom to evaluate qualitatively the evidence supporting claims about how atoms absorb and emit energy in the form of electromagnetic radiation.	**Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in the total bond energy.** A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1.A)
HS+C.P1U1.4 (Plus Standard)	**HS-PS1-7**
Use mathematical representation to determine stoichiometric relationships in all phases of matter in chemical reactions.	**Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.** The fact that atoms are conserved, together with knowledge of chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1.B)

HS.P1U1.2 (Essential Standard)	HS-PS1-3
Describe patterns in the transfer or sharing of electrons to predict the formation of ions, molecules, and compounds in both natural and synthetic processes.	
HS.P1U4.3 (Essential Standard)	**Indoctrination- no politics in Science just facts!**
Engage in argument from evidence about how the use of chemical reactions has positive and negative ethical, social, economic, and/or political implications!	**Reword or delete standard!**
HS+C.P1U1.7 (Plus Standards)	**Subjective-need to know scientific facts first!**
Plan and conduct investigations to test predictions of the outcomes of chemical reactions, based on patterns of chemical properties.	
HS+C.P1U4.8	**HS-PS1-6**
Construct an explanation, design a solution, or refine the design of a chemical system in equilibrium to maximize production.	**Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products of equilibrium.** In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the number of all types of molecules present. (HS-PS1.B)
HS.P1U1.4 (Essential Standard)	**HS-PS1-5**
Plan and carry out investigations to explore the cause and effect relationship between reaction rate factors.	**Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1.B)

Arizona Physical Science Standards (Physics) vs. NGSS

HS-P2U1.5 (Essential Standard)	HS-PS3-5
Construct an explanation for a field's strength and influence on an object (electric, gravitational, magnetic)	**Develop and use a model of two objects through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.** When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3.C)
HS+Phy.P2U1.1 (Plus Standard)	**HS-PS4-3 and HS-PS4-4**
Plan and conduct investigations to provide evidence that an electric current can produce a magnetic field	**Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can**

and that a changing magnetic field can produce an electric current.	**be described either by a wave model or a particle model, and that for some situation one model is more useful than the other. (HS-PS4-3) Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. (HS-PS4-4)**
HS.P2U3.6 (Essential Standard)	**HS-PS4-5**
Investigate and communicate how fields (electric, gravitational, magnetic) are utilized and how they influence the structure and function of different technologies.	**Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.** Multiple technologies based on the understanding of waves and their interaction with mater are part of everyday experiences in the modern world (e.g. medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contains in them. (HS-PS4.C)
HS+Phy.P2U3.2 (Plus Standard)	**HS-PS3-5**
Design, build, and refine a device that works within given constraints to demonstrate that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.	**Develop and use a model of two objects through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.** When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3.C)
HS.P3U2.7 (Essential Standard)	**HS-PS2-1**
Develop a mathematical model, using Newton's laws, to predict the change in motion of an object or system in ***one dimension.***	**Analyze data to support the claim that Newton's second law of motions describes the mathematical relationship among the net force on a macroscopic object, its mass and its acceleration.** Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2.A)
HS+Phy.P3U2.3 (Plus Standard)	**HS-PS2-1**
Develop a mathematical model, using Newton's laws, to predict the change in motion of an object or system in ***two dimensions*** (projectile and circular motion).	**Analyze data to support the claim that Newton's second law of motions describes the mathematical relationship among the net force on a macroscopic object, its mass and its acceleration.** Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2.A)
HS+Phy.P3U1.4 (Plus Standard)	**HS-PS2-4**
Develop and use mathematical representations of Newton's law of gravitation and Coulomb's law to describe and predict the gravitational and electrostatic forces between objects.	**Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.** Newton's law of universal gravitation and Coulomb's law provide

