Unit 08: Evolution

Content Area: **Science**
Course(s): **AP Biology**
Time Period: **March**
Length: **4 weeks**
Status: **Published**

Transfer Skills

The concepts in Unit 8 build on foundational content from previous units as students discover natural selection, a mechanism of evolution—the theory that populations that are better adapted to their environment will survive and reproduce. Thus, the evolution of a species involves a change in its genetic makeup over time. In this unit, students study the evidence for and mechanisms of evolutionary change. Students also learn what happens when a species does not adapt to a changing or volatile environment and about the Hardy-Weinberg equilibrium as a model for describing and predicting allele frequencies in nonevolving populations. Students will learn to calculate and draw conclusions about the evolution, or lack thereof, of a population from data related to allele frequencies. Innate and learned behaviors in relationship to evolutionary fitness are also covered in this unit.

The principle of natural selection and its components appears throughout the course. It is important that students are precise in the language they use when writing about evolution, being careful to avoid writing statements that are Lamarckian. A common student error is using buzzwords such as “fitness” without proper explanation of the underlying concept. Students should recall the sources of genetic variation learned in the heredity unit in order to demonstrate the understanding that genetic variation is necessary for natural selection and describe its role in reproductive success. In their writing, students should be clear that while natural selection acts on individuals, it is populations that evolve. Another common error on the exam is that students do not clearly differentiate the types of reproductive isolating mechanisms that lead to speciation.

Enduring Understandings

Evolution is characterized by change in the genetic make-up of a population over time and is supported by multiple lines of evidence.

Organisms are linked by lines of descent from common ancestry.

Life continues to evolve within a changing environment.

Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Timing and coordination of biological mechanisms involved in growth, reproduction, and homeostasis depend on organisms responding to environmental cues.

Transmission of information results in changes within and between biological systems.

Essential Questions

What conditions in a population make it more or less likely to evolve?

Scientifically defend the theory of evolution.

How does species interaction encourage or slow changes in species?

How does diversity among and between species in a biological system affect the evolution of species within the system?

How do species interactions affect the survival of an ecosystem?

Content

Darwinś theory of evolution

Evidence for evolution

Natural selection

Population genetics and Hardy-Weinberg Law

Other mechanisms of evolution: genetic drift, gene flow, sexual selection

Speciation (allopatric vs. sympatric)

Cladograms

Learning Objectives

EVO-1.C Describe the causes of natural selection.
EVO-1.D Explain how natural selection affects populations.
EVO-1.E Describe the importance of phenotypic variation in a population.
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.
EVO-1.H Explain how random occurrences affect the genetic makeup of a population.
EVO-1.I Describe the role of random processes in the evolution of specific populations.
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 HardyWeinberg are not met.
EVO-1.M Describe the types of data that provide evidence for evolution.
EVO-1.N Explain how morphological, biochemical, and geological data provide evidence that organisms have changed over time.
EVO-2.B Describe the fundamental molecular and cellular features shared across all domains of life, which

provide evidence of common ancestry.
EVO-2.C Describe structural and functional evidence on cellular and molecular levels that provides evidence for the common ancestry of all eukaryotes.
EVO-3.A Explain how evolution is an ongoing process in all living organisms.
EVO-3.B Describe the types of evidence that can be used to infer an evolutionary relationship.
EVO-3.C Explain how a phylogenetic tree and/or cladogram can be used to infer evolutionary relatedness.
EVO-3.D Describe the conditions under which new species may arise.
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.
EVO-3.G Describe factors that lead to the extinction of a population.
EVO-3.H Explain how the risk of extinction is affected by changes in the environment.
EVO-3.I Explain species diversity in an ecosystem as a function of speciation and extinction rates.
EVO-3.J Explain how extinction can make new environments available for adaptive radiation.
SYI-3.D Explain how the genetic diversity of a species or population affects its ability to withstand environmental pressures.
ENE-3.D Explain how the behavioral and/or physiological response of an organism is related to changes in internal or external environment.
IST-5.A Explain how the behavioral responses of organisms affect their overall fitness and may contribute to the success of the population.
EVO-1.O Explain the interaction between the environment and random or preexisting variations in populations.

