Utah Science

Grades 9, 10, 11, 12

Adopted 2020

Biology

1. **Interactions With Organisms And The Environment** 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. BIO.1.1
    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. BIO.1.2
    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. Emphasize the cycling of carbon through the biosphere, atmosphere, hydrosphere, and geosphere and how changes to various reservoirs impact ecosystems. Examples of changes to the scale and proportion of reservoirs could include deforestation, fossil fuel combustion, or ocean uptake of carbon dioxide. BIO.1.3
    4. Develop an argument from evidence for how ecosystems maintain relatively consistent numbers and types of organisms in stable conditions. Emphasize how changing conditions may result in changes to an ecosystem. Examples of changes in ecosystem conditions could include moderate biological or physical changes such as moderate hunting or a seasonal flood; and extreme changes, such as climate change, volcanic eruption, or sea level rise. BIO.1.4
    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. Examples of human activities could include building dams, pollution, deforestation, or introduction of invasive species. BIO.1.5

2. **Structure And Function Of Life** 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. Emphasize that molecules are often transformed through enzymatic processes and the atoms involved are used to make carbohydrates, proteins, fats/lipids, and nucleic acids. BIO.2.1

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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. Examples could include mitochondria in muscle and nerve cells, chloroplasts in leaf cells, ribosomes in pancreatic cells, or the shape of nerve cells and muscle cells. BIO.2.2
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. BIO.2.3
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. BIO.2.4
5. Construct an explanation about the role of mitosis in the production, growth, and maintenance of systems within complex organisms. Emphasize the major events of the cell cycle including cell growth and DNA replication, separation of chromosomes, and separation of cell contents. BIO.2.5
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. BIO.2.6
7. Plan and carry out an investigation to provide evidence of homeostasis and that feedback mechanisms maintain stability in organisms. Examples of investigations could include heart rate response to changes in activity, stomata response to changes in moisture or temperature, or root development in response to variations in water level. BIO.2.7

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3. **Genetic Patterns** 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. Emphasize a conceptual understanding that the sequence of nucleotides in DNA determines the amino acid sequence of proteins through the processes of transcription and translation. BIO.3.1
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. BIO.3.2
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. BIO.3.3

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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. Emphasize the distribution of traits as it relates to both genetic and environmental influences on the expression of those traits. Examples of variation and patterns in distribution of traits could include sickle-cell anemia and malaria, hemoglobin levels in humans at high elevation, or antibiotic resistance. BIO.3.4
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. BIO.3.5

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4. Evolutionary Change BIO.4

1. Obtain, evaluate, and communicate information to identify the patterns in the evidence that support biological evolution. Examples of evidence could include DNA sequences, amino acid sequences, anatomical structures, the fossil record, or order of appearance of structures during embryological development. BIO.4.1
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. BIO.4.2
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. Emphasize analyzing shifts in the numerical distribution of traits and using these shifts as evidence to support explanations. BIO.4.3
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. Emphasize the cause and effect relationships for how changes and the rate of change to the environment affect distribution or disappearance of traits in a species. Examples of changes in environmental conditions could include deforestation, application of fertilizers, drought, or flood. BIO.4.4
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. Examples of real-world problems could include bacterial resistance to drugs, plant resistance to herbicides, or the effect of changes in climate on food sources and pollinators. BIO.4.5

Chemistry

1. The Structure And Properties Of Atoms CHEM.1

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1. Obtain, evaluate, and communicate information regarding the structure of the atom on the basis of experimental evidence. Emphasize the relationship between proton number and element identity, isotopes, and electrons in atoms. Examples of experimental evidence could include the gold foil experiment, cathode ray tube, or atomic spectrum data. CHEM.1.1
2. Analyze and interpret data to identify patterns in the stability of isotopes and predict likely modes of radioactive decay. Emphasize that different isotopes of the same element decay by different modes and at different rates depending on their nuclear stability. Examples of data could include band of stability charts, mass or nuclear binding energy per nucleon, or the inverse relationship between half-life and nuclear stability. CHEM.1.2
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. Emphasize a conceptual understanding of half-life. Examples could include radiocarbon dating, nuclear waste management, or nuclear medicine. CHEM.1.3
4. Construct an explanation about how fusion can form new elements with greater or lesser nuclear stability. Emphasize the nuclear binding energy, with the conceptual understanding that when fusion of elements results in a more stable nucleus, large quantities of energy are released, and when fusion results in a less stable nucleus, large quantities of energy are required. Examples could include the building up of elements in the universe starting with hydrogen to form heavier elements, the composition of stars, or supernovae producing heavy elements. CHEM.1.4
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. Emphasize conceptual understanding of trends and patterns. Examples could include trends in ionization energy, atomic radius, or electronegativity. Examples of properties for main group elements could include general reactivity, bonding type, or ion formation. CHEM.1.5

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2. **The Structure And Properties Of Molecules** 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. Emphasize the types and strengths of attractions between charged particles in ionic, covalent, and metallic bonds. Examples could include the attraction between electrons on one atom and the nucleus of another atom in a covalent bond or between ions in an ionic compound. CHEM.2.1
    2. Plan and carry out an investigation to compare the properties of substances at the bulk scale and relate them to molecular structures. Emphasize using models to explain or describe the strength of electrical forces between particles. Examples of models could include Lewis dot structures or ball and stick models. Examples of particles could include ions, atoms, molecules, or networked materials (such as graphite). Examples of properties could include melting point and boiling point, vapor pressure, solubility, or surface tension. CHEM.2.2