	the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2.B)
HS+Phy.P3U1.5 (Plus Standard)	**HS-PS2-2**
Engage in an argument, from evidence, regarding the claim that the total momentum of a system is conserved when there is no net force on the system	**Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.** Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2.A)
HS.P3U3.8 (Essential Standard)	**HS-PS4-5**
Analyze mathematically how Newton's laws are use in engineering and technologies to create products to serve human ends.	**Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.** Multiple technologies based on the understanding of waves and their interaction with mater are part of everyday experiences in the modern world (e.g. medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contains in them. (HS-PS4.C)
HS+Phy.P3U3.6 (Plus Standard)	**HS-PS2-1**
Design, evaluate, and refine a device that minimizes or maximizes the force on a macroscopic object during a collision.	**Analyze data to support the claim that Newton's second law of motions describes the mathematical relationship among the net force on a macroscopic object, its mass and its acceleration.** Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2.A)
HS.P4U1.9 (Essential Standard)	**HS-PS3-1**
Engage in argument from evidence that the next change of energy in a system is always equal to the total energy exchanged between the system and the surroundings.	**Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. Energy is a quantitative property of a system that depends on the motion and interactions of** matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms (HS-PS3.A)
HS+Phy.P4U1.7 (Plus Standard)	**HS-PS4-1**
Determine the graphical and mathematical relationships among the frequency, wavelength, and speed of waves traveling in various media	**Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of wave**

	traveling in various media. The wavelength and frequency of a wave are related to one another by the speed of the travel of the wave, which depends on the type of wave and the medium through which it is passing (HS-PS4.A)
HS+Phy.P4U1.9 (Plus Standard)	**HS-PS3-1**
Analyze and interpret data to quantitatively describe change in energy within a system and/or energy flows in and out of a system.	**Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. Energy is a quantitative property of a system that depends on the motion and interactions of** matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms (HS-PS3.A)
HS+Phy.P4U3.10 (Plus Standard)	**HS-PS4-3**
Engage in argument, from evidence, that electromagnetic radiation can be described either by a wave model or a particle model, and, that for some situations in engineering and technology, one model is more beneficial than the other.	**Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.** Waves can add or cancel one another as they cross, depending on their relative phase, but they emerge unaffected by each other. (HS-PS4.A)
HS.P4U4.10 (Essential Standard)	**Indoctrination- no politics in Science just facts!**
Engage in argument from evidence regarding the ethical, social, economic, and/or political benefit and liabilities of energy usage and transfer.	**Reword or delete standard! Human activities can damage the environment but leave politics out of it.**
HS+Phy.P4U4.11 (Plus Standard)	**Indoctrination- no politics in Science just facts!**
Engage in argument, from evidence, regarding the ethical, social, economic, and/or political benefits and liabilities of fission, fusion, and radioactive decay.	**Reword or delete standard! Human activities can damage the environment but leave politics out of it.**
HS+Phy.P4U3.13 (Plus Standard)	**HS-PS3-3**
Design, build, and refine a device that works within given constraints to covert one form of energy into another form of energy.	**Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.** Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS3.A)

Arizona Earth and Space Science Standards vs. NGSS

HS.E1U1.11 (Essential Standard)	**HS-ESS2-4**
Analyze and interpret data to determine how energy from the Sun affects weather patterns and climate.	**Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.** The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetations, and human activities. These changes can occur on a variety of time scales from sudden (e.g. volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.
HS+E.E1U1.2 (Plus Standard)	**HS-ESS2-4**
Use a model to describe how variations in the flow of energy into and out of Earth's systems results in changes in climate.	**Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.** The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetations, and human activities. These changes can occur on a variety of time scales from sudden (e.g. volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.
HS+E.E1U2.3 (Plus Standard)	**HS-ESS2-2**
Analyze geoscience data and the results from global climate models to make evidence-based predications of the current rate and scale of global or regional climate changes.	**Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth's systems.** Earth's systems, being dynamic and interacting, cause feedback effects that can increase and decrease the original changes (HS-ESS2.A)
HS.E1U2.12 (Essential Standard)	**HS-ESS2-4**
Develop and use a model of the Earth that explains the role of energy in Earth's constantly changing internal and external systems (geosphere, hydrosphere, atmosphere, biosphere)	**Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.** The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetations, and human activities. These changes can occur on a variety of time scales from sudden (e.g. volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.
HS+E.E1U1.4 (Plus Standard)	**HS-ESS2-2**

Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.	**Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth's systems.** Earth's systems, being dynamic and interacting, cause feedback effects that can increase and decrease the original changes (HS-ESS2.A)
HS+E.E1U2.5 (Plus Standard)	**HS-ESS2-3**
Develop and use a model, based on the characteristics of Earth's interior, to describe the cycling of matter.	**Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.** Evidence from deep probes and seismic waves, reconstruction of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantel and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2.A)
HS+E.E1U1.6 (Plus Standard)	**HS-ESS2-5**
Plan and conduct investigations on the effect of water on Earth's materials, surface processes, and groundwater systems.	**Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the plant's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks (HS-ESS2.C)
HS+E.E1U2.7 (Plus Standard)	**HS-ESS2-6**
Develop and use a quantitative model to describe the cycling of matter among the hydrosphere, atmosphere, geosphere, and biosphere.	**Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.** Gradual atmospheric changes were due to plans and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2.D)
HS.E1U2.13 (Essential Standard)	**HS-ESS2-3**
Evaluate explanations and theories about the role of energy and matter in geological changes over time.	**Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.** Evidence from deep probes and seismic waves, reconstruction of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust.

	Motions of the mantel and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2.A)
HS+E.E1U1.8 (Plus Standard)	**HS-ESS1-5**
Evaluate evidence of the Theory of Plate Tectonics to explain the difference in age, structure, and composition of Earth's crust.	**Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.** Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1.C)
HS+E.E1U2.9 (Plus Standard)	**HS-ESS1-6**
Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to explain Earth's formation and early history.	**Apply scientific reasoning and evidence from ancient Earth material, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.** Although active geological processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1.C)
HS+E.E1U2.10 (Plus Standard)	**HS-ESS2-1**
Develop and use a model to illustrate how Earth's internal and surface processes operate over time to form, modify, and recycle continental and ocean floor features.	**Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2.A)
HS+E.E1U1.11 (Plus Standard)	**HS-ESS2-6**
Construct an argument, based on evidence, about the impact of changes in Earth's systems on the biosphere.	**Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.** Gradual atmospheric changes were due to plans and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2.D)
HS.E1U4.14 (Essential Standard)	**HS-ESS3-1**
Engage in argument from evidence about the availability of natural resources, occurrence of natural hazards, changes in climate, and human activity and how they influence each other.	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** Resource availability has guided the development of human society. (HS-ESS3.A) Natural hazards and other

	geological events have shaped the course of human history; [they] have significantly altered the sized of human populations and have driven human migrations. (HS-ESS3.B)
HS+E.E1U3.12 (Plus Standard)	**HS-ESS3-2**
Evaluate competing design solution for developing, managing, and utilizing mineral resources.	**Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.** All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3.A)
HS+E.E1U4.13 (Plus Standard)	**HS-ESS3-3**
Construct an explanation, based on evidence, for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.	**Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity.** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources (HS-ESS3.C)
HS+E.E1U4.14 (Plus Standard)	**HS-ESS3-4**
Evaluate a solution to a complex problem, based on prioritized criteria and tradeoffs, that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.	**Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.** Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and the preclude ecosystem degradation. (HS-ESS3.C)
HS+E.E1U4.15 (Plus Standard)	**HS-ESS3-6**
Design a quantitative model to illustrate the relationships among Earth's systems and the degree to which those relationships are being modified due to human activity.	**Use a computational representation to illustrate the relationships among Earth system and how those relationships are being modified due to human activity.** Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3.D)
HS.E2U1.15 (Essential Standard)	**HS-ESS1-1**
Construct an explanation based on evidence to illustrate the role of nuclear fusion in the life cycle of a star.	**Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fission in the sun's core to release energy that eventually reaches Earth in the form of radiation.** The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1.A)
HS+E.E2U2.16 (Plus Standard)	**HS-ESS1-1**

