AP Biology Extension Lessons for The Beetle Project: Overview

|  |  |
| --- | --- |
| **Subject:** AP Biology, Biology II | **Teacher:** Aaron Mathieu  Acton-Boxborough Regional High School  Acton, MA  [amathieu@abschools.org](mailto:amathieu@abschools.org) |
| Curriculum Background:   * This module was designed as a curriculum extension to the Understanding Evolution website [Natural selection from the gene up: The work of Elizabeth Dahlhoff and Nathan Rank](https://evolution.berkeley.edu/evolibrary/article/0_0_0/dahlhoff_rank_01), <https://evolution.berkeley.edu/evolibrary/article/dahlhoff_rank_01>. * The Beetle Project has three NGSS-aligned lessons written by Nikki Chambers that may be a good place to start your class, particularly for first year biology classes. (For access to these and all other lessons referenced below, see the project website, <https://evolution.berkeley.edu/evolibrary/teach/lessons/beetle-project-overview.php>). These include a series of labs using lady beetles (also called ladybugs or ladybird beetles) as a model organism to provide students an opportunity to ask their own experimental questions:   + Climbing rate of beetles   + Cold coma recovery time of beetles   + A series of molecular labs involving the amplification of PGI from beetles (not yet created) * The Data Nuggets lesson [Beetle, it’s cold outside!](http://datanuggets.org/2018/11/beetle-its-cold-outside/), <http://datanuggets.org/2018/11/beetle-its-cold-outside/>, Is another resource that supports the curriculum. It can be used at a number of places in this sequence, but it works well right before the “Performance and Cell Respiration” activity. * There will also be a resource to help learn some basic statistical analysis using data from this project with the document Using Lady Beetle Data to Understand Statistics (not yet created) * The lessons below are sequenced as a potential storyline, the one used at Acton-Boxborough in our AP Biology Classes, but the lessons are written to be used as stand alone lessons. * These lessons focus on using AP Biology Task Verbs as used in the Free Response Question of the May AP Exam. * The AP Biology alignments are to the May 2019 AP Biology CED.   AP Biology Lessons (alignment below):   * Community Interactions and the Willow Leaf Beetle * Evolutionary Trade-Offs * Relationship between PGI and HSPs * Performance and Cell Respiration * Population Differences & Hardy-Weinberg Equilibrium * Population Shifts and a Changing Climate | |
| **Lesson 1: Community Interactions and the Willow Leaf Beetle** (to access lesson, see AP materials on the Beetle Project homepage: <https://evolution.berkeley.edu/evolibrary/teach/lessons/beetle-project-overview.php>) | AP Unit Connections:   * Unit 8: Ecology   + Community Ecology   + Population Ecology   + Effect of Density of Populations |
| AP Science Practices:   * Scientific Explanation [1.B, 1.C] * Visual Representations [2.A, 2.B, 2.D] * Statistical Tests and Data Analysis [5.B, 5.D] * Argumentation [6.A, 6.B, 6.C, 6.D, 6.E] | |
| AP Biology Learning Objectives:   * ENE-4.A - **Describe** the structure of a community according to its species composition and diversity. * ENE-4.B - **Explain** how interactions within and among populations influence community structure. * SYI-1.G - **Describe** factors that influence growth dynamics of populations. * SYI-1.H - **Explain** how the density of a population affects and is determined by resource availability in the environment. | AP Biology Essential Knowledge:   * ENE-4.A.1 - The structure of a community is measured and described in terms of species composition and species diversity. * ENE-4.B.1 - Communities change over time depending on interactions between populations. * ENE-4.B.2 - Interactions among populations determine how they access energy and matter within a community. * ENE-4.B.3 - Relationships among interacting populations can be characterized by positive and negative effects and can be modeled. Examples include predator/prey interactions, trophic cascades, and niche partitioning. * ENE-4.B.4 - Competition, predation, and symbioses, including parasitism, mutualism, and commensalism, can drive population dynamics. * SYI-1.G.1 - Populations comprise individual organisms that interact with one another and with the environment in complex ways. * SYI-1.G.2 Many adaptations in organisms are related to obtaining and using energy and matter in a particular environment—   a. Population growth dynamics depend on a number of factors.  i. Reproduction without constraints results in the exponential growth of a population.   * SYI-1.H.1 - A population can produce a density of individuals that exceeds the system’s resource availability. * SYI-1.H.2 - As limits to growth due to density-dependent and density-independent factors are imposed, a logistic growth model generally ensues. |
