High School Biology

Instructional Focus:

- Given data, calculate the mean, median, mode and formulate conclusions.
- Students construct an original hypothesis to test a question or problem.
- Design a method to test a hypothesis.
- While conducting an experiment students make observations, record and organize data.
- Analyze data and draw conclusions supported by the data.
- Compare results to literature values.
- Identify bias that may hinder logical conclusions.
- Identify bias that may unduly influence methodology.
- Recognize that scientific knowledge changes based on experimental and observational data.
- Recognize that scientific advancements depend on curiosity, creativity, imagination and a broad knowledge base.
- Ask questions that arise from examining models or a theory to clarify relationships.
- Communicate scientific information in multiple formats including orally, graphically, textually, and mathematically.
- Apply concepts of statistics and probability to scientific and engineering questions and problems, using digital tools when feasible.
- Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.
- Discuss that scientific theories can be modified with the discovery of new evidence.

Life Science

From Molecules to Organisms: Structures and Processes

Cross Cutting: Investigating or designing new systems or structures requires a detailed examination of the properties of different materials. The structures of different components, and connections of components to reveal its function and/or solve a problem.

Objective	Examples
Students will: • Understand systems of specialized cells within organisms help them perform the essential functions of life. • Understand that all cells contain genetic information in the form of DNA molecules. • Understand that genes are regions in the DNA that contain the instructions that code for the formation of proteins. • Describe the relationship between chromosomes and DNA along with their basic structure and function. • Define gene, allele and genome. • Explain how the unique shape and activity of each protein is determined by the sequence of its amino acids. • Describe the process by which DNA directs the production of protein within a cell. (replication, transcription, translation) (Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)	DNA structure, Double helix, Nucleotide, DNA Extraction Lab. Build a model similar to Watson and Crick's model that demonstrates the structure of and function of DNA. Explain the central dogma of biology; DNA –RNA-Proteins.

Standard

HS.LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

Heredity: Inheritance and Variation of Traits

Cross Cutting:

- Cause and Effect–Empirical is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Scale, Proportion, and Quantity–Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

- Science is a Human Endeavor–Technological advances have influenced the progress of science and science has influenced advances in technology. (HS-LS3-3) Science and engineering are influenced by society and society is influenced by science and engineering.

Objective	**Examples**
Students will: • Understand that all cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. • Understand that each chromosome consists of a single very long DNA molecule. • Understand that each gene on the chromosome is a particular segment of that DNA. • Explain the instructions for forming species' characteristics and how they are carried in DNA. • Understand that all cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. • Understand that not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.	

Standards

HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. **HS.LS1-A** Systems of specialized cells within organisms help them perform the essential functions of life. All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)**, HS.LS3-A** Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species characteristics are carried in DNA. All cells in an organism have the sam e genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.

Objective	**Examples**
Students will: • Understand that in sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. • Know that although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. • Understand that environmental factors can also cause mutations in genes, and viable mutations are inherited. • Understand that environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. • Define gene mutation. • Describe that meiosis is a reduction; division of a diploid nucleus to form haploid nuclei.	Emphasis is on using data to support arguments for the way variation occurs.

Standards

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Objective	Examples
Students will: • Define genotype, phenotype, dominant allele, recessive allele, homozygous, heterozygous and carrier. • Determine the genotypes and phenotypes of the offspring of a monohybrid cross using a Punnett square. • Determine the likelihood of the appearance of a specific trait in an offspring given the genetic make-up of the parents. • Explain how the sex chromosomes control gender. • Describe co dominant sex-linked, incomplete dominance and polygenic traits. • Illustrate inheritance patterns over multiple generations.	Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.
Standards	
HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.	
Objective	**Examples**
Students will: • State examples of the current uses of genetically modified crops or animals. • Discuss the potential benefits and possible harmful effects of genetic modification. • Discuss the ethical issues of therapeutic cloning in humans.	
Standards	
BIO 4: Discuss current societal issues related to genetics.	
Cells and Ecology	
Objective	**Examples**
Students will: • Understand systems of specialized cells within organisms help them perform the essential functions of life. • Understand that all cells contain genetic information in the form of DNA molecules. • Understand that genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)	DNA Extraction Lab. Build a model similar to Watson and Crick's model that demonstrates the structure of and function of DNA. Explain the central dogma of biology; DNA–RNA-Proteins.
Standards	
HS-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.	
Objective	**Examples**
Students will: • Understand the principal that multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. • Explain that cells have specialized structures in which chemical reactions occur. • Explain the importance of surface area to volume ratio as a factor limiting cell size. • Explain that cells in multicellular organisms differentiate to carry out specialized functions by expressing some of their genes, but not others. • Compare prokaryotic and eukaryotic cells. • Investigate a variety of different cell types and relate the proportion of different organelles with in these cells to their functions. (Yale website is good) • State three differences between plant and animal cells. • Describe features common to all cells that are essential for growth and survival.	This concept is integrated into all aspects of biology. Compare plant cells to animal cells under a microscope. Be able to identify basic organelle structures in a cell using a compound microscope.
Standards	
HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. **BIO 1:** State the functions of cell organelles; including the nucleus, mitochondria and chloroplast. **SC2.2** [10] Explaining that cells have specialized structures in which chemical reactions occur. [11] Describing the learned behaviors (e.g., classical conditioning, imprinting, trial and error) that are utilized by living organisms to meet the requirements of life.	