Develop and use a model to relate the role of nuclear fusion in the Sun's core to the life cycle of stars.	**Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fission in the sun's core to release energy that eventually reaches Earth in the form of radiation.** The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1.A)
HS+E.E2U1.17 (Plus Standard)	**HS-ESS1-3**
Communicate scientific ideas about the way stars, throughout their stellar stages, produce elements and energy.	**Communicate scientific ideas about the way stars, over their life cycle, produce elements.** Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produce all atomic nuclei lighter than and including iron, and the process release electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. HS-ESS1.A)
HS.E2U2.16 (Essential Standard)	**HS-ESS1-4**
Apply mathematical and/or computational representations of Kepler's laws as they relate to the movement of plants and objects in the solar system.	**Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.** Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1.B)

Arizona Life Science Standards vs. NGSS

HS.L2U2.19 (Essential Standard)	**HS-LS2-4**
Develop and use models that show how changes in the transfer of matter and energy within an ecosystem may affect organisms and their environment.	**Use mathematical representations to support claims for the cycling of matter and flow of energy in aerobic and anaerobic conditions.** Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food wed. Some matter reacts to release energy for life functions, some matter is stored in a newly made structures, and is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (Hs-LS2.B)

HS+B.L2U2.5 (Plus Standard)	HS-LS2-4
Use mathematical representations to support claims for the cycling of matter and flow of energy through trophic levels in an ecosystem	**Use mathematical representations to support claims for the cycling of matter and flow of energy in aerobic and anaerobic conditions.** Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food wed. Some matter reacts to release energy for life functions, some matter is stored in a newly made structures, and is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2.B)
HS+B.L2U2.6 (Plus Standard)	**MS-LS2-3 (Middle School!)**
Model the cycling of carbon and nitrogen among the biotic and abiotic components of and ecosystem.	**Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.** Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact with in an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2.B)
HS.L1U1.10 (Essential Standard)	**MS-LS1-1 and MS-LS1-2 (Middle School!)**
Generate questions and/or predictions based on observations and evidence to explain cellular organization, structure, and function.	**Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells (MS-LS1-1)** **Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function. (MS-LS1-2)**
HS.L2U2.21 (Essential Standard)	**HS-LS1-5**
Use a model to develop a scientific explanation that illustrates how photosynthesis transforms light energy into stored chemical energy.	**Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.** The process of photosynthesis converts light energy to stored chemical energy by converting

	carbon dioxide plus water into sugars plus released oxygen. (HS-LS1.C)
HS.L2U2.22 (Essential Standard)	**HS-LS1-7**
Use a model to develop a scientific explanation that illustrated how cellular respiration transforms glucose into stored chemical energy.	**Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are forms, resulting in a net transfer of energy.** As matter and energy flow through different organizational levels of living system, chemical elements are recombined in different ways to form different products (HS-LS1.C)
HS+B.L2U2.8 (Plus Standard)	**HS-LS1-5**
Obtain, evaluate, and communicate data showing the relationship of photosynthesis and cellular respiration; flow of energy and cycling of matter.	**Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.** The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1.C)
HS.L1U1.23 (Essential Standard)	**HS-LS1-2**
Construct and explanation for how organisms regulate internal functions.	**Develop and use a model to illustrate the hierarchical organization of interacting system that provide specific function within multicellular organisms.** Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1.A)
HS.L1U2.24 (Essential Standard)	**HS-LS1-1**
Obtain, evaluate, and communicate information to show that systems of specialized cells within organisms (plant and animal) help them perform the essential functions of life.	**Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialize cells.** Systems of specialized cells within organisms help them perform the essential functions of life (HS-LS1.A)
HS+B.L1U2.11 (Plus Standard)	**HS-LS1-2**
Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms (plant and animal)	**Develop and use a model to illustrate the hierarchical organization of interacting system that provide specific function within multicellular organisms.** Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1.A)
HS.L2U1.25 (Essential Standard)	**HS-LS1-6**
Construct and explanation demonstrating how organisms combine carbon and other atoms from the environment to form macromolecules.	**Construct and revise and explanation based on evidence for how carbon, hydrogen, and oxygen form sugar molecules and may combine with other elements to form amino acids and/or other**

