Utah Core Standards Benchmarks
Science

Test Name	Form	Number of Items	Standard	Description of the standard
Benchmark Module: Biology	**A**	**5**	**BIO.1.1**	**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. Emphasize stability and change in populations' carrying capacities and an ecosystem's biodiversity.
	A	**5**	**BIO.1.2**	**Develop and use a model** to explain cycling of matter and flow of energy among organisms in an ecosystem. Emphasize the movement of matter and energy through the different living organisms in an ecosystem. Examples of models could include food chains, food webs, energy pyramids or pyramids of biomass.
	A	**6**	**BIO.1.3**	**Analyze and interpret data** to determine the effects of photosynthesis and cellular respiration on the scale and proportion of carbon reservoirs in the carbon cycle.
	A	**5**	**BIO.1.4**	**Develop an argument from evidence** for how ecosystems maintain relatively consistent numbers of types of organisms in stable conditions.
	A	**5**	**BIO.1.5**	**Design a solution** that reduces the impact caused by human activities on the environment and biodiversity. Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution.
	A	**5**	**BIO.2.1**	**Construct an explanation** based on evidence that all organisms are primarily composed of carbon, hydrogen, oxygen, and nitrogen, and that the matter taken into an organism is broken down and recombined to make macromolecules necessary for life functions.
	A	**6**	**BIO.2.2**	**Ask questions to plan and carry out an investigation** to determine how (a) the structure and function of cells, (b) the proportion and quantity of organelles, and (c) the shape of cells result in cells with specialized functions.
	A	**5**	**BIO.2.3**	**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. Emphasize how the products of one reaction are the reactants of the other and how the energy transfers in these reactions.

Benchmark Module: Biology continued	**A**	**5**	**BIO.2.4**	**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. Emphasize that large and small particles can pass through the cell membrane to maintain homeostasis.
	A	**5**	**BIO.2.5**	**Construct an explanation** about the role of mitosis in the production, growth, and maintenance of systems within complex organisms.
	A	**5**	**BIO.2.6**	**Ask questions to develop an argument** for how the structure and function of interacting organs and organ systems, that make up multicellular organisms, contribute to homeostasis within the organism. Emphasize the interactions of organs and organ systems with the immune, endocrine, and nervous systems.
	A	**5**	**BIO.2.7**	**Plan and carry out an investigation** to provide evidence of homeostasis and that feedback mechanisms maintain stability in organisms.
	A	**6**	**BIO.3.1**	**Construct an explanation** for how the structure of DNA is replicated, and 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.
	A	**5**	**BIO.3.2**	**Use computational thinking** and patterns to make predictions about the expression of specific traits that are passed in genes on chromosomes from parents to offspring. Emphasize that various inheritance patterns can be predicted by observing the way genes are expressed. Examples of tools to make predictions could include Punnett squares, pedigrees, or karyotypes. Examples of allele crosses could include dominant/recessive, incomplete dominant, codominant, or sex-linked alleles.
	A	**6**	**BIO.3.3**	**Engage in argument** from evidence that inheritable genetic variation is caused during the formation of gametes. Emphasize that genetic variation may be caused by epigenetics, during meiosis from new genetic combinations, or viable mutations.
	A	**5**	**BIO.3.4**	**Plan and carry out an investigation and use computational thinking** to explain the variation and patterns in distribution of the traits expressed in a population.

