**Biology Learning Goals (Proficiency Scales)**

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| **UTAH SCIENCE WITH ENGINEERING EDUCATION (SEEd) STANDARDS** |
| ***Science Literacy for All Students***  *Science is a way of knowing, a process for gaining knowledge and understanding of the natural world. Engineering combines the ﬁelds of science, technology, and mathematics to provide solutions to real-world problems. The nature and process of developing scientiﬁc knowledge and understanding includes constant questioning, testing, and reﬁnement, which must be supported by evidence and has little to do with popular consensus. Since progress in the modern world is tied so closely to this way of knowing, scientiﬁc literacy is essential for a society to be competitively engaged in a global economy. Students should be active learners who demonstrate their scientiﬁc understanding by using it. It is not enough for students to read about science; they must participate in the three dimensions of science. They should observe, inquire, question, formulate and test hypotheses, analyze data, report, and evaluate ﬁndings. The students, as scientists, should have hands-on, active experiences throughout the instruction of the science curriculum. These standards help students ﬁnd value in developing novel solutions as they engage with complex problems.*  ***Organization of Standards***  *The Utah SEEd standards are organized into* ***strands****, which represent signiﬁcant areas of learning within content areas. Within each strand are* ***standards****. A standard is an articulation of the demonstrated proﬁciency to be obtained. A standard represents an essential element of the learning that is expected. While some standards within a strand may be more comprehensive than others, all standards are essential for mastery.*  *The Biology SEEd standards focus on patterns, processes, relationships, and the environment of living organisms. Students analyze data on the role of matter cycles and energy ﬂow when organisms interact with their environment, to explain how the stability and change of an ecosystem and biodiversity can be affected. Students investigate the structures and functions of living organisms needed in order to support necessary life functions. Students explore the cause and eﬀect relationships of heredity, the role of DNA in gene expression and protein synthesis, and how gene expression can be altered by environmental and genetic causes. Students investigate how the mechanisms of genetic variation can lead to diversity within and among species, and explain how the unity among species, as well as the great diversity of species, is a result of evolution by natural selection. Additionally, students design and evaluate solutions to problems that exist in these areas.*  ***Three Dimensions of Science***  *Science education includes three dimensions of science understanding: science and engineering practices, crosscutting concepts, and disciplinary core ideas. Every standard includes each of the three dimensions.*   * ***Science and Engineering Practices***   + *Asking questions or deﬁning problems*   + *Developing and using models*   + *Planning and carrying out investigations*   + *Analyzing and interpreting data*   + *Using mathematics and computational thinking*   + *Constructing explanations and designing solutions*   + *Engaging in argument from evidence*   + *Obtaining, evaluating, and communicating information* * ***Crosscutting Concepts***   + *Patterns*   + *Cause and eﬀect: mechanism and explanation*   + *Scale, proportion, and quantity*   + *Systems and system models*   + *Energy and matter: ﬂow, cycles, and conservation*   + *Structure and function*   + *Stability and change* * ***Disciplinary Core Idea***   + *Life Science (Biology)* |
| ***Learning Goal #1***  **BIO.1: INTERACTIONS WITH ORGANISMS AND THE ENVIRONMENT**  *The cycling of matter and ﬂow of energy are part of a complex system of interactions within an ecosystem. Through these interactions, an ecosystem can sustain relatively stable numbers and types of organisms. A stable ecosystem is capable of recovering from moderate biological and physical changes. Extreme changes may have signiﬁcant impact on an ecosystem's carrying capacity and biodiversity, altering the ecosystem. Human activities can lead to signiﬁcant impacts on an ecosystem, including extinction of species.* |