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3. Engage in argument supported by evidence that the functions of natural and designed macromolecules are related to their chemical structures. Emphasize the roles of attractive forces between and within molecules. Examples could include non-covalent interactions between base pairs in DNA allowing it to be unzipped for replication, the network of atoms in a diamond conferring hardness, or the nonpolar nature of polyester (PET) making it quick-drying. CHEM.2.3
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. CHEM.2.4

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3. Stability And Change In Chemical Systems CHEM.3

1. Use mathematics and computational thinking to analyze the distribution and proportion of particles in solution. Emphasize proportional reasoning and the impact of concentration on solution properties, rather than algorithmic calculations. Examples of concentrations affecting solutions could include the Beer-Lambert Law, colligative properties, or pH. CHEM.3.1
2. Analyze data to identify patterns that assist in making predictions of the outcomes of simple chemical reactions. Emphasize patterns based on the outermost electrons of atoms, trends in the periodic table, and knowledge of chemical properties. Examples could include reactions between main group elements, combustion reactions, or reactions between Arrhenius acids and bases. CHEM.3.2
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. Emphasize that the visible macroscopic changes in chemical reactions are a result of changes on the molecular level. Examples of observable properties could include changes in color or the production of a solid or gaseous product. CHEM.3.3
4. Use mathematics and computational thinking to support the observation that matter is conserved during chemical reactions and matter cycles. Emphasize that chemical reactions occur on both small and global scales, and that matter is always conserved. Examples of small scale reactions could include ratios of reactants and products in a single chemical reaction or simple stoichiometric calculation. Examples of global scale matter cycles could include tracing carbon through the chemical reactions of photosynthesis, combustion, or respiration. CHEM.3.4

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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. Emphasize the conservation of matter and minerals as a limited resource. Examples of Utah mineral resources could include copper, uranium, potash, coal, oil, or natural gas. Examples of constraints could include cost, safety, reliability, or possible social, cultural, and environmental impacts. CHEM.3.5
6. Construct an explanation using experimental evidence for how reaction conditions affect the rate of change of a reaction. Emphasize collision theory as an explanatory principle. Examples of reaction conditions could include temperature, concentration, particle size, or presence of a catalyst. CHEM.3.6
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. Emphasize a qualitative understanding of Le Châtelier's Principle and connections between macroscopic and molecular level changes. CHEM.3.7
8. Obtain, evaluate, and communicate information regarding the effects of designed chemicals in a complex real-world system. Emphasize the role of chemistry in solving problems, while acknowledging unintended consequences. Examples could include ozone depletion and restoration, DDT, development of medicines, the preservation of historical artifacts, or use of bisphenol-A in plastic manufacturing. CHEM.3.8

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4. **Energy In Chemical Systems** CHEM.4

1. Construct an argument from evidence about whether a simple chemical reaction absorbs or releases energy. Emphasize that the overall change in energy is related to the energy absorbed when bonds are broken and the energy released when bonds are formed. Examples could include chemical reactions releasing or absorbing energy to or from the surrounding solution or the metabolism of glucose. CHEM.4.1
2. Construct an explanation of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. Emphasize a qualitative understanding. Examples could include that low energy electromagnetic radiation can increase molecular rotation and bond vibration, visible light can cause electronic transitions, and high energy electromagnetic radiation can result in ionization and bond breaking. CHEM.4.2
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. Emphasize chemical potential energy as a type of stored energy. Examples of sources of chemical potential energy could include oxidation-reduction or combustion reactions. CHEM.4.3

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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. Emphasize a qualitative understanding of nuclear changes. Examples of nuclear processes could include the formation of elements through fusion in stars, generation of electricity in a nuclear power plant, radioactive decay, or the use of radioisotopes in nuclear medicine. CHEM.4.4
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. CHEM.4.5

Earth and Space Science

1. **Matter And Energy In Space** 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. ESS.1.1
    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. ESS.1.2
    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. ESS.1.3
    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. ESS.1.4

2. **Patterns In Earth's History And Processes** 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. ESS.2.1
    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. ESS.2.2

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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. ESS.2.3
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. ESS.2.4
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. ESS.2.5
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. ESS.2.6

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3. **System Interactions: Atmosphere, Hydrosphere, And Geosphere** 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. ESS.3.1
    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. ESS.3.2
    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. ESS.3.3
    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. ESS.3.4

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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. ESS.3.5
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. ESS.3.6
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. ESS.3.7

4. **Stability And Change In Natural Resources** 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. ESS.4.1
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. ESS.4.2
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. ESS.4.3
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. ESS.4.4

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Physics

1. **Forces And Interactions** 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. PHYS.1.1
    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. PHYS.1.2
    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. PHYS.1.3

2. **Energy** 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. PHYS.2.1
    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 results 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. PHYS.2.2
    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. PHYS.2.3
    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. PHYS.2.4

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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. PHYS 2.5

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3. Fields 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. PHYS.3.1
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. PHYS.3.2
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. PHYS.3.3
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 wire. PHYS.3.4

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4. Waves 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. PHYS.4.1
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. PHYS.4.2

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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. PHYS.4.3
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. PHYS.4.4
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 wave particle duality of electromagnetic radiation. Examples could include solar cells, medical imaging devices, or communication technologies. PHYS.4.5