Standards, Curriculum, Instruction, and Assessment

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

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

Instruction - The methods and processes used by teachers in planning, instruction and assessment. Instructional techniques are employed by individual teachers in response to the needs of the students in their classes to help them progress through the curriculum in order to master the standards.

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

Innovations for 2018 Science Standards

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

Sources:

Bybee, R.W. (2015). *NGSS Innovations.* Retrieved from https://www.amnh.org/content/download/133084/2214178/file/NGSS%20Innovations.pdf
Harlen, W. (2015). *Working with big ideas of science education.* Global Network of Science Academies (IAP) Science Education Programme: Trieste, Italy.
Moulding, B.D., Bybee, R.W., Paulson, N. (2015). *A vision and plan for science teaching and learning.* USA: Essential Teaching and Learning Publications.
National Research Council (NRC). (2012). *A Framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: The National Academies Press.
Schwarz, C.V., Passmore, C., Reiser, B.J. (2017). *Helping students make sense of the world using next generation science and engineering practices.* Arlington, VA: NSTA Press
What are NGSS Performance Expectations? (2017). Retrieved from https://www.albert.io/blog/what-are-ngss-performance-expectations/

While there is some correlation between the 2004 and 2018 science content standards, the 2018 standards encompass many performance objectives in one core idea. The depth and focus of the 2018 standards do not correlate to the 2004 standards well. Therefore, a crosswalk between 2004 and 2018 standards will not be provided.

Why Move Toward Broad Standards and Away from Performance Objectives?

AzSS standards are expectations of student performance. Neuroscience research has identified factors that facilitate effective learning. A relevant finding is that ideas that are connected are more readily used in new situations than unconnected ideas. In other words, a few big ideas enable understanding of the world and our experiences in it, rather than disjointed facts of content (Big Ideas pg. 5).

Moving Toward Broad Standards	Moving Away from Performance Objectives
• Facts and terminology learned as needed while developing explanations and designing solutions supported by evidence-based arguments and reasoning	• Rote memorization of facts and terminology
• Systems thinking and modeling to explain phenomena and to give a context for the ideas to be learned	• Learning of ideas disconnected from questions about phenomena
• Students conducting investigations, solving problems, and engaging in discussions with teachers' guidance	• Teachers providing information to the whole class
• Students discussing open-ended questions that focus on the strength of the evidence used to generate claims	• Teachers posing questions with only one right answer
• Students reading multiple sources, including science-related magazine and journal articles and web-based resources; students developing summaries of information	• Students reading textbooks and answering questions at the end of the chapter
• Multiple investigations driven by students' questions with a range of possible outcomes that collectively lead to a deep understanding of established core scientific ideas	• Pre-planned outcome for "cookbook" laboratories or hands-on activities
• Student writing of journals, reports, posters, and media presentations that explain and argue	• Worksheets
• Provision of supports so that all students can engage in sophisticated science and engineering practices	• Oversimplification of activities for students who are perceived to be less able to do science and engineering

Source: National Research Council. (2015). Guide to Implementing the Next Generation Science Standards (pp. 8-9). Washington, DC: National Academies Press. http://www.nap.edu/catalog/18802/guide-to-implementing-the-next-generation-science-standards.

<table>
<tr><th colspan="3">Three Dimensions of Science
Sense-making in science occurs with the integrating of three essential dimensions: science and engineering practices, crosscutting concepts, and core ideas.</th></tr>
<tr><th>Science and Engineering Practices</th><th>Crosscutting Concepts</th><th>Core Ideas</th></tr>
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<td>Science and engineering practices describe a robust process for how scientists investigate and build models and theories of the natural world or how engineers design and build systems. As students conduct investigations, they engage in multiple practices as they gather information to solve problems, answer their questions, reason about how the data provide evidence to support their understanding, and then communicate their understanding of phenomena. Student investigations may be observational, experimental, use models or simulations, or use data from other sources. These eight practices identified in A Framework for K-12 Science Education are critical components of scientific literacy, not instructional strategies:

● Asking questions (for science) and defining problems (for engineering)
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations (for science) and designing solutions (for engineering)
● Engaging in argument from evidence
● Obtaining, evaluating, and communicating information</td>
<td>Crosscutting concepts are a tool for students that cross boundaries between science disciplines and provide an organizational framework to connect knowledge from various disciplines into a coherent and scientifically based view of the world. Their purpose is to provide a lens to help students deepen their understanding of the core ideas as they make sense of phenomena. The seven crosscutting concepts identified in A Framework for K-12 Science Education are:

● Patterns
● Cause and effect: Mechanism and explanation
● Scale, proportion, and quantity
● Systems and system models
● Energy and matter: Flow, cycles and conservations
● Structure and function
● Stability and change</td>
<td>Core ideas for knowing science and using science develop scientific literacy through science content knowledge, understanding the nature of science, applications of science and engineering, and social implications. The thirteen core ideas modified from Working with Big Ideas of Science Education are:
<u>Physical Science</u>
P1: All matter in the Universe is made of very small particles.
P2: Objects can affect other objects at a distance.
P3: Changing the movement of an object requires a net force to be acting on it.
P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event.
<u>Earth and Space Science</u>
E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.
E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe.
<u>Life Science</u>
L1: Organisms are organized on a cellular basis and have a finite life span.
L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.
L3: Genetic information is passed down from one generation of organisms to another.
L4: The unity and diversity of organisms, living and extinct, is the result of evolution.
<u>Using Science</u>
U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.
U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.
U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.</td>
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HS Essential Arizona Science Standards (AzSS)
Alignment to Next Generation Science Standards (NGSS)

The ADE acknowledges that the acronym "NGSS" is consistently used throughout science resources. To avoid confusion, we want to ensure the community understands that Arizona is not considered an "NGSS" state. To further clarify, AzSS and the NGSS were both designed using the research document *A Framework for K-12 Science Education.* Both documents include a strong focus on three-dimensional instruction, which includes: Science and Engineering Practices, Crosscutting Concepts, and Core Ideas. The major difference between the AzSS and the NGSS is that Arizona used an additional research document, *Working with Big Ideas of Science Education*, in the development of the Core Ideas of Knowing and Using Science.

Alignment of the AzSS to NGSS Performance Expectations

Note: An "S" or "P" alignment indicates that an NGSS resources could be used. An "NC" indicates that an NGSS resources cannot be used.

- **S = Strong: Both the Core Idea and Science and Engineering Practice (SEP*) are the same**
- **P = Partial: Core idea is closely related; SEP may or may not match**
- **NC** = Not Closely Correlated: There is no strong or partial correlation in this grade band**

**The bolded section of each standard refers to the Science and Engineering Practice that correlates to each standard. However, others should be utilized throughout the learning for this grade level. Naturally one practice can lead to the use of others.*
***The NGSS performance expectation may be in a different grade level.*

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

Physical Science Essential Standards

Physical science encompasses physical and chemical sub-processes that occur within systems. At the high school level, students gain an understanding of these processes at both the micro and macro levels through the intensive study of matter, energy, and forces. Students are expected to apply these concepts to real world phenomena to gain a deeper understanding of causes, effects, and solutions for physical processes in the real world. The essential standards are those that every high school student is expected to know and understand. It is suggested to use the metric system within measurement.

Arizona Science Standards- HS Physical Science		Next Generation Science Standards- HS Physical Science
Essential HS.P1U1.1 **Develop and use models** to explain the relationship of the structure of atoms to patterns and properties observed in the Periodic Table and describe how these models are revised with new evidence.	P P	**HS-PS1-1** Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. **HS-PS1-2** Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
Essential HS.P1U1.2 **Develop and use models** for the transfer or sharing of electrons to predict the formation of ions, molecules, and compounds in both natural and synthetic processes.	P P	**HS-PS1-2** Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. **HS-PS1-3** Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Arizona Science Standards- HS Physical Science		Next Generation Science Standards- HS Physical Science
Essential HS.P1U1.3 **Ask questions**, **plan, and carry out investigations** to explore the cause and effect relationship between reaction rate factors.	P	**HS-PS1-5** 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.
Essential HS.P1U3.4 **Obtain, evaluate, and communicate information** about how the use of chemistry related technologies have had positive and negative ethical, social, economic, and/or political implications.	NC	There is no strong or partial correlation to an NGSS standard in this grade band.
Essential HS.P2U1.5 **Construct an explanation** for a field's strength and influence on an object (electric, gravitational, magnetic).	P P	**HS-PS3-5** Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. **HS-PS2-4** Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
Essential HS.P3U1.6 **Collect, analyze and interpret data** regarding the change in motion of an object or system in one dimension, to construct an explanation using Newton's Laws.	P P	**HS-PS2-1** Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. **HS-PS2-2** 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.
Essential HS.P3U2.7 **Use mathematics and computational thinking** to explain how Newton's laws are used in engineering and technologies to create products to serve human ends.	P	**HS-PS2-1** Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
Essential HS.P4U1.8 **Engage in argument from evidence** that the net change of energy in a system is always equal to the total energy exchanged between the system and the surroundings.	P P	**HS-PS3-1** 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. **HS-PS3-4** Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Arizona Science Standards- HS Physical Science		Next Generation Science Standards- HS Physical Science
Essential HS.P4U3.9 **Engage in argument from evidence** regarding the ethical, social, economic, and/or political benefits and liabilities of energy usage and transfer.	NC	There is no strong or partial correlation to an NGSS standard in this grade band.
Essential HS.P4U1.10 **Construct an explanation** about the relationships among the frequency, wavelength, and speed of waves traveling in various media, and their applications to modern technology.	P	**HS-PS4-1** Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Earth and Space Science Essential Standards