Benchmark Module: Biology continued	**A**	**5**	**BIO.3.5**	Evaluate **design solutions** where biotechnology was used to identify and/or modify genes in order to solve (effect) a problem. Define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution. Emphasize arguments that focus on how effective the solution was at meeting the desired outcome.
	A	**5**	**BIO.4.1**	**Obtain, evaluate, and communicate information** to identify the patterns in the evidence that support biological evolution.
	A	**4**	**BIO.4.2**	**Construct an explanation** based on evidence that natural selection is a primary cause of evolution. Emphasize that natural selection is primarily caused by the potential for a species to increase in number, the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, competition for limited resources, and the proliferation of those organisms that are better able to survive and reproduce in the environment.
	A	**5**	**BIO.4.3**	**Analyze and interpret data** to identify patterns that explain the claim that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
	A	**4**	**BIO.4.4**	**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, and/or the extinction of other species.
	A	**5**	**BIO.4.5**	Evaluate **design solutions** that can best solve a real-world problem caused by natural selection and adaptation of populations. Define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution.
Benchmark Module: Chemistry	**A**	**6**	**CHEM.1.1**	**Obtain, evaluate, and communicate information** regarding the structure of the atom on the basis of experimental evidence.
	A	**4**	**CHEM.1.2**	**Analyze and interpret data** to identify patterns in the stability of isotopes and predict likely modes of radioactive decay.
	A	**5**	**CHEM.1.3**	**Use mathematics and computational thinking** to relate the rates of change in quantities of radioactive isotopes through radioactive decay (alpha, beta, and positron) to ages of materials or persistence in the environment.
	A	**6**	**CHEM.1.4**	**Construct an explanation** about how fusion can form new elements with greater or lesser nuclear stability.

Benchmark Module: Chemistry continued	**A**	**6**	**CHEM.1.5**	**Use** the periodic table as **a model** to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
	A	**5**	**CHEM.2.1**	**Analyze data** to predict the type of bonding most likely to occur between two elements using the patterns of reactivity on the periodic table.
	A	**5**	**CHEM.2.2**	**Plan and carry out an investigation** to compare the properties of substances at the bulk scale and relate them to molecular structures.
	A	**5**	**CHEM.2.3**	**Engage in argument supported by evidence** that the functions of natural and designed macromolecules are related to their chemical structures.
	A	**5**	**CHEM.2.4**	Evaluate **design solutions** where synthetic chemistry was used to solve a problem (cause and effect). Define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution. Emphasize the design of materials to control their properties through chemistry. Examples could include pharmaceuticals that target active sites, teflon to reduce friction on surfaces, or nanoparticles of zinc oxide to create transparent sunscreen.
	A	**6**	**CHEM.3.1**	**Use mathematics and computational thinking** to analyze the distribution and proportion of particles in solution.
	A	**5**	**CHEM.3.2**	**Analyze data** to identify patterns that assist in making predictions of the outcomes of simple chemical reactions.
	A	**5**	**CHEM.3.3**	**Plan and carry out an investigation** to observe the change in properties of substances in a chemical reaction to relate the macroscopically observed properties to the molecular level changes in bonds and the symbolic notation used in chemistry.
	A	**6**	**CHEM.3.4**	**Use mathematics and computational thinking** to support the observation that matter is conserved during chemical reactions and matter cycles.
	A	**6**	**CHEM.3.5**	**Develop solutions** related to the management, conservation, and utilization of mineral resources (matter). Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution.
	A	**5**	**CHEM.3.6**	**Construct an explanation** using experimental evidence for how reaction conditions affect the rate of change of a reaction.

Benchmark Module: Chemistry continued	**A**	**5**	**CHEM.3.7**	**Design a solution** that would refine a chemical system by specifying a change in conditions that would produce increased or decreased amounts of a product at equilibrium. Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution.
	A	**5**	**CHEM.3.8**	**Obtain, evaluate, and communicate information** regarding the effects of designed chemicals in a complex real-world system.
	A	**5**	**CHEM.4.1**	**Construct an argument from evidence** about whether a simple chemical reaction absorbs or releases energy.
	A	**5**	**CHEM.4.2**	**Construct an explanation** of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
	A	**5**	**CHEM.4.3**	**Design** a device that converts energy from one form into another to solve a problem. Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution.
	A	**6**	**CHEM.4.4**	**Use models** to describe the changes in the composition of the nucleus of the atom during nuclear processes, and compare the energy released during nuclear processes to the energy released during chemical processes.
	A	**5**	**CHEM.4.5**	**Develop an argument from evidence** to evaluate a proposed solution to societal energy demands based on prioritized criteria and trade-offs that account for a range of constraints that could include cost, safety, reliability, as well as possible social, cultural, and environmental impacts.
Benchmark Module: Earth Science	**A**	**5**	**ESS.1.1**	**Develop a model** based on evidence to illustrate the life span of the Sun and the role of nuclear fusion releasing energy in the Sun's core. Emphasize energy transfer mechanisms that allow energy from nuclear fusion to reach Earth. Examples of evidence for the model could include observations of the masses and lifetimes of other stars, or non-cyclic variations over centuries.
	A	**5**	**ESS.1.2**	**Construct an explanation** of the Big Bang theory based on astronomical evidence of electromagnetic radiation, motion of distant galaxies, and composition of matter in the universe. Emphasize redshift of electromagnetic radiation, cosmic microwave background radiation, and the observed composition and distribution of matter in the universe.