| **Lesson 2: Evolutionary Trade-Offs** (to access lesson, see AP materials on the Beetle Project homepage: <https://evolution.berkeley.edu/evolibrary/teach/lessons/beetle-project-overview.php>) | AP Unit Connections:  Unit 7: Natural Selection   * Artificial Selection   Unit 5 - Heredity   * Environmental Effects on Phenotype |
| AP Science Practices:   * Visual Representations [2.B, 2.C] * Representing and Describing Data [4.B] * Argumentation [6.C, 6.E] | |
| AP Biology Learning Objectives:   * EVO-1.G - Explain the relationship between changes in the environment and evolutionary changes in the population. * SYI-3.B - Explain how the same genotype can result in multiple phenotypes under different environmental conditions. | AP Biology Essential Knowledge:   * EVO-1.G.1 Convergent evolution occurs when similar selective pressures result in similar phenotypic adaptations in different populations or species. * SYI-3.B.1 Environmental factors influence gene expression and can lead to phenotypic plasticity. Phenotypic plasticity occurs when individuals with the same genotype exhibit different phenotypes in different environments. |
| **Lesson 3: Relationship Between PGI and HSPs** (to access lesson, see AP materials on the Beetle Project homepage: <https://evolution.berkeley.edu/evolibrary/teach/lessons/beetle-project-overview.php>) | AP Unit Connections:   * Unit 1 - Chemistry of Life   + Structure and Function of Biological Macromolecules |
| AP Science Practices:   * Visual Representations [2.B, 2.C] * Questions and Methods [3.B, 3.E] * Argumentation [6.A, 6.B, 6.C, 6.E] | |
| AP Biology Learning Objectives:   * SYI-1.C - Explain how a change in the subunits of a polymer may lead to changes in structure or function of the macromolecule. | AP Biology Essential Knowledge:   * SYI-1.C.1 * Directionality of the subcomponents influences structure and function of the polymer—  1. Nucleic acids have a linear sequence of nucleotides that have ends, defined by the 3’ hydroxyl and 5’ phosphates of the sugar in the nucleotide. During DNA and RNA synthesis, nucleotides are added to the 3’ end of the growing strand, resulting in the formation of a covalent bond between nucleotides. 2. DNA is structured as an antiparallel double helix, with each strand running in opposite 5’ to 3’ orientation. Adenine nucleotides pair with thymine nucleotides via two hydrogen bonds. Cytosine nucleotides pair with guanine nucleotides by three hydrogen bonds. 3. Proteins comprise linear chains of amino acids, connected by the formation of covalent bonds at the carboxyl terminus of the growing peptide chain. 4. Proteins have primary structure determined by the sequence order of their constituent amino acids, secondary structure that arises through local folding of the amino acid chain into elements such as alpha-helices and beta-sheets, tertiary structure that is the overall three-dimensional shape of the protein and often minimizes free energy, and quaternary structure that arises from interactions between multiple polypeptide units. The four elements of protein structure determine the function of a protein. 5. Carbohydrates comprise linear chains of sugar monomers connected by covalent bonds. Carbohydrate polymers may be linear or branched. |
| **Lesson 4: Performance and Cell Respiration** (to access lesson, see AP materials on the Beetle Project homepage: <https://evolution.berkeley.edu/evolibrary/teach/lessons/beetle-project-overview.php>) | AP Unit Connections:   * Unit 7 - Natural Selection   + Continuing Evolution   + Speciation |
| AP Science Practices:   * Visual Representations [2.A, 2.B] * Questions and Methods [3.C] * Representing and Describing Data [4.B] * Argumentation [6.B, 6.C] | |
| AP Biology Learning Objectives:   * EVO-3.A - Explain how evolution is an ongoing process in all living organisms. * EVO-3.D - Describe the conditions under which new species may arise. | AP Biology Essential Knowledge:   * EVO-3.A.1 Populations of organisms continue to evolve. * EVO-3.A.2 All species have evolved and continue to evolve—  1. Genomic changes over time. 2. Continuous change in the fossil record. 3. Evolution of resistance to antibiotics, pesticides, herbicides, or chemotherapy drugs. 4. Pathogens evolve and cause emergent diseases.  * EVO-3.D.1 Speciation may occur when two populations become reproductively isolated from each other. * EVO-3.D.2 The biological species concept provides a commonly used definition of species for sexually reproducing organisms. It states that species can be defined as a group capable of interbreeding and exchanging genetic information to produce viable, fertile offspring. |
| **Lesson 5: Population Differences & Hardy-Weinberg Equilibrium** (to access lesson, see AP materials on the Beetle Project homepage: <https://evolution.berkeley.edu/evolibrary/teach/lessons/beetle-project-overview.php>) | AP Unit Connections:   * Unit 7 - Natural Selection   + Population Genetics   + Hardy-Weinberg Equilibrium   + Speciation |