	large carbon-based molecules. The sugar molecules thus formed contained carbon, hydrogen, and oxygen; their hydrocarbon backbones are used to make amino acids and other carob-based molecules that can be assembled into larger molecules (such as proteins or DNA), use for example to form new cells (HS-LS1.C)
HS+B.L2U2.12 (Plus Standard)	**HS-LS1-7**
Use evidence to construct and revise an explanation regarding how bonds are broken and formed resulting in a net transfer of energy within an organism (plants and animals)	**Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are forms, resulting in a net transfer of energy.** As matter and energy flow through different organizational levels of living system, chemical elements are recombined in different ways to form different products (HS-LS1.C)
HS.L3U2.26 (Essential Standard)	**HS-LS1-4**
Develop and use a model to communicate how a cell copies genetic information to make replica new cells during asexual reproduction (mitosis)	**Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.** In multicellular organisms' individual cells grow and then divide via a process called mitosis, thereby allowing the organisms to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1.B)
HS+B.L1U2.13 (Plus Standard)	**HS-LS1-4**
Construct an explanation for how cellular division (mitosis) is the process by which organisms grow and maintain complex, interconnected systems.	**Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.** In multicellular organisms' individual cells grow and then divide via a process called mitosis, thereby allowing the organisms to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1.B)
HS.L1U4.27 (Essential Standard)	**Reword or delete standard!**

Evaluate and communicate the ethical, social, economic and/or political implications of the detection and treatment of abnormal cell function.	**Subjective- No politics in Science, just facts!**
HS.L3U2.28 (Essential Standard)	**HS-LS3-1**
Construct and explanation of how the process of sexual reproduction contributes to genetic variation.	**Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.** All cells contain genetic information in the form of SNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. (HS-LS1.A)
HS+B.L3U2.15 (Plus Standard)	**HS-LS3-3**
Use mathematics and statistical probability to explain the variation and distribution of expressed traits in a population.	**Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.** Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of environmental factors. (HS-LS3.B)
HS.L3U1.29 (Essential Standard)	**HS-LS3-2**
Obtain, evaluate, and communicate information about the causes and implications of DNA mutation.	**Make and defend a claim based on evidence that inheritable genetic variations may results from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.** In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3.B)
HS+B.L3U1.17 (Plus Standard)	**HS-LS3-2**
Analyze how mutations can lead to increased genetic variation in a population.	**Make and defend a claim based on evidence that inheritable genetic variations may results from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.** In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation.

	Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3.B)
HS.L3U4.30 (Essential Standard)	**Reword or delete Standard!**
Construct an argument, based on evidence, regarding the ethical, social, economic, and/or political implications of a current genetic technology.	**Subjective- No politics in Science, just facts!**
HS+B.L3U1.18 (Plus Standard)	**Reword or delete Standard!**
Design problems and design solutions regarding the ethical, social, economic, and/or political implications of a current genetic technology.	**Subjective- No politics in Science, just facts!**
HS.L4U2.31 (Essential Standard)	**HS-LS4-1**
Obtain, evaluate, and communicate evidence that describes how inherited traits in a population can lead to biological diversity.	**Communicate scientific information that common ancestry and biological evolution are supported by multiple empirical evidence.** Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence (HS-LS4.A)
HS+B.L4U1.19 (Plus Standard)	**HS-LS4-2**
Construct an explanation based on evidence that the process of evolution may result from natural selection.	**Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.** Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information- that is, trait variation- that leads to differences in performance among individuals. (HS-LS4.B)
HS+B.L4U2.20 (Plus Standard)	**HS-LS4-5**
Gather, evaluate, and communicate multiple lines of empirical evidence to explain the change in genetic composition of a population over successive generations.	**Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.** Changes in the physical environment, whether naturally occurring or human induced, have thus

	contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline-and sometime the extinction-of some species. (HS-LS4.C)

