UTAH HIGH SCHOOL SUPPLEMENTAL

SEEd Standards

ASTRONOMY, BOTANY, ENVIRONMENTAL SCIENCE, WILDLIFE BIOLOGY, AND ZOOLOGY

Adopted May 2021
by the
Utah State Board of Education
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https://www.schools.utah.gov

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UTAH STATE BOARD OF EDUCATION

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INTRODUCTION

UTAH HIGH SCHOOL SUPPLEMENTAL SCIENCE WITH ENGINEERING EDUCATION STANDARDS

Utah's High School Supplemental Science and Engineering Education (SEEd) standards were written with support from Utah educators and scientists, using a wide array of resources and expertise. A great deal is known about good science instruction. The writing team used sources including *A Framework for K–12 Science Education*[1], the *Science Georgia Standards of Excellence (GSE)*[2], and related works to craft research-based standards for Utah. These standards were written with high school students in mind to provide them with developmentally appropriate learning that extends from the Utah foundation SEEd Standards in Biology, Chemistry, Earth and Space Science, and Physics. These courses are intended to foster learning that is age-appropriate and enduring with the aim of addressing what an educated citizenry should know and understand to embrace the value of scientific thinking and make informed decisions. All Utah SEEd standards are founded on what science is, how science is learned, and the multiple dimensions of scientific work.

As these high school science supplemental courses are taught in both semester and yearlong formats, the standards were written to be able to be taught in a semester. Educators teaching these as yearlong courses will be able to expand them to meet the needs of their students. Teaching these courses as a semester or yearlong format is a local school or district decision.

Principles of Scientific Literacy

Science is a way of knowing, a process for understanding the natural world. Engineering applies the fields of science, technology, and mathematics to produce solutions to real-world problems. The process of developing scientific knowledge includes ongoing questioning, testing, and refinement of ideas when supported by empirical evidence. Since progress in modern society is tied so closely to this way of knowing, scientific literacy is essential for a society to be engaged in political and economic choices on personal, local, regional, and global scales. As such, the Utah SEEd standards are based on the following essential elements of scientific literacy.

Science is valuable, relevant, and applicable.
Science produces knowledge that is inherently important to our society and culture. Science and engineering support innovation and enhance the lives of individuals and society. Science is supported from and benefited by an equitable and democratic culture. Science is for all people, at all levels of education, and from all backgrounds.

Science is a shared way of knowing and doing.
Science learning experiences should celebrate curiosity, wonder, skepticism, precision,

and accuracy. Scientific habits of mind include questioning, communicating, reasoning, analyzing, collaborating, and thinking critically. These values are shared within and across scientific disciplines, and should be embraced by students, teachers, and society at large.

Science is principled and enduring.
Scientific knowledge is constructed from empirical evidence; therefore, it is both changeable and durable. Science is based on observations and inferences, an understanding of scientific laws and theories, use of scientific methods, creativity, and collaboration. The Utah SEEd standards are based on current scientific theories, which are powerful and broad explanations of a wide range of phenomena; they are not simply guesses nor are they unchangeable facts.

Science is principled in that it is limited to observable evidence. Science is also enduring in that theories are only accepted when they are robustly supported by multiple lines of peer reviewed evidence. The history of science demonstrates how scientific knowledge can change and progress, and it is rooted in the cultures from which it emerged. Scientists, engineers, and society, are responsible for developing scientific understandings with integrity, supporting claims with existing and new evidence, interpreting competing explanations of phenomena, changing models purposefully, and finding applications that are ethical.

Principles of Science Learning

Just as science is an active endeavor, students best learn science by engaging in it. This includes gathering information through observations, reasoning, and communicating with others. It is not enough for students to read about or watch science from a distance; learners must become active participants in forming their ideas and engaging in scientific practice. The Utah SEEd standards are based on several core philosophical and research-based underpinnings of science learning.

Science learning is personal and engaging.
Research in science education supports the assertion that students at all levels learn most when they are able to construct and reflect upon their ideas, both by themselves and in collaboration with others. Learning is not merely an act of retaining information but creating ideas informed by evidence and linked to previous ideas and experiences. Therefore, the most productive learning settings engage students in authentic experiences with natural phenomena or problems to be solved. Learners develop tools for understanding as they look for patterns, develop explanations, and communicate with others. Science education is most effective when learners invest in their own sense-making and their learning context provides an opportunity to engage with real-world problems.

Science learning is multi-purposed.
Science learning serves many purposes. We learn science because it brings us joy and appreciation but also because it solves problems, expands understanding, and informs

society. It allows us to make predictions, improve our world, and mitigate challenges. An understanding of science and how it works is necessary in order to participate in a democratic society. So, not only is science a tool to be used by the future engineer or lab scientist but also by every citizen, every artist, and every other human who shares an appreciation for the world in which we live.

All students are capable of science learning.
Science learning is a right of all individuals and must be accessible to all students in equitable ways. Independent of grade level, geography, gender, economic status, cultural background, or any other demographic descriptor, all K–12 students are capable of science learning and science literacy. Science learning is most equitable when students have agency and can engage in practices of science and sense-making for themselves, under the guidance and mentoring of an effective teacher and within an environment that puts student experience at the center of instruction. Moreover, all students are capable learners of science, and all grades and classes should provide authentic, developmentally appropriate science instruction.