Benchmark Module: Earth Science continued	**A**	**5**	**ESS.1.3**	**Develop a model** to illustrate the changes in matter occurring in a star's life cycle. Emphasize that the way different elements are created varies as a function of the mass of a star and the stage of its lifetime.
	A	**4**	**ESS.1.4**	**Design a solution** to a space exploration challenge by breaking it down into smaller, more manageable problems that can be solved through the structure and function of a device. Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution. Examples of problems could include, cosmic radiation exposure, transportation on other planets or moons, or supplying energy to space travelers.
	A	**4**	**ESS.2.1**	**Analyze and interpret data** to construct an explanation for the changes in Earth's formation and 4.6 billion year history. Examples of data could include the absolute ages of ancient Earth materials, the size and composition of solar system objects like meteorites, or the impact cratering record of planetary surfaces.
	A	**5**	**ESS.2.2**	**Develop and use a model** based on evidence of Earth's interior and describe the cycling of matter by thermal convection. Emphasize the density of Earth's layers and mantle convection driven by radioactive decay and heat from Earth's early formation. Examples of evidence could include maps of Earth's three dimensional structure obtained from seismic waves or records of the rate of change of Earth's magnetic field.
	A	**5**	**ESS.2.3**	**Construct an explanation** for how plate tectonics results in patterns on Earth's surface. Emphasize past and current plate motions. Examples could include continental and ocean floor features such as mountain ranges and mid-ocean ridges, magnetic polarity preserved in seafloor rocks, or regional hot spots.
	A	**5**	**ESS.2.4**	**Develop and use a model** to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales. Emphasize how the appearance of land and seafloor features are a result of both constructive forces and destructive mechanisms. Examples of constructive forces could include tectonic uplift or mountain building. Examples of destructive mechanisms could include weathering or mass wasting.

Benchmark Module: Earth Science continued	**A**	**6**	**ESS.2.5**	**Engage in argument from evidence** for how the simultaneous coevolution of Earth's systems and life on Earth led to periods of stability and change over geologic time. Examples could include how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants or how the evolution of corals created reefs that altered patterns of coastal erosion and deposition providing habitats for the evolution of new life forms.
	A	**5**	**ESS.2.6**	**Evaluate design solutions** that reduce the effects of natural disasters on humans. Define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution. Examples of natural disasters could include earthquakes, tsunamis, hurricanes, drought, landslides, floods, or wildfires.
	A	**6**	**ESS.3.1**	**Plan and carry out an investigation** of the properties of water and its effects on Earth materials and surface processes. Examples of properties could include water's capacity to expand upon freezing, dissolve and transport material, or absorb, store, and release energy.
	A	**5**	**ESS.3.2**	**Construct an explanation** of how heat (energy) and water (matter) move throughout the oceans causing patterns in weather and climate. Emphasize the mechanisms for surface and deep ocean movement. Examples of mechanisms for surface movement could include wind, Sun's energy, or the Coriolis effect. Examples of mechanisms for deep ocean movement could include water density differences due to temperature or salinity.
	A	**5**	**ESS.3.3**	**Construct an explanation** for how energy from the Sun drives atmospheric processes and how atmospheric currents transport matter and transfer energy. Emphasize how energy from the Sun is reflected, absorbed, or scattered; how the greenhouse effect contributes to atmospheric energy; and how uneven heating of Earth's atmosphere combined with the Coriolis effect creates an atmospheric circulation system.
	A	**5**	**ESS.3.4**	**Analyze and interpret** patterns in **data** about the factors influencing weather of a given location. Emphasize the amount of solar energy received due to latitude, elevation, the proximity to mountains and/or large bodies of water, air mass formation and movement, and air pressure gradients.