From the 2006 Massachusetts Science/Technology Standards (High School):

- "**In high school**, students develop greater independence in designing and carrying out experiments, most often working alone or in small groups. They come up with questions and hypotheses that build on what they have learned from secondary sources. They learn to critique and defend their findings, and to revise their explanations of phenomena as new findings emerge. Their facility with using a variety of physical and conceptual models increases. Students in the final two years of high school can be encouraged to carry out extended independent experiments that explore a scientific hypothesis in depth, sometimes with the assistance of a scientific mentor from outside the school setting."

  "Preparation for post-secondary opportunities is another reason to provide regular laboratory and fieldwork experiences in high school science and technology/engineering courses. The Massachusetts Board of Higher Education's *Admissions Standards for the Massachusetts State Colleges and University* (www.mass.edu\a_f) states that three science courses, including two courses with laboratory work, must be completed in order to fulfill the minimum science requirement for admission to the Commonwealth's four-year public institutions. All high school courses based on the standards presented in this document should include substantial laboratory and/or fieldwork to allow all students the opportunity to meet or exceed this requirement of the Massachusetts Board of Higher Education."

High School

"This *Framework* introduces four **Scientific Inquiry Skills** (SIS) standards that are included in each introductory high school course (except Technology/Engineering, where they are replaced by the steps of the Engineering Design Process):

SIS1. Make observations, raise questions, and formulate hypotheses.
SIS2. Design and conduct scientific investigations.
SIS3. Analyze and interpret results of scientific investigations.
SIS4. Communicate and apply the results of scientific investigations.

"In each course, each Scientific Inquiry Skills standard includes an example skill set that further defines and articulates the standard."

"Also new to the 2006 *Framework* are the lists of **mathematical skills** needed for a solid understanding of each high school science and technology/engineering course. Engaging in science and technology/engineering often involves the use of mathematics to analyze and support findings of investigations or the design process. Most mathematical skills listed are based on grade-appropriate standards outlined in the *Massachusetts Mathematics Curriculum Framework.* Any specialized mathematical skills not detailed in the *Mathematics Framework* are listed separately. Please note that these lists are provided only as examples and are not exhaustive; the lists do not represent all mathematical skills students might need in a typical course."

Earth and Space Science

- "At the **high school** level, students review geological, meteorological, oceanographic, and astronomical data to learn about Earth's matter, energy, processes, and cycles. Through these data they also learn about the origin and evolution of the universe. Students gain knowledge about Earth's internal and external energy sources, local weather and climate, and the dynamics of ocean currents. Students learn about the renewable and non-renewable

energy resources of Earth and what impact these have on the environment. Through learning about Earth's processes and cycles, students gain a better understanding of nitrogen and carbon cycles, the rock cycle, and plate tectonics. Students also learn about the origin of the universe and how scientists are currently studying deep space and the solar system."

"High school learning standards fall under the following four subtopics: *Matter and Energy in the Earth System; Energy Resources in the Earth System; Earth Processes and Cycles;* and *The Origin and Evolution of the Universe."*

Life Science (Biology)

- "At the **high school** level, a solid understanding of the processes of life allows students to make scientifically informed decisions related to their health and to the health of the planet. Students in high school study life through cell biology and genetics (molecular level), vertebrate anatomy and physiology (tissue and organ levels), and ecology (organism and population levels)."

