Plymouth Public Schools' Science and Technology/Engineering Program High School Biology Learning Standards

STE0022 Biology Honors
STE0023 Biology CP1
STE0024 Biology CP2
STE3014 Biology for MCAS

An Introduction to the Massachusetts Department of Elementary and Secondary Education Science and Technology/Engineering Curriculum Framework

Effective teaching and learning in science fosters engagement and has rigor, relevance, and coherence embedded within. It couples practice with content to give the context for performance. A program with these components encourages students to analyze and explain phenomena and experience; engages with practices to build, use, and apply knowledge; and builds a storyline over time and among disciplines. The state standards that form this program are outcomes that reflect what a student should know and be able to do as a result of instruction. Science and engineering practices, which are included in these standards, are not teaching strategies; they are important learning goals and skills to be learned, also as a result of instruction. The standards listed below are not intended to represent an exhaustive list of all that could be included in our district's science program, nor should this list prevent students from going beyond the standards where appropriate. (Excerpts from Curriculum Framework)

Disciplinary Core Ideas – Biology

High school biology standards build from middle school to explain additional and more complex phenomena related to genetics, the functioning of organisms, and interrelationships between organisms, populations, and the environment. More specifically, students are expected to use multiple types of models, including mathematical models, to make predictions and develop explanations, analyze and identify flaws in the model, and communicate ideas that accurately represent or simulate the biological system. Students are asked to construct and revise explanations and claims based on valid and reliable evidence and apply scientific reasoning to evaluate complex real-world problems such as the effects of human activity on biodiversity and ecosystem health. Students must be able to find and interpret scientific literature to compare, integrate, and evaluate sources and communicate phenomena related to genetics, the functioning of organisms, and interrelationships between organisms, populations, and the environment. These expectations help students formulate answers to the following questions which help frame their understanding: how organisms live and grow; how and why organisms interact with their environment, and what are the effects of these interactions; how characteristics of one generation are passed to the next; how individuals of the same species and even siblings have different characteristics; and what evidence shows that different species are related. (Excerpts from Curriculum Framework)

LS1. From Molecules to Organisms: Structures and Processes

HS-LS1-1. Construct a model of transcription and translation to explain the roles of DNA and RNA that code for proteins that regulate and carry out essential functions of life.

Clarification Statements:

1. Proteins that regulate and carry out essential functions of life include enzymes (which speed up chemical reactions), structural proteins (which provide structure and enable movement), and hormones and receptors (which send and receive signals).
2. The model should show the double-stranded structure of DNA, including genes as part of DNA's transcribed strand, with complementary bases on the non-transcribed strand.

State Assessment Boundaries:

1. Specific names of proteins or specific steps of transcription and translation are not expected in state assessment.
2. Cell structures included in transcription and translation will be limited to nucleus, nuclear membrane, and ribosomes for state assessment.

HS-LS1-2. Develop and use a model to illustrate the key functions of animal body systems, including (a) food digestion, nutrient uptake, and transport through the body; (b) exchange of oxygen and carbon dioxide; (c) removal of wastes; and (d) regulation of body processes.

Clarification Statement:
Emphasis is on the primary function of the following body systems (and structures): digestive (mouth, stomach, small intestine [villi], large intestine, pancreas), respiratory (lungs [alveoli], diaphragm), circulatory (heart, veins, arteries, capillaries), excretory (kidneys, liver, skin), and nervous (neurons, brain, spinal cord).

State Assessment Boundary:
Chemical reactions in cells, details of particular structures (such as the structure of the neuron), or the identification of specific proteins in cells are not expected in state assessment.

HS-LS1-3. Provide evidence that homeostasis maintains internal body conditions through both body-wide feedback mechanisms and small-scale cellular processes.

Clarification Statements:

1. Feedback mechanisms include the promotion of a stimulus through positive feedback (e.g., injured tissues releasing chemicals in blood that activate platelets to facilitate blood clotting), and the inhibition of stimulus through negative feedback (e.g., insulin reducing high blood glucose to normal levels).