Benchmark Module: Earth Science continued	**A**	**6**	**ESS.3.5**	**Develop and use** a quantitative **model** to describe the cycling of carbon among Earth's systems. Emphasize each of Earth's systems (hydrosphere, atmosphere, geosphere, and biosphere) and how the movement of carbon from one system to another can result in changes to the system(s). Examples could include more carbon absorbed in the oceans leading to ocean acidification or more carbon present in the atmosphere leading to a stronger greenhouse effect.
	A	**5**	**ESS.3.6**	**Analyze and interpret data** from global climate records to illustrate changes to Earth's systems throughout geologic time and make predictions about future variations using modern trends. Examples of data could include average sea surface temperature, average air temperature, composition of gasses in ice cores, or tree rings.
	A	**6**	**ESS.3.7**	**Engage in argument from evidence** to support the claim that one change to Earth's surface can create climate feedback loops that cause changes to other systems. Examples of climate feedbacks could include ice-albedo or warming oceans.
	A	**5**	**ESS.4.1**	**Construct an explanation** for how the availability of natural resources, the occurrence of natural hazards, and changes in climate affect human activity. Examples of natural resources could include access to fresh water, clean air, or regions of fertile soils. Examples of factors that affect human activity could include that rising sea levels cause humans to move farther from the coast or that humans build railroads to transport mineral resources from one location to another.
	A	**5**	**ESS.4.2**	**Use computational thinking** to explain the relationships between the sustainability of natural resources and biodiversity within Earth systems. Emphasize the importance of responsible stewardship of Earth's resources. Examples of factors related to sustainability could include costs of resource extraction, per-capita consumption, waste management, agricultural efficiency, or levels of conservation. Examples of natural resources could include minerals, water, or energy resources.

Benchmark Module: Earth Science continued	**A**	**6**	**ESS.4.3**	**Evaluate design solutions** for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios on large and small scales. Define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution. Emphasize the conservation, recycling, and reuse of resources where possible and minimizing impact where it is not possible. Examples of large-scale solutions could include developing best practices for agricultural soil use or mining and production of conventional, unconventional, or renewable energy resources. Examples of small-scale solutions could include mulching lawn clippings or adding biomass to gardens.
	A	**6**	**ESS.4.4**	Evaluate **design solutions** for a major global or local environmental problem based on one of Earth's systems. Define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution. Examples of major global or local problems could include water pollution or availability, air pollution, deforestation, or energy production.
Benchmark Module: Physics	**A**	**5**	**PHYS.1.1**	**Analyze and interpret data** to determine the cause and effect relationship between the net force on an object and its change in motion as summarized by Newton's Second Law of Motion. Emphasize one-dimensional motion and macroscopic objects moving at non-relativistic speeds. Examples could include objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force. (PS2.A)
	A	**4**	**PHYS.1.2**	**Use mathematics and computational thinking** to support the claim that the total momentum of a system is conserved when there is no net force acting on the system. Emphasize the quantitative conservation of momentum in interactions and the qualitative meaning of this principle. Examples could include one-dimensional elastic or inelastic collisions between objects within the system. (PS2.A)
	A	**6**	**PHYS.1.3**	**Design a solution** that has the function of minimizing the impact force on an object during a collision. Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution. Emphasize problems that require application of Newton's Second Law of Motion or conservation of momentum. (PS2.A, ETS1.A, ETS1.B, ETS1.C)

Benchmark Module: Physics continued	**A**	**5**	**PHYS.2.1**	**Analyze and interpret data** to track and calculate the transfer of energy within a system. Emphasize the identification of the components of the system, along with their initial and final energies, and mathematical descriptions to depict energy transfer in the system. Examples of energy transfer could include the transfer of energy during a collision or heat transfer. (PS3.A, PS3.B)
	A	**6**	**PHYS.2.2**	**Plan and conduct an investigation** to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system result in a more uniform energy distribution among the components in the system. Emphasize that uniform distribution of energy is a natural tendency. Examples could include the measurement of the reduction of temperature of a hot object or the increase in temperature of a cold object. (PS3.B)
	A	**5**	**PHYS.2.3**	**Develop and use models** on the macroscopic scale to illustrate that energy can be accounted for as a combination of energies associated with the motion of objects and energy associated with the relative positions of objects. Emphasize relationships between components of the model to show that energy is conserved. Examples could include mechanical systems where kinetic energy is transformed to potential energy or vice versa. (PS3.A)
	A	**6**	**PHYS.2.4**	**Design a solution** by constructing a device that converts one form of energy into another form of energy to solve a complex real-life problem. Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution. Examples of energy transformation could include electrical energy to mechanical energy, mechanical energy to electrical energy, or electromagnetic radiation to thermal energy. (PS3.A, PS3.B, ETS1.A, ETS1.B, ETS1.C)