Three Dimensions of Science

Science is composed of multiple types of knowledge and tools. These include the processes of doing science, the structures that help us organize and connect our understandings, and the deep explanatory pieces of knowledge that provide predictive power. These facets of science are represented as "three dimensions" of science learning, and together these help us to make sense of all that science does and represents. These include science and engineering practices, crosscutting concepts, and disciplinary core ideas. Taken together, these represent how we use science to make sense of phenomena, and they are most meaningful when learned in concert with one another. These are described in *A Framework for K–12 Science Education*, referenced above, and briefly described here:

Science and Engineering Practices (SEPs): Practices refer to the things that scientists and engineers do and how they actively engage in their work. Scientists do much more than make hypotheses and test them with experiments. They engage in wonder, design, modeling, construction, communication, and collaboration. The practices describe the variety of activities that are necessary to do science, and they also imply how scientific thinking is related to thinking in other subjects, including math, writing, and the arts. For a further understanding of science and engineering practices see Chapter 3 in *A Framework for K–12 Science Education*.

Crosscutting Concepts (CCCs): Crosscutting concepts are the organizing structures that provide a framework for assembling pieces of scientific knowledge. They reach across disciplines and demonstrate how specific ideas are united into overarching principles. For example, a mechanical engineer might design some process that transfers energy from a fuel source into a moving part, while a biologist might study how predators and prey are interrelated. Both of these would need to model systems of energy to understand how all of the features interact, even though they are studying different subjects. Understanding crosscutting concepts enables us to make connections among different subjects and to utilize science in diverse settings. Additional information on crosscutting concepts can be found in Chapter 4 of *A Framework for K–12 Science Education*.

Disciplinary Core Ideas (DCIs): Core ideas within the foundation High School SEEd Standards for Biology, Chemistry, Earth and Space Science, and Physics include those most fundamental and explanatory pieces of knowledge in a discipline. They are often what we traditionally associate with science knowledge and specific subject areas within science. Seeing as how the High School Supplemental Standards are an extension of the foundation High School courses, the content in these standards move beyond those identified as Disciplinary Core Ideas in Chapters 5 through 7 of *A Framework for K–12 Science Education*. The standards within this document with a specific focus on engineering are closely aligned to the Core Ideas found in Chapter 8 of the *K–12 Framework for K–12 Science Education*. For this reason, the Disciplinary Core Idea Codes (listed in parentheses after each standard in the foundation High School SEEd Standards) will not be included in these standards.

ARTICULATION OF SEPS, CCCS, AND DCIS

Science and Engineering Practices

Asking questions or defining problems: Students engage in asking testable questions and defining problems to pursue understandings of phenomena.

Developing and using models: Students develop physical, conceptual, and other models to represent relationships, explain mechanisms, and predict outcomes.

Planning and carrying out investigations: Students plan and conduct scientific investigations in order to test, revise, or develop explanations.

Analyzing and interpreting data: Students analyze various types of data in order to create valid interpretations or to assess claims/conclusions.

Using mathematics and computational thinking: Students use fundamental tools in science to compute relationships and interpret results.

Constructing explanations and designing solutions: Students construct explanations about the world and design solutions to problems using observations that are consistent with current evidence and scientific principles.

Engaging in argument from evidence: Students support their best explanations with lines of reasoning using evidence to defend their claims.

Obtaining, evaluating, and communicating information: Students obtain, evaluate, and derive meaning from scientific information or presented evidence using appropriate scientific language. They communicate their findings clearly and persuasively in a variety of ways including written text, graphs, diagrams, charts, tables, or orally.

Crosscutting Concepts

Patterns:
Students observe patterns to organize and classify factors that influence relationships.

Cause and effect:
Students investigate and explain causal relationships in order to make tests and predictions.

Scale, proportion, and quantity:
Students compare the scale, proportions, and quantities of measurements within and between various systems.

Systems and system models:
Students use models to explain the parameters and relationships that describe complex systems.

Energy and matter:
Students describe cycling of matter and flow of energy through systems, including transfer, transformation, and conservation of energy and matter.

Structure and function:
Students relate the shape and structure of an object or living thing to its properties and functions.

Stability and change:
Students evaluate how and why a natural or constructed system can change or remain stable over time.

Disciplinary Core Ideas*

Physical Sciences:
(PS1) Matter and Its Interactions
(PS2) Motion and Stability: Forces and Interactions
(PS3) Energy
(PS4) Waves

Life Sciences:
(LS1) Molecules to Organisms
(LS2) Ecosystems
(LS3) Heredity
(LS4) Biological Evolution

Earth and Space Sciences:
(ESS1) Earth's Place in the Universe
(ESS2) Earth's Systems
(ESS3) Earth and Human Activity

Engineering Design:
(ETS1.A) Defining and Delimiting an Engineering Problem
(ETS1.B) Developing Possible Solutions
(ETS1.C) Optimizing the Design Solution

** These core ideas are specifically aligned in each of the standards for Biology, Chemistry, Earth and Space Science, and Physics courses, however these High School Supplemental SEEd Standards focus on content beyond these core ideas and direct alignment will not be made within the standards document.*

Organization of Standards

The Utah SEEd standards are organized into **strands** which represent significant areas of learning within grade level progressions and content areas. Each strand introduction is an orientation for the teacher in order to provide an overall view of the concepts needed for foundational understanding. These include descriptions of how the standards tie together thematically and science content is used to unite that theme. Within each strand are **standards**. A standard is an articulation of how a learner may demonstrate their proficiency, incorporating not science content but also a crosscutting concept and a science and engineering practice. While a standard represents an essential element of what is expected, it does not dictate curriculum—it only represents a proficiency level for that grade. While some standards within a strand may be more comprehensive than others, all standards are essential for a comprehensive understanding of a strand's purpose.