Objective	Examples
Students will: • Understand feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. • Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. • State that homeostasis involves maintaining the internal environment between limits (pH, CO2 concentration, body temperature, water balance)	Osmosis and diffusion lab. Determine if objects are living or non-living by using the characteristics of life. Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels.
Standards	
HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.	
Objective	**Examples**
Students will: • Understand that the organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. • Identify the cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. • Outline the stages in the cell cycle, including interphase (G1, S, and G2), mitosis and cytokinesis. • Describe the events that occur in the phases of mitosis. • State that tumors/cancer is the result of uncontrolled cell division. • Explain how mitosis produces two genetically identical nuclei. • List process that involve mitosis. (growth, embryonic development, tissue repair, asexual reproduction)	Observe cells undergoing mitosis (onion cells).
Standards	
HS-LS1-4. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.	
Objective	**Examples**
Students will: • Demonstrate the process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. • State that photosynthesis involves the conversion of light energy into chemical energy. • Explain that the chloroplasts are the key sites of photosynthesis.	Make a model demonstrating the processes of the Calvin cycle, light-dependent and light-independent reactions. Examples of models could include diagrams, chemical equations, and conceptual models.
Standards	
HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.	
Objective	**Examples**
Students will: • Understand that organic molecules thus formed contain carbon, hydrogen, nitrogen, and oxygen: their hydrocarbon backbones are used to make carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. • Understand that as matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • Distinguish between organic and inorganic compounds. • Identify amino acids, glucose and fatty acids from diagrams showing their structure. • Describe how most organisms can combine and recombine the elements contained in sugar molecules to a variety of biologically essential components. • Compare the structure and function of lipids, carbohydrates and proteins.	Compare different foods and analyze their compositions using indicators for simple sugars, starches, amino acids, proteins, lipids etc.

• Compare the use of carbohydrates and lipids in energy storage.	
Standards	
HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.	
Objective	**Examples**
Students will: • Understand that as matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • Understand that as a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. • Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. • Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. • Explain that mitochondria convert chemical energy into useable energy for the cell (ATP).	Using yeast and different sugar solutions to demonstrate the process of cellular respiration and the production of carbon dioxide and ethanol as a by-product of anaerobic cellular respiration.
Standards	
HS-LS1-7. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.	
Ecosystems: Interactions, Energy, and Dynamics	
Objective	**Examples**
Students will: • Understand that ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. • These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. • List factors that limit population increases. • Identify biotic and abiotic limiting factors in an ecosystem.	Perform a population dynamics lab modeling population fluctuations between lynx and hares. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.
Standards	
HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.	
Objective	**Examples**
Students will: • Understand that a complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. • Explain if a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. • Explain the extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. • Outline how population size is affected by natality, immigration, mortality and emigration. • Describe the consequences of introducing non-native species into an ecosystems and identify the impact it may have on the ecosystem. • Outline the consequences of global temperature rise on arctic ecosystems.	Show students what an ecological pyramid is and explain the importance of preserving the organisms that exist at the upper trophic levels.
Standards	
HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.	

Objective	Examples
Students will: • Understand that photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.	Show students that the waste products of photosynthesis are the useful reactants that are used in the process of cellular respiration and vice versa.