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

Arizona Science Standards- HS Earth & Space		Next Generation Science Standards- HS Earth & Space
Essential HS.E1U1.11 **Analyze and interpret data** to determine how energy from the Sun affects weather patterns and climate.	P	**HS-ESS2-4** Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
Essential HS.E1U1.12 **Develop and use models** of the Earth that explains the role of energy and matter in Earth's constantly changing internal and external systems (geosphere, hydrosphere, atmosphere, biosphere).	S P P	**HS-ESS2-3** Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. **HS-ESS2-4** Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. **HS-ESS2-6** Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

Arizona Science Standards- HS Earth & Space		Next Generation Science Standards- HS Earth & Space
Essential HS.E1U1.13 **Evaluate explanations** and theories about the role of energy and matter in geologic changes over time.	P	**HS-ESS2-3** Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
Essential HS.E1U3.14 **Engage in argument from evidence** about the availability of natural resources, occurrence of natural hazards, changes in climate, and human activity and how they influence each other.	P P	**HS-ESS3-1** Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. **HS-ESS3-6** Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
Essential HS.E2U1.15 **Construct an explanation** based on evidence to illustrate the role of nuclear fusion in the life cycle of a star.	P	**HS-ESS1-1** Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.
Essential HS.E2U1.16 **Construct an explanation** of how gravitational forces impact the evolution of planetary motion, structure, surfaces, atmospheres, moons, and rings.	P	**HS-ESS1-4** Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
Essential HS.E2U1.17 **Construct an explanation** of the origin, expansion, and scale of the universe based on astronomical evidence.	S	**HS-ESS1-2** Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

Life Science Essential Standards

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

Arizona Science Standards- HS Life		Next Generation Science Standards- HS Life
Essential HS.L2U3.18 **Obtain, evaluate, and communicate** about the positive and negative ethical, social, economic, and political implications of human activity on the biodiversity of an ecosystem.	P P	**HS-LS2-2** Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. **HS-LS2-7** Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
Essential HS.L2U1.19 **Develop and use models** that show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment	P P	**HS-LS2-4** Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. **HS-LS2-5** Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
Essential HS.L1U1.20 **Ask questions** and/or make predictions based on observations and evidence to demonstrate how cellular organization, structure, and function allow organisms to maintain homeostasis.	P	**HS-LS1-3** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
Essential HS.L2U1.21 **Obtain, evaluate, and communicate** data showing the relationship of photosynthesis and cellular respiration; flow of energy and cycling of matter.	P P	**HS-LS2-3** Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. **HS-LS2-5** Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

Arizona Science Standards- HS Life		Next Generation Science Standards- HS Life
Essential HS.L1U1.22 **Construct an explanation** for how cellular division (mitosis) is the process by which organisms grow and maintain complex, interconnected systems.	P	**HS-LS1-4** Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
Essential HS.L1U3.23 **Obtain, evaluate, and communicate** the ethical, social, economic and/or political implications of the detection and treatment of abnormal cell function.	NC	There is no strong or partial correlation to an NGSS standard in this grade band.
Essential HS.L3U1.24 **Construct an explanation** of how the process of sexual reproduction contributes to genetic variation.	P	**HS-LS3-2** Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
Essential HS.L3U1.25 **Obtain, evaluate, and communicate** information about the causes and implications of DNA mutation.	P	**HS-LS3-2** Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
Essential HS.L3U3.26 **Engage in argument from evidence** regarding the ethical, social, economic, and/or political implications of a current genetic technology.	NC	There is no strong or partial correlation to an NGSS standard in this grade band.
Essential HS.L4U1.27 **Obtain, evaluate, and communicate** evidence that describes how changes in frequency of inherited traits in a population can lead to biological diversity.	P P	**HS-LS4-3** Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. **HS-LS4-5** 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.
Essential HS.L4U1.28 **Gather, evaluate, and communicate** multiple lines of empirical evidence to explain the mechanisms of biological evolution.	S	**HS-LS4-1** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.