| **Level 3 – Proficient:** I consistently demonstrate an understanding of concepts, skills, and/or processes of Biology Standard 1.   * I can plan and carry out an investigation to analyze and interpret data to determine how biotic and abiotic factors can aﬀect the stability and change of a population. *[Std 1.1]* * I can use data to show stability and change in a population’s carrying capacity and an ecosystem's biodiversity. *[Std 1.1]* * I can develop and use a model to explain the cycling of matter and ﬂow of energy among organisms in an ecosystem. *[Std 1.2]* * I can model the movement of matter and energy through the living organisms in an ecosystem. *[Std 1.2]* * I can use models and data to explain food chains, food webs, and energy pyramids*. [Std 1.2]* * I can analyze and interpret data to determine the role of photosynthesis and cellular respiration. *[Std 1.3]* * I can analyze and interpret data to determine the scale and proportion of carbon reservoirs in the carbon cycle. *[Std 1.3]* * I can model the cycling of carbon through the biosphere, atmosphere, hydrosphere, and geosphere. *[Std 1.3]* * I can use models and data to show how changes in scale and proportion of various reservoirs impact ecosystems. *(Examples may include, but are not limited to: deforestation, fossil fuel combustion, ocean uptake of carbon dioxide.)* *[Std 1.3]* * I can develop an argument from evidence for how ecosystems maintain relatively consistent numbers and types of organisms in stable conditions. *[Std 1.4*] * I can interpret evidence that demonstrates how changing conditions may result in changes to an ecosystem. *(Examples may include, but are not limited to: hunting, seasonal ﬂoods, climate change, volcanic eruption, rising sea levels.)* *[Std 1.4]* |
| **Level 4 – Advanced**: I am highly proficient and demonstrate an advanced application of the **Level 3** concepts, skills and/or processes of Biology Standard 1.   * I can demonstrate a *high level* of proficiency in the **Level 3** requirements for Standard 1 above. * I can design a solution that reduces the impact caused by human activities on the environment and biodiversity by doing the following: 1) define a problem, 2) identify criteria and constraints, 3) develop possible solutions using models, 4) analyze data to make improvements using mathematics and computations, and 5) optimize a solution. *(Examples may include, but are not limited to: urbanization, building dams, pollution, deforestation, introduction of invasive species.) [Std 1.5]* |
| **Level 2 – Approaching**: I can demonstrate *some* understanding of the **Level 3** concepts, skills, and/or processes for Biology Standard 1, but *lack proficiency* in *key areas*. |
| **Level 1 – Beginning**: I *do not* yet demonstrate an understanding of the **Level 3** concepts, skills, and/or processes for Biology Standard 1, and *require support* to complete *key tasks*. |

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| ***Learning Goal #2***  **BIO.2: STRUCTURE AND FUNCTION OF LIFE**  *Living cells are composed of chemical elements and molecules that form macromolecules. The macromolecules in a cell function to carry out important reactions that allow cycling of matter and flow of energy within and between organisms. All organisms are made of one or more cells. The structure and function of a cell determines the cell’s role in an organism. Multicellular organisms have systems of tissues and organs that work together to meet the needs of the whole organism. Cells grow, divide and function in order to accomplish essential life processes. Feedback systems help organisms maintain homeostasis.* |
| **Level 3 – Proficient**: I consistently demonstrate an understanding of concepts, skills, and/or processes of Biology Standard 2.   * I can construct an explanation, based on evidence, that all organisms are primarily composed of carbon, hydrogen, oxygen, and nitrogen. *[Std 2.1]* * I can construct an explanation, based on evidence, that the matter taken into an organism is broken down and recombined to make macromolecules necessary for life functions. *[Std 2.1]* * I can explain how enzymes break molecules apart during digestion and cellular respiration, and how the resulting atoms make carbohydrates, proteins, fats, and nucleic acids. *[Std 2.1]* * I can ask questions to plan and carry out an investigation to determine how the structure and function of cells, the proportion and quantity of cell organelles, and the shape of cells result in cells with specialized functions. *(Examples may include, but are not limited to: mitochondria in muscle and nerve cells, chloroplasts in leaf cells, ribosomes in pancreatic cells, the shape of nerve cells and muscle cells.)* *[Std 2.2]* * I can develop and use a model to illustrate the cycling of matter and flow of energy through living things by the processes of photosynthesis and cellular respiration. *[Std 2.3]* * I can use a model to illustrate how the products of one reaction (photosynthesis) are the reactants of the other (cellular respiration). *[Std 2.3]* * I can use a model to illustrate the transfer of energy during photosynthesis and cellular respiration. *[Std 2.3]* * I can plan and carry out an investigation to determine how cells maintain stability within a range of changing conditions by the transport of materials across the cell membrane (cell transport). *[Std 2.4]* * I can demonstrate how both large and small particles can pass through the cell membrane to maintain homeostasis. *[Std 2.4]* * I can construct an explanation about the role of mitosis in the production, growth, and maintenance of systems within complex organisms. *[Std 2.5]* * I can model and explain the major events of the cell cycle, including cell growth and DNA replication, separation of chromosomes, and separation of cell contents (cytokinesis). *[Std 