| AP Science Practices:   * Visual Representations [2.A, 2.B] * Representing and Describing Data [4.B] * Argumentation [6.A, 6.B, 6.C, 6.D, 6.E] | |
| AP Biology Learning Objectives:   * EVO-1.J - Describe the change in the genetic makeup of a population over time. * EVO-1.K - Describe the conditions under which allele and genotype frequencies will change in populations. * EVO-1.L - Explain the impacts on the population if any of the conditions of Hardy-Weinberg are not met. * EVO-3.E - Describe the rate of evolution and speciation under different ecological conditions. * EVO-3.F - Explain the processes and mechanisms that drive speciation. | AP Biology Essential Knowledge:   * EVO-1.J.1 Mutation results in genetic variation, which provides phenotypes on which natural selection acts. * EVO-1.K.1 Hardy-Weinberg is a model for describing and predicting allele frequencies in a nonevolving population. Conditions for a population or an allele to be in Hardy-Weinberg equilibrium are—(1) a large population size, (2) absence of migration, (3) no net mutations, (4) random mating, and (5) absence of selection. These conditions are seldom met, but they provide a valuable null hypothesis. * EVO-1.K.2 Allele frequencies in a population can be calculated from genotype frequencies. * EVO-1.L.1 Changes in allele frequencies provide evidence for the occurrence of evolution in a population. * EVO-1.L.2 Small populations are more susceptible to random environmental impact than large populations. * EVO-3.E.1 Punctuated equilibrium is when evolution occurs rapidly after a long period of stasis. Gradualism is when evolution occurs slowly over hundreds of thousands or millions of years. * EVO-3.E.2 Divergent evolution occurs when adaptation to new habitats results in phenotypic diversification. Speciation rates can be especially rapid during times of adaptive radiation as new habitats become available. * EVO-3.F.1 Speciation results in diversity of life forms. * EVO-3.F.2 Speciation may be sympatric or allopatric. * EVO-3.F.3 Various prezygotic and postzygotic mechanisms can maintain reproductive isolation and prevent gene flow between populations. |
| **Lesson 6: Populations Shifts and a Changing Climate** (to access lesson, see AP materials on the Beetle Project homepage: <https://evolution.berkeley.edu/evolibrary/teach/lessons/beetle-project-overview.php>) | AP Unit Connections:   * Unit 7 - Natural Selection   + Artificial Selection * Unit 8 - Ecology   + Disruptions to Ecosystems * Unit 3 - Cellular Energetics   + Fitness |
| AP Science Practices:   * Representing and Describing Data [4.A, 4.B] * Argumentation [6.C, 6.D, 6.E] | |
| AP Biology Learning Objectives:   * EVO-1.F - Explain how humans can affect diversity within a population. * EVO-1.G - Explain the relationship between changes in the environment and evolutionary changes in the population. * SYI-2.B - Describe human activities that lead to changes in ecosystem structure and/ or dynamics. * SYI-3.A - Explain the connection between variation in the number and types of molecules within cells to the ability of the organism to survive and/or reproduce in different environments. | AP Biology Essential Knowledge:   * EVO-1.F.1 Through artificial selection, humans affect variation in other species. * EVO-1.G.1 Convergent evolution occurs when similar selective pressures result in similar phenotypic adaptations in different populations or species. * SYI-2.B.1 The distribution of local and global ecosystems changes over time. * SYI-2.B.2 Human impact accelerates change at local and global levels—   1. The introduction of new diseases can devastate native species.   2. Habitat change can occur because of human activity. * SYI-3.A.1 Variation at the molecular level provides organisms with the ability to respond to a variety of environmental stimuli. * SYI-3.A.2 Variation in the number and types of molecules within cells provides organisms a greater ability to survive and/or reproduce in different environments. |

References:

Otto, Sonja B. et al (2008) Predator Diversity And Identity Drive Interaction Strength And Trophic Cascades In A Food Web. Ecology, 89(1), 2008, pp. 134–144

Wang, W. et al (2004) Role of plant heat-shock proteins and molecular chaperones in the abiotic stress response. Trends Plant Sci. May;9(5):244-52.

Rank, N.E. et al (2007) Phosphoglucose isomerase genotype affects running speed and heat shock protein expression after exposure to extreme temperatures in a montane willow beetle.

Journal of Experimental Biology 210: 750-764.

Rank, N.E. & Dahlhoff, E.P. (2002) Allele frequency shifts in response to climate change and physiological consequences of allozyme variation in a montane insect. Evolution 56, 2278–2289.

Hall et al. (2018) Climate Change in the Sierra Nevada: California’s Water Future. University of California, Los Angeles Center for Climate Science.