  "Organic evolution, a concept fundamental to understanding modern biology, unifies these diverse topics. Students learn that the DNA molecule is the functional unit of the evolutionary process, and that it dictates all of the physical traits that are inherited across generations. They learn that variation in traits also is inherited and that the unit of inheritance is the gene. Students learn that variation can give some individuals a selective advantage – perhaps due to morphological, physiological or behavioral traits – that allow them to survive better, and to be more competitive in a given environment. This understanding provides students with a framework for explaining why there are so many different kinds of organisms on Earth; why organisms of distantly related species share biochemical, anatomical, and functional characteristics; why species become extinct; and how different kinds of organisms are related to one another."

  "Learning standards for Biology at the high school level fall under the following six subtopics: *The Chemistry of Life; Cell Biology; Genetics; Anatomy and Physiology; Evolution and Biodiversity;* and *Ecology."*

Physical Sciences (Chemistry and Physics)

- "In **high school Chemistry**, students learn about the properties of matter and how these properties help to organize elements on the periodic table. Students develop a better understanding of the structure of the atom. Students develop an understanding of chemical reactions, including the involvement of energy and sub-atomic particles, to better understand the nature of chemical changes. Students learn about chemical reactions that occur around us every day as they learn about chemical reactions such as oxidation-reduction, combustion, and decomposition. Students also gain a deeper understanding of acids and bases, rates of reactions, and factors that affect those rates. From calculating stoichiometry problems and molar concentrations, students learn about proportionality and strengthen their mathematical skills."

  "Learning standards for high school Chemistry fall under the following eight subtopics: *Properties of Matter; Atomic Structure and Nuclear Chemistry; Periodicity; Chemical Bonding; Chemical Reactions and Stoichiometry; States of Matter, Kinetic Molecular Theory, and Thermochemistry; Solutions, Rates of Reaction, and Equilibrium;* and *Acids and Bases and Oxidation-Reduction Reactions."*

- "In **high school Introductory Physics**, students recognize the nature and scope of physics, including its relationship to the other sciences. Students learn about basic topics such as motion, forces, energy, heat, waves, electricity, and magnetism. They learn about natural phenomena by using physical laws to calculate quantities such as velocity, acceleration, momentum, and energy."

  "Students of introductory physics learn about the relationships between motion and forces through Newton's laws of motion. They study the difference between vector and scalar quantities and learn how to solve basic problems

involving these quantities. Students learn about conservation of energy and momentum and how these are applied to everyday situations. They learn about heat and how thermal energy is transferred throughout the different phases of matter. Students extend their knowledge of waves and how they carry energy. Students gain a better understanding of electric current, voltage, and resistance by learning about Ohm's law. They also gain knowledge about the electromagnetic spectrum in terms of wavelength and frequency."

"Learning standards for high school Introductory Physics fall under the following six subtopics: *Motion and Forces; Conservation of Energy and Momentum; Heat and Heat Transfer; Waves; Electromagnetism;* and *Electromagnetic Radiation."*

Technology/Engineering

- "In **high school,** students develop their ability to solve problems in technology/engineering using mathematical and scientific concepts. High school students are able to relate concepts and principles they have learned in science with knowledge gained in the study of technology/engineering. For example, a well-rounded understanding of energy and power equips students to tackle such issues as the ongoing problems associated with energy supply and energy conservation."

  "In a high school technology/engineering course, students pursue engineering questions and technological solutions that emphasize research and problem solving. They achieve a more advanced level of skill in engineering design by learning how to conceptualize a problem, develop possible solutions, design and build prototypes or models, test the prototypes or models, and make modifications as necessary. Throughout the process of engineering design, high school students are able to work safely with hand and/or power tools, various materials and equipment, and other resources. In high school, courses in technology/engineering should be taught by teachers who are certified in that discipline and who are familiar with the safe use of tools and machines."

  "Learning standards for high school fall under the following seven subtopics: *Engineering Design; Construction Technologies; Energy and Power Technologies—Fluid Systems; Energy and Power Technologies—Thermal Systems; Energy and Power Technologies—Electrical Systems; Communication Technologies;* and *Manufacturing Technologies."*