2.5]* * I can ask questions to develop an argument for how the structure and function of interacting organs and organ systems make up multicellular organisms. *[Std 2.6]* * I can ask questions to develop an argument for how organ systems contribute to homeostasis within the organism. *[Std 2.6]* * I can construct an explanation for the interactions of organs and organ systems. *(Examples may include, but are not limited to: digestive, cardiovascular, respiratory, muscular, nervous, skeletal, integumentary, urinary, excretory, endocrine, exocrine, immune.) [Std 2.6]* * I can plan and carry out an investigation to provide evidence of homeostasis. *[Std 2.7]* * I can plan and carry out an investigation to provide evidence that feedback mechanisms maintain stability in organisms. *(Examples may include, but are not limited to: heart rate response to changes in activity, stomata response to changes in moisture or temperature, root development in response to variations in water level.)* *[Std 2.7]* |
| **Level 4 – Advanced**: I am highly proficient and demonstrate an advanced application of the **Level 3** concepts, skills and/or processes of Biology Standard 1.   * I can demonstrate a *high level* of proficiency in the **Level 3** requirements for Standard 2 above. * I can use a model to illustrate the shape, size, quantity, structure and function of the major cell organelles: cell membrane, cytoplasm, nucleus, ribosome, rough endoplasmic reticulum (RER), smooth endoplasmic reticulum (SER), Golgi apparatus, mitochondria, lysosome, centrosome, vacuole, cell wall, and chloroplast. *[Std 2.2]* * I can construct an explanation and use a model to illustrate the role of meiosis for gamete production during the process of sexual reproduction. *[Std 2.5]* * I can plan and carry out an investigation to illustrate asexual reproduction. *(Examples may include, but are not limited to: budding in yeast, binary fission in bacteria, propagation in plants.)* *[Std 2.5]*   3 |
| **Level 2 – Approaching**: I can demonstrate *some* understanding of the **Level 3** concepts, skills, and/or processes for Biology Standard 2, but *lack proficiency* in *key areas*. |
| **Level 1 – Beginning**: I *do not* yet demonstrate an understanding of the **Level 3** concepts, skills, and/or processes for Biology Standard 2, and *require support* to complete *key tasks*. |
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| ***Learning Goal #3***  **BIO.3: GENETIC PATTERNS**  *Heredity is a unifying biological principle that explains how information is passed from parent to oﬀspring through DNA (deoxyribonucleic acid) molecules in the form of chromosomes. Distinct sequences of DNA, called genes, carry the code for speciﬁc proteins, which are responsible for the speciﬁc traits and life functions of organisms. There are predictable patterns of inheritance; however, changes in the DNA sequence, and/or environmental factors, may alter genetic expression. The variation and distribution of traits observed in a population depend on both genetic and environmental factors. Research in the ﬁeld of heredity has led to the development of multiple genetic technologies that may improve the quality of life.* |
| **Level 3 – Proficient:** I consistently demonstrate an understanding of concepts, skills, and/or processes of Biology Standard 3.   * I can construct an explanation for how the structure of DNA is replicated. *[Std 3.1]* * I can construct an explanation for how DNA and RNA code for the structure of proteins, which regulate and carry out the essential functions of life and result in speciﬁc traits. *[Std 3.1]* * I can obtain, evaluate and communicate a conceptual understanding that the sequence of nucleotides in DNA determines the amino acid sequence of proteins through the processes of transcription and translation. *[Std 3.1]* * I can use computational thinking and patterns to make predictions about the expression of specific traits passed on by genes on chromosomes, from parents to offspring. *[Std 3.2]* * I can obtain, evaluate and communicate a conceptual understanding that various inheritance patterns can be predicted by observing the way genes are expressed. *(Examples may include, but are not limited to: Punnett squares, pedigrees, karyotypes.) [Std 3.2]* * I can construct an explanation of common allele crosses, including dominant/recessive (Mendelian), incomplete dominance, codominance, or sex-linked alleles. *[Std 3.2]* * I can engage in argument from evidence that inheritable genetic variation results from the formation of gametes via sexual reproduction. *[Std 3.3]* * I can engage in argument from evidence that genetic variation may be caused by epigenetics, from new genetic combinations (sexual reproduction, fertilization, crossing over), or from viable mutations during the process of meiosis. *[Std 3.3]* * I can plan and carry out an investigation, using computational thinking, to explain the variation and patterns of trait distribution within a population. *[Std 3.4]* * I can construct an explanation of the distribution of traits as it relates to both genetic and environmental inﬂuences on the expression of traits. *(Examples may include, but are not limited to: sickle-cell anemia and malaria, hemoglobin levels in humans at high elevation, antibiotic resistance.)* *[Std 3.4]* * I can evaluate design solutions where biotechnology was used to identify and/or modify genes (gene modification) in order to solve/affect a problem. *[Std 3.5]* |