Standards

HS-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

Objective	Examples
Students will: • Understand that photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. • Understand that energy transformations are never 100% efficient. • Explain that energy enters and leaves ecosystems, but nutrients must be recycled. • Compare the flow of energy in aerobic and anaerobic conditions. • Distinguish between autotroph and heterotroph • Give an example of a food chain with four organisms. • Compare food chains and food webs. • Deduce the trophic level of organisms in a food chain and a food web. • State that light is the initial energy source for almost all communities. • Explain the energy flow in a food chain.	Show students that the waste products of photosynthesis are the useful reactants that are used in the process of cellular respiration and vice versa. Students can construct a food web or their local ecosystem or an ecosystem of Alaska.

Standards

HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

Objective	Examples
Student will: • Understand that photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. • Understand that the main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. • Draw and label a diagram of the carbon cycle to show the processes involved. • Explain the relationship between rises in concentration of atmospheric CO2, methane and oxides of nitrogen and the enhanced greenhouse effect. • Discuss the role of human activities in the carbon cycle.	Explain the importance of biogeochemical cycles such as the carbon and oxygen cycle, the nitrogen cycle, the phosphorus cycle etc.

Standards

HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

Objective	Examples
Students will: • Outline the progression of ecological succession. • Compare stable and changing ecosystems in terms of biotic and abiotic factors. • Predict the possible effects of minor and major changes to an ecosystem. • Predict how changing climate may influence ecosystems in Alaska. • Explain what is meant by a resilient ecosystem.	Students can play a game that illustrates the changes that take place during ecological succession. Explain the differences between primary succession and secondary succession.

Standards

HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Objective	Examples
Students will: • Understand that anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. • Understand that biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). • Understand that humans depend on the living world for the resources and other benefits provided by biodiversity. • Sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.) • Understand that when evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.	Have students do a research project on the effects of a local invasive species on our environment (ex. Northern pike).

Standards
HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Objective	Examples
Students will: • Understand that group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.	Discuss examples of adaptations related to specific ecosystems. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.

Standards
HS-LS2-8. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

Biological Evolution: Unity and Diversity

Cross Cutting:

- Patterns – Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
- Cause and effect – Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

Objective	Examples
Students will: • Describe that DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA. • Outline the evidence for evolution provided by the fossil record, selective breeding, amino acid sequences, embryological evidence and homologous structures • Evaluate a cladogram to determine common ancestry.	Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.

Standards
HS-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

Objective	Examples
Students will: • Explain how natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. • State that populations tend to produce more offspring than the environment can support. • Describe a consequence of overproduction of offspring is a struggle for survival. • State that the members of a species show variation. • Explain how sexual reproduction promotes variation is a species. • Explain how natural selection leads to evolution. • Understand that evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.	Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.

Standards

HS-LS4-2. Construct an explanation based on evidence that the process of evolution primarily results from four factors: (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 the environment. **HS.LS4.B** Natural selection leads to the predominance of certain traits in a population, and the suppression of others. **HS.LS4.C** Natural selection is the result of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. Natural selection leads to adaptation—that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. Adaptation also means that the distribution of traits in a population can change when conditions change. Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' evolution is lost.

Objective	Examples
Students will: • Analyze that the natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. • Understand the traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. • Explain how natural selection leads to adaptation. • Adaptation also means that the distribution of traits in a population can change when conditions change. • Explain examples of evolution in response to environmental change.	Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.

Standards

HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. **HS.LS4.B** Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information-that is trait variation-that leads to differences in performance among individuals. The traits that positively affect survival are more likely to

be reproduced, and thus are more common in the population. **HS.LS4.C** Adaptation also means that the distribution of traits in a population can change when conditions change.	
Objective	**Examples**
Students will: • Describe how organisms with beneficial traits are more likely to survive, reproduce, and pass on their genetic information due to genetic variations, environmental forces and reproductive pressures. • Explain how genetic variation within a population (i.e., a species) can be attributed to mutations as well as random assortments of existing genes.	Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.
Standards	
HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.	
Objective	**Examples**
Students will: • List natural physical changes that could lead to speciation or extinction. • List human induced physical changes that could lead to speciation or extinction. • Investigate a real-world example of speciation and extinction.	Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.
Standards	
HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.	
Objective	**Examples**
Students will: • Explain how organisms are classified and named based on their evolutionary relationships into taxonomic categories. • Use anatomical and molecular evidence to establish evolutionary relationships among organisms. • Describing and comparing the characteristics of phyla/divisions from each kingdom. • Compare and contrast the characteristics the domains and kingdoms. • Identify eight hierarchical levels of classification. • Correctly use the format for writing scientific names; (genus species).	
Standards	
Classification of Life	