The standards of any given grade or course are not independent. SEEd standards are written with developmental levels and learning progressions in mind so that many topics are built upon from one grade to another. In addition, SEPs and CCCs are especially well paralleled with other disciplines, including English language arts, fine arts, mathematics, and social sciences. Therefore, SEEd standards should be considered to exist not as an island unto themselves, but as a part of an integrated, comprehensive, and holistic educational experience.

Each standard is framed upon the three dimensions of science to represent a cohesive, multi-faceted science learning outcome.

- Within each SEEd Standard **Science and Engineering Practices are bolded**.
- Crosscutting Concepts are underlined.
- Science content including and extending from the Disciplinary Core Ideas are added to the standard in normal font. The Disciplinary Core Idea Codes (listed in parentheses after each standard in the foundation High School SEEd Standards) are not included in these standards.
- Standards with *specific engineering expectations are italicized*.
- Many standards contain additional emphasis and example statements that clarify the learning goals for students.
  - Emphasis statements highlight a required and necessary part of the student learning to satisfy that standard.
  - Example statements help to clarify the meaning of the standard and are not required for instruction.

An example of a SEEd standard:

■ **Standard ENVS.3.4** **Design a solution** in the form of a resource management plan to sustain (stability) a natural resource in your city, town, county, or region of the state. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize the solution*. Emphasize basing the plan on scientific principles. Examples of natural resources could include water, air, land, or organisms like trees or fish.

Each part of the above SEEd standard is identified in the following list:

Science and Engineering Practices (SEP) are bolded:

Design a solution in the form of a resource management plan

Crosscutting Concepts (CCC) are underlined:

to sustain (stability) a natural resource in your city, town, county,

Disciplinary Core Ideas (DCI) are added in the standard in regular/normal font:

Design a solution in the form of a resource management plan to sustain (stability) a natural resource in your city, town, county, or region of the state. *Define the problem, identify criteria and*

Engineering Expectations are italicized:

or region of the state. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize the solution*. Emphasize basing the plan on scientific

Emphasis Statements start with the word "Emphasize…":

the solution. Emphasize basing the plan on scientific principles. Examples of natural resources could include water, air,

Example Statements start with "Examples could include…":

Examples of natural resources could include water, air, land, or organisms like trees or fish.

Goal of the SEEd Standards

The Utah SEEd Standards is a research-grounded document aimed at providing accurate and appropriate guidance for educators and stakeholders. But above all else, the goal of this document is to provide students with the education they deserve, honoring their abilities, their potential, and their right to utilize scientific thought and skills for themselves and the world that they will build.

[1] National Research Council. 2012. *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13165. This consensus research document and its chapters are referred to throughout this document as a research basis for much of Utah's SEEd standards.

[2] Some Utah High School Supplemental SEEd Standards are based on the *Science Georgia Standards of Excellence* (Georgia Department of Education. 2016–2019. Science Georgia Standards of Excellence. Atlanta, GA. https://www.georgiastandards.org/Georgia-Standards/Pages/Science.aspx

ASTRONOMY

INTRODUCTION

The Astronomy High School Supplemental SEEd Standards explore the patterns, forces, relationships, and systems of matter and energy found in the Universe. Students develop models and investigate patterns observed on Earth and in the night sky of phenomena that affect life on Earth. Students ask questions and model objects in our solar system and design solutions to determine where and how humans could colonize off of our planet someday. Students build models and construct arguments for the life and death of stars predicting the final stage of stars based on their mass. Students develop models and explain the formation and characteristics of the Universe.

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Strand ASTR.1: PATTERNS OBSERVED ON EARTH AND IN THE NIGHT SKY AFFECT LIFE ON EARTH AND SPACE EXPLORATION

The study of astronomy started as curious people observed and tried to explain phenomena observed on Earth by looking up at the sky. Models help to investigate and explain these phenomena using evidence for our current understanding. Space Exploration helps us better understand our planet and cause leaps in technology, culture, knowledge, and inspiration.

- **Standard ASTR.1.1** **Develop and use models** to evaluate the relationship between the relative positions of the Earth, Sun, and Moon and the phenomena caused by the relationship as observed from Earth. Emphasize how the location of the Earth, Sun, and Moon cause the phenomena. Examples of observable phenomena may include the day/night cycle, seasons, equinoxes and solstices, moon phases, eclipses, or tides.

- **Standard ASTR.1.2** **Plan and carry out an investigation** using the celestial sphere to explain how latitude and time of year affect the visibility of constellations, planets, and other celestial objects.

- **Standard ASTR.1.3** **Obtain, evaluate, and communicate information** about how patterns in ancient structures, instruments, philosophies, and civilizations influenced the study of astronomy. Examples of philosophies could include astronomical models (e.g., geocentric, heliocentric), Aristotelian physics, or Ptolemaic models with epicycles.

- **Standard ASTR.1.4** **Plan and carry out an investigation** to analyze patterns in telescopic data of various electromagnetic spectra to explain astronomical phenomena. Emphasize evaluating the uses and advantages of data to explain phenomena. Examples of data of various electromagnetic spectra could include absorption, redshift/blueshift, emission spectra, or blackbody curves.

- **Standard ASTR.1.5** **Construct an argument** based on evidence for the significance of historical and future space exploration as they relate to affecting leaps in technology, cultural cooperation, knowledge, and inspiration. Emphasize that historical space exploration began with Sputnik and continues to the present day.

Strand ASTR.2: STRUCTURES IN THE SOLAR SYSTEM AND THEIR FORMATION

Earth is one part of a larger solar system and objects within the solar system can be compared and classified. The objects and motions in the solar system provide evidence for the formation of the solar system. The solar system shares common forces, energy, and matter that can explain its characteristics and motion. Advances in technology make space travel and colonization possible if risks and constraints can be evaluated and overcome.