2. Cellular processes include (a) passive transport and active transport of materials across the cell membrane to maintain specific concentrations of water and other nutrients in the cell and (b) the role of lysosomes in recycling wastes, macromolecules, and cell parts into monomers.

State Assessment Boundary:
Interactions at the molecular level (for example, how insulin is produced) are not expected in state assessment.

HS-LS1-4. Construct an explanation using evidence for why the cell cycle is necessary for the growth, maintenance, and repair of multicellular organisms. Model the major events of the cell cycle, including (a) cell growth and DNA replication, (b) separation of chromosomes (mitosis), and (c) separation of cell contents.

State Assessment Boundary:
Specific gene control mechanisms or specific details of each event (e.g., phases of mitosis) are not expected in state assessment.

HS-LS1-5. Use a model to illustrate how photosynthesis uses light energy to transform water and carbon dioxide into oxygen and chemical energy stored in the bonds of sugars and other carbohydrates.

Clarification Statements:
1. Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms.
2. Examples of models could include diagrams, chemical equations, and conceptual models.

State Assessment Boundary:
Specific biochemical steps of light reactions or the Calvin Cycle, or chemical structures of molecules are not expected in state assessment.

HS-LS1-6. Construct an explanation based on evidence that organic molecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form monomers that can further combine to form large carbon-based macromolecules.

Clarification Statements:
1. Monomers include amino acids, mono- and disaccharides, nucleotides, and fatty acids.
2. Organic macromolecules include proteins, carbohydrates (polysaccharides), nucleic acids, and lipids.

State Assessment Boundary:
Details of specific chemical reactions or identification of specific macromolecule structures are not expected in state assessment.

HS-LS1-7. Use a model to illustrate that aerobic cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new bonds form, resulting in new compounds and a net transfer of energy.

Clarification Statements:

1. Emphasis is on the conceptual understanding of the inputs and outputs of the process of aerobic cellular respiration.
2. Examples of models could include diagrams, chemical equations, and conceptual models.
3. The model should include the role of ATP for energy transfer in this process.
4. Food molecules include sugars (carbohydrates), fats (lipids), and proteins.

State Assessment Boundary:
Identification of the steps or specific processes involved in cellular respiration is not expected in state assessment.

LS2. Ecosystems: Interactions, Energy, and Dynamics

HS-LS2-1. Analyze data sets to support explanations that biotic and abiotic factors affect ecosystem carrying capacity.

Clarification Statements:

1. Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses, competition) and disease.
2. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources.
3. Example data sets can be derived from simulations or historical data.

HS-LS2-2. Use mathematical representations to support explanations that biotic and abiotic factors affect biodiversity, including genetic diversity within a population and species diversity within an ecosystem.

Clarification Statements:

1. Examples of biotic factors could include relationships among individuals (feeding relationships, symbiosis, competition) and disease.
2. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources.

3. Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.

HS-LS2-4. Use a mathematical model to describe the transfer of energy from one trophic level to another. Explain how the inefficiency of energy transfer between trophic levels affects the relative number of organisms that can be supported at each trophic level and necessitates a constant input of energy from sunlight or inorganic compounds from the environment.

Clarification Statement:
The model should illustrate the "10% rule" of energy transfer and show approximate amounts of available energy at each trophic level in an ecosystem (up to five trophic levels).

HS-LS2-5. Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere.

Clarification Statements:
1. The primary forms of carbon include carbon dioxide, hydrocarbons, waste (dead organic matter), and biomass (organic materials of living organisms).
2. Examples of models could include simulations and mathematical models.

State Assessment Boundary:
The specific chemical steps of respiration, decomposition, and combustion are not expected in state assessment.

HS-LS2-6. Analyze data to show ecosystems tend to maintain relatively consistent numbers and types of organisms even when small changes in conditions occur but that extreme fluctuations in conditions may result in a new ecosystem. Construct an argument supported by evidence that ecosystems with greater biodiversity tend to have greater resistance to change and resilience.