| **Level 4 – Advanced**: I am highly proficient and demonstrate an advanced application of the **Level 3** concepts, skills and/or processes of Biology Standard 3.   * I can demonstrate a high level of proficiency in the **Level 3** requirements for Standard 3 above. * I can evaluate biotechnology design solutions used to identify and/or modify genes, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution in order to solve a genetic problem. *[Std 3.5]* * I can engage in argument from evidence that focuses on the effectiveness of a genetic biotechnology solution. *[Std 3.5]*   4 |
| **Level 2 – Approaching**: I can demonstrate *some* understanding of the **Level 3** concepts, skills, and/or processes for Biology Standard 3, but *lack proficiency* in *key areas*. |
| **Level 1 – Beginning**: I *do not* yet demonstrate an understanding of the **Level 3** concepts, skills, and/or processes for Biology Standard 3, and *require support* to complete *key tasks*. |
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| ***Learning Goal #4***  **BIO.4: EVOLUTIONARY CHANGE**  *The unity among species, as evidenced in the fossil record, similarities in DNA and other biomolecules, anatomical structures, and embryonic development, is the result of evolution. Evolution also explains the diversity within and among species. Evolution by natural selection is the result of environmental factors selecting for and against genetic traits. Traits that allow an individual to survive and reproduce are likely to increase in the next generation, causing the proportions of speciﬁc traits to change within a population. Over longer periods of time, changes in proportions of traits due to natural selection, and changes in selective pressures can cause both speciation and extinction. Changes in environmental conditions impact biodiversity in ecosystems, aﬀecting the natural selection of species.* |
| **Level 3 – Proficient**: I consistently demonstrate an understanding of concepts, skills, and/or processes of Biology Standard 4.   * I can obtain, evaluate, and communicate information to identify the patterns in the evidence that supports biological evolution, including DNA sequences, amino acid sequences, anatomical structures (homologous structures, atavism), the fossil record, or order of appearance of structures during embryological development (embryology). *[Std 4.1]* * I can construct an explanation, based on evidence, that natural selection is primarily caused by: 1) the potential for a species to increase in number, 2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, 3) competition for limited resources, and 4) the proliferation of those organisms that are better able to survive and reproduce in a given environment. *[Std 4.2]* * I can analyze and interpret data to identify patterns that support the claim that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. *[Std 4.3*] * I can analyze and interpret shifts in the numerical distribution of traits, using these shifts as evidence to support my explanation of biological evolution. *[Std 4.3]* * I can engage in argument from evidence that changes in environmental conditions may cause increases in the number of individuals of some species, the emergence of new species over time (speciation), and/or the extinction of other species. *[Std 4.4]* * I can engage in argument from evidence for how changes and the rate of change to the environment affect distribution or disappearance of traits in a species. *(Examples may include, but are not limited to: deforestation, application of fertilizers, drought, flood.) [Std 4.4]* * I can evaluate design solutions that can best solve a real-world problem caused by natural selection and adaptation of populations. *[Std 4.5]* |
| **Level 4 – Advanced**: I am highly proficient and demonstrate an advanced application of the **Level 3** concepts, skills and/or processes of Biology Standard 4.   * I can demonstrate a *high level* of proficiency in the **Level 3** requirements for Standard 4 above. * I can define a real-world natural selection/adaptation problem, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution. *(Examples may include, but are not limited to: bacterial resistance to drugs, plant resistance to herbicides, the eﬀect of changes in climate on food sources and pollinators.) [Std 4.4]* |
| **Level 2 – Approaching**: I can demonstrate *some* understanding of the **Level 3** concepts, skills, and/or processes for Biology Standard 4, but *lack proficiency* in *key areas*. |
| **Level 1 – Beginning**: I *do not* yet demonstrate an understanding of the **Level 3** concepts, skills, and/or processes for Biology Standard 4, and *require support* to complete *key tasks*. |

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