- **Standard ASTR.2.1** **Ask questions** to **investigate** and communicate the structure and properties of objects in our solar system and the zones they inhabit. Emphasize grouping the objects found in the solar system into different categories based on their major properties. Examples of objects in the solar system could include planets, dwarf planets, major moons, asteroids, or comets. Examples of zones could include asteroid belt, Kuiper belt, or the Oort cloud.

- **Standard ASTR.2.2** **Develop and use models**, based on evidence, to explain the formation of the solar system and the different proportions of matter and energy within regions of the system. Emphasize the cause of observed patterns of matter distribution in the solar system. Examples of matter distribution could include low amounts of ice found inside the frost line or the location of gas planets.

- **Standard ASTR.2.3** **Use computational thinking** to model gravitational force at varying scale and proportion that explain motion and interaction of objects in the solar system. Emphasize that these forces are also at play throughout the universe. Examples of models could be conceptual, comparing force and motion of different objects in space, and do not require that students solve for the force of gravity acting on an object.

- **Standard ASTR.2.4** **Design a solution** (plan) for a functioning human colony on an object in the solar system other than Earth. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize the solution*. Emphasize analyzing which planet/world of the solar system would have the best chance for a successful colony based on specific criteria. Examples of planets/worlds of the solar system could include Mars or moons of the Jovian planets. Examples of specific criteria could include distance from Earth, available energy sources, amounts of water or solvent, protection from solar radiation, or amount of resources/building materials.

Strand ASTR.3: STABILITY AND CHANGE IN THE LIFE OF STARS

Stars are born and die over a period of time in a process called stellar evolution. During a star's existence they may change in elemental composition, density, luminosity, temperature, and other ways. These changes can both be recognized and predicted.

- **Standard ASTR.3.1** **Develop and use models** to explain stability and change during the process of stellar evolution from birth to death of a star. Emphasize the causes for the changes during stellar evolution and the evidence that supports current understanding.
- **Standard ASTR.3.2** **Construct an argument** based on evidence from the Hertzsprung-Russell diagram to investigate properties (structure) of stars. Examples of properties of stars could include density, luminosity, temperature, rates of fusion, absolute magnitude, or spectral class.
- **Standard ASTR.3.3** **Ask questions** to evaluate evidence that predicts the stability and change of a star during its lifespan and its final stage of stellar evolution based on mass. Emphasize stellar remnants and events such as white dwarfs, neutron stars, pulsars, black holes, and supernovae.

Strand ASTR.4: MATTER AND ENERGY IN GALAXIES AND THE UNIVERSE

All matter and energy in the universe originate from a single event called the Big Bang. Since that time, matter in the form of different elements was formed through many processes, including the birth and death of stars. Dark matter and energy exist in the universe and affect its evolution. Galaxies also form and change through galactic evolution.

- **Standard ASTR.4.1** **Construct an argument** from evidence to explain the patterns that describe the formation of the universe. Emphasize the scientific theory of the Big Bang and evidence that supports it. Examples of evidence for the Big Bang could include the cosmological principle, cosmic microwave background radiation, Hubble's Law, observed galactic redshift, and time-space expansion.
- **Standard ASTR.4.2** **Use models** to describe the conditions of the early universe that led the formation and evolution of matter including the birth of the first stars and galaxies.
- **Standard ASTR.4.3** **Construct an explanation** using evidence to support the existence of dark matter and dark energy. Emphasize indirect evidence to support their existence.
- **Standard ASTR.4.4** **Develop and use models** to relate the cause for how galactic evolution occurs. Emphasize the processes of mergers and collisions.

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BOTANY

INTRODUCTION

The Botany High School Supplemental SEEd Standards explore the patterns, processes, structures, functions, and relationships of plants on Earth. Students investigate and explain the major structures, functions, and processes plants use to survive and respond to their environment. Students construct explanations and arguments to classify plants into major plant taxa and determine their relationships, adaptations, and evolution. Students investigate and analyze data to explain how plants interact with and depend upon their environment for survival. Students investigate and explain the many ways that humans use and depend on plants.

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Strand BOTN.1: STRUCTURES, FUNCTIONS, AND PROCESSES IN PLANTS

Plants have many different specialized structures (cells, tissues, and organs) that function to help them survive in their environment. These structures carry out specific life processes in plants. Plants have the ability to sense and respond to external stimuli in their environment.

- **Standard BOTN.1.1** **Ask questions** to **investigate** and provide explanations about basic plant structures and their related functions. Emphasize structures at the cellular, tissue, and organ levels. Examples of plant structures could include roots, root hairs, stem, phloem, xylem, cambium, leaf, stoma, flower, ovary, petal, stamen, or pistil.
- **Standard BOTN.1.2** **Construct an explanation** supported by evidence relating plant structures to plant processes. Examples of processes could include photosynthesis, respiration, transport, growth, reproduction, or seed dispersal.
- **Standard BOTN.1.3** **Develop and use models** to explain the cause for how plants sense and respond to external stimuli in their environment. Examples of external stimuli could include light, water, or soil changes.

Strand BOTN.2: PLANT EVOLUTION AND TAXONOMY

Plants can be compared taxonomically by comparing their structures, genes, and chemical processes. Plants are organized into taxonomic groups. Methods used to classify plants have changed over time with advancements in technology. The fossil record and other evidence show major changes in plants through geologic time. Plants coevolve with animals and other plants that have shared a symbiotic relationship for millions of years.

