Botany SEEd Standards DRAFT

Introduction

The Botany High School Elective 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, how plants are grown and cared for by humans, and how genetic engineering has affected plant characteristics.

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.

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.

1.2 **Construct an explanation** supported by evidence relating plant structures to plan processes. Examples of processes could include photosynthesis, respiration, transport, growth, reproduction, or seed dispersal.

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.

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.

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.

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 classify plants. Examples of technologies could be a dichotomous key, field guide, or molecular analysis (genes or chemicals).

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 ssues or changing from spores to seeds.

2.4 **Construct an explana on** about the coevolu on (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.

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.

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.

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.

3.3 **Construct an argument based on evidence** to predict which plant adaptations cause an increased survival rate in different stressful environments. Examples of stressful environments include changes in water, salinity, or temperature extremes.

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.

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.

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 pests and disease and may also be a solution to food shortages, however they may also come with risks.

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.

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.

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.

4.4 **Construct an argument based on evidence** for or against the use and effects of genetically modified plants. Emphasize comparing the risks and benefits for genetic modification. Examples of genetic modification could be through cross pollination and modern biotechnology.

Environmental Science SEED Standards DRAFT

Introduction

The Environmental Science High School Elective 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.

ENVS.1: Ecological Systems

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

1.1 **Ask questions** to **collect and analyze data** for how abiotic and biotic factors affect ecosystem dynamics and population adaptations. Examples of abiotic factors could include precipitation, temperature, elevation, or soil composition. Examples of biotic factors could include organism and population behaviors, adaptations, or relationships.

1.2 **Develop and use models** 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.

1.3 **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.

1.4 **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.

ENVS.2: Availability and Use of Energy Resources

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.

2.1 **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.

2.2 **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.

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

ENVS.3: Availability, Use, and Management of Natural Resources

Natural resources can be renewable and non-renewable and 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.

3.1 **Engage in argument based on evidence** for the effects humans have by obtaining and using natural resources. Emphasize the uses and importance of resources and the potential impacts of obtaining them. Examples of human activities to obtain resources could include agriculture, ranching, mining, forestry, fishing, water use, or desalination. Examples of potential impacts could include pollution, habitat destruction, or overuse.

3.2 **Obtain, evaluate, and communicate information** 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.

3.3 **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.

ENVS.4: Sustainability and Human Impacts Both Local and Global

Human use of natural and energy resources have 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.

4.1 **Construct an argument** to evaluate how human population growth affects natural resources and the potential solutions to these effects. Emphasize the role of environmental justice and sustainable practices to support both humans and nature. 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.

4.2 **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. 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.

4.3 **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.

4.4 **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 SEEd Standards Draft

Introduction

The Wildlife Biology Science High School Elective 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/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.

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.

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, 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

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.

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.

WILD.2: Identifying organisms and their function in their environment

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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 an wildlife habitat and/or specific species.

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.

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

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

4.4 **Obtain, evaluate, and communication 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.

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 SEEd Standards DRAFT Content Outline

Introduction

The Zoology Science High School Elective SEEd Standards explore 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.

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.

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.

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.

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 platyhelminthes or nematode life cycle; arthropod metamorphosis; or chordata life cycles in fish and amphibians. Examples of embryological development differences could include oviparous, viviparous, ovoviviparous organisms.

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.

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 these classification can be used for phylogenetic context. Most animals show increased complexity in different ways when comparing them from phyla to phyla.

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.

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.

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).

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.

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.

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.

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.

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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