Benchmark Module: Physics continued	**A**	**6**	**PHYS.2.5**	**Design a solution** to a major global problem that accounts for societal energy needs and wants. Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution. Emphasize problems that require the application of conservation of energy principles through energy transfers and transformations. Examples of devices could include one that uses renewable energy resources to perform functions currently performed by nonrenewable fuels or ones that are more energy efficient to conserve energy. (PS3.A, PS3.B, PS3.D, ETS1.A, ETS1.B, ETS1.C)
	A	**6**	**PHYS.3.1**	**Use mathematics and computational thinking** to compare the scale and proportion of gravitational and electric fields using Newton's Law of Gravitation and Coulomb's Law. Emphasize the comparative strength of these two field forces, the effect of distance between interacting objects on the magnitudes of these forces, and the use of models to understand field forces. (PS2.B)
	A	**6**	**PHYS.3.2**	**Plan and conduct an investigation** to provide evidence that an electric current causes a magnetic field and that a changing magnetic field causes an electric current. Emphasize the qualitative relationship between electricity and magnetism without necessarily conducting quantitative analysis. Examples could include electromagnets or generators. (PS2.C)
	A	**6**	**PHYS.3.3**	**Analyze and interpret data** to compare the effect of changes in position of interacting objects on electric and gravitational forces and energy. Emphasize the similarities and differences between charged particles in electric fields and masses in gravitational fields. Examples could include models, simulations, or experiments that produce data or illustrate field lines between objects. (PS3.C)
	A	**5**	**PHYS.3.4**	**Develop and use a model** to evaluate the effects on a field as characteristics of its source and surrounding space are varied. Emphasize how a field changes with distance from its source. Examples of electric fields could include those resulting from point charges. Examples of magnetic fields could include those resulting from dipole magnets or current-bearing wires. (PS3.C)

Benchmark Module: Physics continued	**A**	**5**	**PHYS.4.1**	**Analyze and interpret data** to derive both qualitative and quantitative relationships based on patterns observed in frequency, wavelength, and speed of waves traveling in various media. Emphasize mathematical relationships and qualitative descriptions. Examples of data could include electromagnetic radiation traveling in a vacuum or glass, sound waves traveling through air or water, or seismic waves traveling through Earth. (PS4.A)
	A	**6**	**PHYS.4.2**	**Engage in argument based on evidence** that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model better explains interactions within a system than the other. Emphasize how the experimental evidence supports the claim and how models and explanations are modified in light of new evidence. Examples could include resonance, interference, diffraction, or the photoelectric effect. (PS4.A, PS4.B)
	A	**6**	**PHYS.4.3**	**Evaluate information** about the effects that different frequencies of electromagnetic radiation have when absorbed by biological materials. Emphasize that the energy of electromagnetic radiation is directly proportional to frequency and that the potential damage to living tissue from electromagnetic radiation depends on the energy of the radiation. (PS4.B)
	A	**5**	**PHYS.4.4**	**Ask questions and construct an explanation** about the stability of digital transmission and storage of information and their impacts on society. Emphasize the stability of digital signals and the discrete nature of information transmission. Examples of stability and instability could include that digital information can be stored in computer memory, is transferred easily, copied and shared rapidly can be easily deleted, has limited fidelity based on sampling rates, or is vulnerable to security breaches and theft. (PS4.A)
	A	**6**	**PHYS.4.5**	**Obtain, evaluate, and communicate information** about how devices use the principles of electromagnetic radiation and their interactions with matter to transmit and capture information and energy. Emphasize the ways in which devices leverage the waveparticle duality of electromagnetic radiation. Examples could include solar cells, medical imaging devices, or communication technologies. (PS4.A, PS4.B, PS4.C)