- **Standard BOTN.2.1** **Construct an explanation** based on evidence to compare patterns observed in structures, functions, and processes of different kinds of plants. Emphasize comparisons of nonvascular to vascular plants and seedless to seed plants.
- **Standard BOTN.2.2** **Construct an argument** based on evidence to classify plants into major plant divisions by observing patterns in physical or chemical characteristics. Emphasize traditional methods and emerging technologies used to identify and classify plants. Examples of technologies could be a dichotomous key, field guide, or molecular analysis (genes or chemicals).
- **Standard BOTN.2.3** **Develop and use models** to explain the origin of changes in major plant structures and organs through geologic time in response to environmental changes. Examples of changes in major plant structures could include development of vascular tissues or changing from spores to seeds).
- **Standard BOTN.2.4** **Construct an explanation** about the coevolution (change) of plant structures with animals and other plants. Examples of coevolution of plants could be due to pollination, nitrogen fixation, competition, and defenses from predators/parasites.

Strand BOTN.3: PLANTS AND THEIR ENVIRONMENT

Plants require matter and energy for survival. Plants affect their environment by providing diverse habitats for other organisms. Plant adaptations help them to survive changes that occur regularly in their environments. Changes in nutrient cycles in an environment may affect plant populations. States, counties, and communities create management plans to control invasive plant species and conserve native plants species.

- **Standard BOTN.3.1** **Plan and carry out an investigation** to explain how plants depend upon their environment to obtain the matter and energy necessary for survival. Examples of matter and energy in their environment could include soil, air, weather, other plants, or animals.
- **Standard BOTN.3.2** **Develop a model** to explain how plants affect their environment by providing diverse habitats for other organisms. Examples of other organisms that depend on plants could include birds, insects, or other wildlife.
- **Standard BOTN.3.3** **Construct an argument based on evidence** to predict which plant adaptations have led to (caused) increased survival rates in different stressful environments. Examples of stressful environments include changes in water, salinity, or temperature extremes.
- **Standard BOTN.3.4** **Analyze and interpret data** from investigations or models to describe how changes and disruptions in major nutrient cycles might affect plants. Examples of nutrient cycles could include carbon, oxygen, nitrogen, or phosphorus.
- **Standard BOTN.3.5** **Evaluate** current plans to manage the control of an invasive plant species in Utah or to manage the conservation of a native plant species in Utah focusing on the population's proportion and quantity. *Define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine if the plan is an optimal solution.* Emphasize the impact that the plant species has on its environment.

Strand BOTN.4: HUMAN AND PLANT INTERACTIONS

Humans rely on plants for many different purposes. Investigations and data analysis can help us understand effective techniques for growing plants and improving fruit production. Plant pests and diseases affect plant crops and may have effects on humans and society. Genetically Modified plants may provide solutions to the effects of pest and disease and may also be a solution to food shortages, however, may also come with risks.

- **Standard BOTN.4.1** **Construct an explanation** for how plants and their structures are used in different societies. Examples of the use of plants could include agriculture, horticulture, industry, medicine, or biotechnology.
- **Standard BOTN.4.2** **Plan and carry out investigations** to determine effective techniques that cause improved plant growth and/or fruit production. Examples of testable variables could include soil type, nutrient/fertilizer, watering, spacing, or timing.
- **Standard BOTN.4.3** **Analyze and interpret data** to determine how plants are affected by insect pests, competing weeds, and diseases. Emphasize how plant pests and diseases in major plant crops affect humans, animals, and the economy and solutions to controlling them.
- **Standard BOTN.4.4** **Construct an argument based on evidence** for or against the use and effects of genetically modified plants. Emphasize comparing the benefits and risks for genetic modification. Examples of genetic modification could be through cross pollination and modern biotechnology.

ENVIRONMENTAL SCIENCE

Introduction

The Environmental Science High School Supplemental SEEd Standards explore the energy and material resources found on Earth and how these resources are obtained, used, managed, and conserved to support sustainable societies and ecosystems. Students model and analyze data to explain the organizations, factors, cycles, and changes that determine dynamic ecosystems. Students construct arguments for the risks and benefits of using renewable and nonrenewable energy sources and design energy management plans to identify sustainable energy solutions. Students construct explanations for how humans obtain and use natural resources; why resources can be abundant, scarce, and/or scattered around the world; and design a resource management plan to identify sustainable methods of obtaining and using resources. Students create arguments and explanations for how human use of natural and energy resources have an effect on the environment and what can be done to reduce or reverse human impacts on environments.

Strand ENVS.1: ECOLOGICAL SYSTEMS

Ecological systems have multiple levels of biological organization. Abiotic factors affect ecosystems and populations. Energy is transferred in ecosystems and predictable ways. Matter is cycled through environmental processes and necessary for ecosystem sustainability. Changes in ecosystems occur due to ecological succession. Biodiversity is critical for ecosystem resilience.