Clarification Statement:
Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption, fires, the decline or loss of a keystone species, climate changes, ocean acidification, or sea level rise.

HS-LS2-7. Analyze direct and indirect effects of human activities on biodiversity and ecosystem health, specifically habitat fragmentation, introduction of non-native or invasive species, overharvesting, pollution, and climate change. Evaluate and refine a solution for reducing the impacts of human activities on biodiversity and ecosystem health.

Clarification Statement:
Examples of solutions can include captive breeding programs, habitat restoration, pollution mitigation, energy conservation, and ecotourism.

LS3. Heredity: Inheritance and Variation of Traits

HS-LS3-1. Develop and use a model to show how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction.

Clarification Statement:
The model should demonstrate that an individual’s characteristics (phenotype) result, in part, from interactions among the various proteins expressed by one’s genes (genotype).

State Assessment Boundary:
Identification of specific phases of meiosis or the biochemical mechanisms involved are not expected in state assessment.

HS-LS3-2. Make and defend a claim based on evidence that genetic variations (alleles) may result from (a) new genetic combinations via the processes of crossing over and random segregation of chromosomes during meiosis, (b) mutations that occur during replication, and/or (c) mutations caused by environmental factors. Recognize that mutations that occur in gametes can be passed to offspring.

Clarification Statement:
Examples of evidence of genetic variation can include the work of McClintock in crossing over of maize chromosomes and the development of cancer due to DNA replication errors and UV ray exposure.

State Assessment Boundary:
Specific phases of meiosis or identification of specific types of mutations are not expected in state assessment.

HS-LS3-3. Apply concepts of probability to represent possible genotype and phenotype combinations in offspring caused by different types of Mendelian inheritance patterns.

Clarification Statements:

1. Representations can include Punnett squares, diagrams, pedigree charts, and simulations.

2. Inheritance patterns include dominant-recessive, codominance, incomplete dominance, and sex-linked.

HS-LS3-4(MA). Use scientific information to illustrate that many traits of individuals, and the presence of specific alleles in a population, are due to interactions of genetic factors and environmental factors.

Clarification Statements:

1. Examples of genetic factors include the presence of multiple alleles for one gene and multiple genes influencing a trait.
2. An example of the role of the environment in expressed traits in an individual can include the likelihood of developing inherited diseases (e.g., heart disease, cancer) in relation to exposure to environmental toxins and lifestyle; an example in populations can include the maintenance of the allele for sickle-cell anemia in high frequency in malaria-affected regions because it confers partial resistance to malaria.

State Assessment Boundary:
Hardy-Weinberg calculations are not expected in state assessment.

LS4. Biological Evolution: Unity and Diversity

HS-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence, including molecular, anatomical, and developmental similarities inherited from a common ancestor (homologies), seen through fossils and laboratory and field observations.

Clarification Statement:
Examples of evidence can include the work of Margulis on endosymbiosis, examination of genomes, and analyses of vestigial or skeletal structures.

HS-LS4-2. Construct an explanation based on evidence that Darwin's theory of evolution by natural selection occurs in a population when the following conditions are met: (a) more offspring are produced than can be supported by the environment, (b) there is heritable variation among individuals, and (c) some of these variations lead to differential fitness among individuals as some individuals are better able to compete for limited resources than others.

Clarification Statement:
Emphasis is on the overall result of an increase in the proportion of those individuals with advantageous heritable traits that are better able to survive and reproduce in the environment.

HS-LS4-4. Research and communicate information about key features of viruses and bacteria to explain their ability to adapt and reproduce in a wide variety of environments.

Clarification Statement:
Key features include high rate of mutations and the speed of reproduction which produces many generations with high variability in a short time, allowing for rapid adaptation.

State Assessment Boundary:
Specific types of viral reproduction (e.g., lytic and lysogenic) are not expected in state assessment.

HS-LS4-5. Evaluate models that demonstrate how changes in an environment may result in the evolution of a population of a given species, the emergence of new species over generations, or the extinction of other species due to the processes of genetic drift, gene flow, mutation, and natural selection.