- **Standard ENVS.1.1** **Develop and use a model** to compare and analyze the levels of biological organization within living systems. Examples of levels of biological organization could include organisms, populations, communities, ecosystems, or biospheres.
- **Standard ENVS.1.2** **Ask questions** to **collect and analyze data** for how abiotic factors affect ecosystems and population adaptations. Examples of abiotic factors could include precipitation, temperature, elevation, or soil composition.
- **Standard ENVS.1.3** **Develop and use models** based on Laws of Thermodynamics to predict how energy transfers in ecosystems. Examples of energy transfer could be explained in terms of food chains, food webs, trophic levels, or carrying capacity.
- **Standard ENVS.1.4** **Analyze and interpret data** to construct an argument of the necessity of biogeochemical (matter) cycles to support sustainable ecosystems. Examples of biogeochemical cycles could include, hydrologic, nitrogen, phosphorus, oxygen, or carbon.
- **Standard ENVS.1.5** **Construct an argument from evidence** to predict changes in biomass, biodiversity, and complexity within ecosystems. Emphasize changes in terms of ecological succession over periods of time.
- **Standard ENVS.1.6** **Construct an argument from evidence** to support a claim about the value of biodiversity in ecosystem resilience (stability). Emphasize the value of biodiversity in ecosystem resilience. Examples of key factors in ecosystem resilience could include keystone, invasive, native, endemic, indicator, and endangered species.

Strand ENVS.2: AVAILABILITY AND USE OF NATURAL ENERGY

Energy sources are necessary for human society. Sources of energy can either be renewable or nonrenewable and have varying levels of quantity and proportion. Energy sources originate and are consumed differently. Energy plans provide a way to measure and calculate need and energy consumption in a sustainable way.

- **Standard ENVS.2.1** **Construct an argument** based on evidence about the risks and benefits caused by using renewable and nonrenewable energy sources. Examples of risks and benefits could include environmental, social, or economic factors.

- **Standard ENVS.2.2** **Analyze and interpret data** to communicate information on the origins, quantity/proportion, and consumption of renewable and nonrenewable energy sources. Examples of renewable energy sources could include wind, solar, geothermal, biofuel, or tidal. Examples of non-renewable energy sources could include fossil fuels and nuclear energy.

- **Standard ENVS.2.3** **Design a solution** in the form of a sustainable energy plan for your city, town, county or region of the state. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize the solution.* Emphasize basing the plan on scientific principles and on the sustainability potential of renewable and nonrenewable energy resources

Strand ENVS.3: AVAILABILITY, USE, AND MANAGEMENT OF NATURAL RESOURCES

Natural resources are necessary for human society. How humans obtain and use resources have an impact on their quality/quantity of the resource and their surrounding environment. Resource location, quantity, and proportion may be dependent on environmental factors. Governments and organizations manage the use and effect of natural resources. Resource management plans provide a way to measure and sustain resources for long-term use and effects.

- **Standard ENVS.3.1** **Construct an argument based on evidence** for the effects humans have by obtaining and using natural resources. Emphasize the uses and importance of resources and potential impacts of obtaining them. Examples of human activities to obtain resources could include agriculture, ranching, mining, forestry, fishing, water use, or desalination.

- **Standard ENVS.3.2** **Obtain, evaluate, and communication information** to explain how the location, quantity, and proportion of natural resources may be dependent on multiple environmental factors. Examples of environmental factors course include climate, geologic history, or soil composition.

- **Standard ENVS.3.3** **Construct an explanation** for why governments and organizations manage the use and effect of using natural resources. Emphasize how government and legislation affect management and sustainability plans. Examples of effects of management plans could include sustaining natural populations, market value of goods, or potential environmental impacts.

- **Standard ENVS.3.4** **Design a solution** in the form of a resource management plan to sustain (stability) a natural resource in your city, town, county, or region of the state. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize the solution.* Emphasize basing the plan on scientific principles. Examples of natural resources could include water, air, land, or organisms like trees or fish.

Strand ENVS.4: SUSTAINABILITY AND HUMAN IMPACTS BOTH LOCAL AND GLOBAL

Human use of natural and energy resources has an effect on the environment. Population growth generally requires an increased use of these resources and has an increased effect. Humans have found solutions to some of these effects. There is a relationship between the quality of life and human impact on the environment. Some human impacts can have lasting effects on environments around the world and adjusting practices can reduce and reverse the effects. Global climate change is occurring and has an effect on both human populations and environments. Sustainability plans help individuals, cities, or regions reduce their impact on environments.

- **Standard ENVS.4.1** **Construct an argument** to evaluate how human population growth affects natural resources and the potential solutions to these effects. Examples of resources affected by human population growth could include food demand, food supply, waste disposal, or land use. Examples of potential solutions could include genetically modified organisms, hydroponics, wastewater treatment, or improved recycling systems.

- **Standard ENVS.4.2** **Construct explanations** about the relationship between the quality of life and human impact (effect) on the environment in terms of population growth, education, and gross national product. Emphasize the role of sustainable practices to support both humans and nature.

- **Standard ENVS.4.3** **Obtain, evaluate, and communicate information** for how humans cause an impact on the environment and how individuals, state and local management plans, and government legislation have identified and adjusted practice to reduce and/or reverse these impacts. Emphasize the process and time necessary to pass Examples of impact could include water and air pollution, climate change, ozone depletion, deforestation, ocean acidification, or urbanization. Examples of adjusted practice could include the reduction of fossil fuel use, criminalization of dumping waste, or outlawing the use of chlorofluorocarbons.

- **Standard ENVS.4.4** **Analyze and interpret data** to construct an explanation based on evidence for the causes and impacts of global climate change on human populations and environments. Examples of evidence could include ice cores, ocean acidification, glacier retreat, atmospheric CO_2 levels, or air and ocean temperature.

- **Standard ENVS.4.5** **Design** and defend **a solution** in the form of a sustainability plan to reduce individual, city, or regional contribution (causes) to environmental impacts. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize the solution.* Emphasize how market forces and societal demands influence personal choices.

WILDLIFE BIOLOGY

INTRODUCTION

The Wildlife Biology Science High School Supplemental SEEd Standards explore the factors, processes, relationships, and interactions of wildlife in nature. Students analyze data and construct explanations for the characteristics, behaviors, and interactions of abiotic and biotics factors that make up an ecosystem. Obtain and evaluate information and construct arguments to communicate how organisms are identified and how they, and their effects on their habitat, can be studied in the wild. Analyze data and use mathematical reasoning to determine the health of wildlife observing both quantitative and qualitative factors. Students create arguments and explanations for how human activities have an effect on wildlife and their habitat and design solutions to what can be done to reduce or reverse human impacts on wildlife populations and habitats.

Strand WILD.1: ECOLOGICAL PROCESSES AND ENVIRONMENTAL FACTORS

Ecological habitats are shaped by abiotic factors that determine the living organisms that live there. Energy is a limiting factor for population size and growth in an ecosystem. Behaviors and interaction between organisms also have a role in the dynamics of an ecosystem.

- **Standard WILD.1.1** **Analyze and interpret data** for how abiotic factors affect characteristics of ecosystems and the individual organisms living there. Examples of abiotic factors could include seasonal climate, latitude, elevation, or soil composition. Examples of effects of abiotic factors could include temperature regulation strategies in endothermic and exothermic animals or the effect of day/night lengths on antler growth

- **Standard WILD.1.2** **Use computational thinking** to model and explain how the quantity of available energy is the limiting factor for population size and growth in an ecosystem. Emphasize how the laws of thermodynamics affect the amount of energy available in a trophic level and affect the ecosystem's carrying capacity. Examples of explanatory models could include an ecological energy pyramid or carrying capacity graphs.

- **Standard WILD.1.3** **Construct an explanation** for how behaviors of and interactions between organisms affect populations and population dynamics in an ecosystem. Examples of behaviors could include migration, food storage, or grazing. Examples of interactions could include symbiotic relationships, predator/prey relationships, competition, or decomposers. Examples of population dynamics could include population size, diversity, dispersal, birth/death rate, or survivorship.

Strand WILD.2: IDENTIFYING ORGANISMS AND THEIR FUNCTION IN THEIR ENVIRONMENT CLASSIFICATION

Organisms can be identified and studied based on their physical structure and characteristics using classification tools. Classification systems change as technologies and information about species improve. Organisms can have an impact on their environment and other organisms. Invasive species affect ecosystems in ways that can be predicted and measured.

- **Standard WILD.2.1** **Obtain, evaluate, and communicate information** about organisms by using classification tools to identify and study them based on physical structures and characteristics. Emphasize a focus on different kinds of organisms—plants, animals, fungi, and lichen. Examples of classification tools could include a field guide or dichotomous key.

- **Standard WILD.2.2** **Construct an argument from evidence** for why there are ongoing changes to classification schemes and systems. Emphasize the role of technology to provide added understanding of organisms by looking at their genetic and chemical characteristics.

- **Standard WILD.2.3** **Construct an explanation** for how organism characteristics and behaviors impact their environment (system). Examples of characteristics that impact the environment could include roots of plants affecting how stream or river flows or the presence of a keystone species can determine populations of other species. Examples of behaviors could include migration paths, pollination preferences, or burrow/tunnel creation.

- **Standard WILD.2.4** **Analyze and interpret data** to identify invasive species, describe how they are introduced, describe why they are successful in the environment, and predict/measure their effects on an ecosystem.

Strand WILD.3: DATA COLLECTION AND ANALYSIS OF WILDLIFE POPULATIONS

Understanding the quantitative and qualitative data for an environment or population is critical to understanding its health. There are techniques used to collect data for quantitative and qualitative characteristics of a population. Mathematical reasoning and statistical principles are used to estimate current population sizes based on a sample and to predict how a population may change based on environmental factors. Wildlife Biologists investigate how changes to an ecosystem may affect the ecosystems dynamics.

- **Standard WILD.3.1** **Obtain, evaluate, and communicate information** about techniques used to take population measurements that determine quantity and quality of populations. Emphasize an evaluation of both quantitative and qualitative characteristics of populations. Examples of qualitative measures could include analysis of leaf color, tree core samples, dentition examination, or scat evaluation.
- **Standard WILD.3.2** **Use mathematical reasoning** and statistical principles that use data to estimate current population sizes (scale and quantity) in an ecosystem based on a smaller sample size. Emphasize using grade-level mathematical and statistical principles.
- **Standard WILD.3.3** **Use mathematical reasoning** and statistical principles to model and predict how a population may change given data about current populations and environmental factors. Emphasize using grade-level mathematical and statistical principles.
- **Standard WILD.3.4** **Plan and carry out an investigation** to predict and measure how a single change to an ecosystem may affect the dynamics of the ecosystem.

Strand WILD.4: HUMAN IMPACT AND WILDLIFE MANAGEMENT

Human activities have an effect on ecological systems and wildlife. Humans have found some solutions to minimize or reduce the effects of their actions. Species go extinct for specific reasons and their extinction may have an impact on their environment. Humans identify and protect endangered species to limit the effects of this extinction. Ecological collapse can occur if significant changes to the environment occur. Wildlife management plans are created and executed to support a wildlife habitat and/or specific species.

■ **Standard WILD.4.1** **Construct an argument based on evidence** for the impacts (effects) humans have on ecological systems and wildlife. Emphasize a historical context for how individuals, state and local management plans, and government have identified and adjusted practice to reduce and/or reverse these impacts. Also emphasize how the level of urban development in and around the ecosystem may make management plans more challenging compared to an area where urbanization is just starting. Examples of impacts could include water and air pollution, deforestation, poaching, ocean acidification, or urbanization.

■ **Standard WILD.4.2** **Construct an explanation** for the effects that are caused when species go extinct and how endangered species are determined and protected.

■ **Standard WILD.4.3** **Analyze and interpret data** to explain the causes and effects of ecological collapse. Emphasize investigating specific examples of this happening on Earth.

■ **Standard WILD.4.4** **Obtain, evaluate, and communicate information** for the purpose, creation, execution, and effects of a wildlife management plan. Emphasize how wildlife management plans differ between states and countries and how they have changed over time. Examples of components in the wildlife management plan could include habitats, threats, species management/conservation, monitoring plans, and/or implementation approach.

■ **Standard WILD.4.5** **Design a solution** in the form of a wildlife management, conservation, or restoration plan to support (effect) a specific habitat or a specific population. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize the solution.* Emphasize basing the plan on scientific principles.

ZOOLOGY

INTRODUCTION

The Zoology Science High School Supplemental SEEd Standards explore the patterns, processes, structures, functions, and relationships of animals on Earth. Students model and explain the major structures, functions, and processes animals use to survive in their environment. Students construct explanations and arguments to classify animals into major animal taxa and determine their relationships, adaptations, and evolution. Students will analyze data and build models to explain comparative zoology principles and how animal phyla increase in complexity from the phylum porifera to chordata. Students investigate and explain the many ways that humans use and depend on animals and how humans have an impact on animal populations. Students evaluate plans to control invasive animal species in Utah and/or conserve native Utah animal species.

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Strand ZOOL.1: STRUCTURES, FUNCTIONS, AND PROCESSES IN ANIMALS

Animals share common life functions necessary for survival. They also have similar yet diverse structures that they use to fulfil these life functions. Some animals have a unique life cycle. Animals depend upon their environment for survival.

- **Standard ZOOL.1.1** **Obtain, evaluate, and communicate information** to explain the life functions shared by most animals. Emphasize that most animals depend on and perform these functions in different ways. Examples of life functions could include the need to feed, respire, circulate, excrete, move, respond, or reproduce.
- **Standard ZOOL.1.2** **Develop and use models** to explain the complexity and diversity of common animal structures (systems, organs, tissues, and cells) and their functions to fulfil life functions. Emphasize how different structures in different organisms perform similar functions.
- **Standard ZOOL.1.3** **Develop a model to explain** the patterns in various life cycles and embryological development differences in animals. Emphasize the potential reasons and benefits for these differences. Examples of life cycles could include polyp and medusa in cnidarians; different hosts and stages in the platyhelminths or nematode life cycle; arthropod metamorphosis; or chordates life cycles in fish and amphibians. Examples of embryological development differences could include oviparous, viviparous, ovoviviparous organisms.
- **Standard ZOOL.1.4** **Construct an explanation** for how animals depend upon their environment for survival in their habitat (system). Examples of necessities provided by their environment could include food, weather, or shelter.

Strand ZOOL.2: COMPARATIVE ZOOLOGY, EVOLUTION AND PHYLOGENY

Evolution by natural selection allows populations to adapt to environmental changes. Some animals have coevolved with plants or other animals. Animals are classified into major taxa and this classification can be used for phylogenetic context. Most animals show increased complexity in different ways when comparing them from phyla to phyla.

- **Standard ZOOL.2.1** **Construct an explanation** for how evolution allows populations to adapt to environmental changes. Emphasize the mechanisms that drive evolution in animal populations. Examples of evolution drivers could include adaptation, natural selection, convergence, and speciation.

- **Standard ZOOL.2.2** **Construct an argument from evidence** about the coevolution (change) of animals with plants and other animals. Examples of coevolution with plants could be due to pollination or seed dispersal. Examples of coevolution with other animals could be due to predator/prey relationships or symbiotic relationships.

- **Standard ZOOL.2.3** **Construct an argument based on evidence** to classify animals into major taxa by observing patterns in physical, behavioral, or molecular/genetic characteristics. Emphasize placing taxa into phylogenetic context using different technologies. Examples of technologies could be a dichotomous key, field guide, or molecular analysis (genes or chemicals).

- **Standard ZOOL.2.4** **Analyze and interpret data** to explain patterns in the increasing complexity in the morphology, biochemistry, and genetics of animals to compare taxa within and between phyla. Emphasize focusing the comparisons using the structures, functions, and processes identified in Strand 1 of these standards. Examples of phyla to compare could include Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Mollusca, Arthropoda, Echinodermata, and/or Chordata.

Strand ZOOL.3: HUMAN AND ANIMAL INTERACTIONS

Animal structures are used for different purposes by humans. Human activities may have an impact on natural habitats and populations of animals. Humans can also create management plans and legislation that can reduce or reverse the impacts humans have on animals in the wild. Management plans can be used to control invasive species and conserve native animal species.

- **Standard ZOOL.3.1** **Obtain, evaluate, and communicate** how animal structures are used in different societies. Examples of structures could include muscle, blood, bones, or other tissues and organs. Examples of uses could include food, medicine, or biotechnology.
- **Standard ZOOL.3.2** **Ask questions and define problems** to identify the cause and effect of human activities on natural habitats and populations of animals. Emphasize how individuals, state, and local management plans, and government legislation have identified and adjusted practice to reduce and/or reverse these impacts. Examples of human activities could include habitat destruction, overharvesting, water consumption, or pollution.
- **Standard ZOOL.3.3** **Evaluate** current plans to manage the control of an invasive animal species in Utah or to manage the conservation of a native animal species in Utah focusing on the population's proportion and quantity. *Define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine if the plan is an optimal solution.* Emphasize the impact that the animal species has on its environment.

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