Standards

EVO-1.C.1 Natural selection is a major mechanism of evolution.
EVO-1.C.2 According to Darwin's theory of natural selection, competition for limited resources results in differential survival. Individuals with more favorable phenotypes are more likely to survive and produce more offspring, thus passing traits to subsequent generations.
EVO-1.D.1 Evolutionary fitness is measured by reproductive success.
EVO-1.D.2 Biotic and abiotic environments can be more or less stable/fluctuating, and this affects the rate and direction of evolution; different genetic variations can be selected in each generation.
EVO-1.E.1 Natural selection acts on phenotypic variations in populations.
EVO-1.E.2 Environments change and apply selective pressures to populations.
EVO-1.E.3 Some phenotypic variations significantly increase or decrease fitness of the organism in particular environments.
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.
EVO-1.H.1 Evolution is also driven by random occurrences—
  a. Mutation is a random process that contributes to evolution.
  b. Genetic drift is a nonselective process occurring in small populations—
    i. Bottlenecks.
    ii. Founder effect.
  c. Migration/gene flow can drive evolution.
EVO-1.I.1 Reduction of genetic variation within a given population can increase the differences between populations of the same species.
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-1.M.1 Evolution is supported by scientific evidence from many disciplines (geographical, geological, physical, biochemical, and mathematical data).
EVO-1.N.1 Molecular, morphological, and genetic evidence from extant and extinct organisms adds to our understanding of evolution—
a. Fossils can be dated by a variety of methods. These include:
i. The age of the rocks where a fossil is found
ii. The rate of decay of isotopes including carbon-14
iii. Geographical data b. Morphological homologies, including vestigial structures, represent features shared by common ancestry.
EVO-1.N.2 A comparison of DNA nucleotide sequences and/or protein amino acid sequences provides evidence for evolution and common ancestry.
EVO-2.B.1 Many fundamental molecular and cellular features and processes are conserved across organisms.
EVO-2.B.2 Structural and functional evidence supports the relatedness of organisms in all domains.
EVO-2.C.1 Structural evidence indicates common ancestry of all eukaryotes—
a. Membrane-bound organelles
b. Linear chromosomes
c. Genes that contain introns
EVO-3.A.1 Populations of organisms continue to evolve.
EVO-3.A.2 All species have evolved and continue to evolve—
a. Genomic changes over time.
b. Continuous change in the fossil record.
c. Evolution of resistance to antibiotics, pesticides, herbicides, or chemotherapy drugs.
d. Pathogens evolve and cause emergent diseases.
EVO-3.B.1 Phylogenetic trees and cladograms show evolutionary relationships among lineages—
a. Phylogenetic trees and cladograms both show relationships between lineages, but phylogenetic trees show the amount of change over time calibrated by fossils or a molecular clock.
b. Traits that are either gained or lost during evolution can be used to construct phylogenetic trees and cladograms—
i. Shared characters are present in more than one lineage.
ii. Shared, derived characters indicate common ancestry and are informative for the construction of phylogenetic trees and cladograms.
iii. The out-group represents the lineage that is least closely related to the remainder of the organisms in the phylogenetic tree or cladogram.
c. Molecular data typically provide more accurate and reliable evidence than morphological traits in the construction of phylogenetic trees or cladograms.
EVO-3.C.1 Phylogenetic trees and cladograms can be used to illustrate speciation that has occurred. The nodes on a tree represent the most recent common ancestor of any two groups or lineages.
EVO-3.C.2 Phylogenetic trees and cladograms can be constructed from morphological similarities of living or fossil species and from DNA and protein sequence similarities.
EVO-3.C.3 Phylogenetic trees and cladograms represent hypotheses and are constantly being revised, based on evidence.
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.
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.
EVO-3.G.1 Extinctions have occurred throughout Earth's history.
EVO-3.G.2 Extinction rates can be rapid during times of ecological stress.
EVO-3.H.1 Human activity can drive changes in ecosystems that cause extinctions.
EVO-3.I.1 The amount of diversity in an ecosystem can be determined by the rate of speciation and the rate of extinction.
EVO-3.J.1 Extinction provides newly available niches that can then be exploited by different species.
SYI-3.D.1 The level of variation in a population affects population dynamics—
a. Population ability to respond to changes in the environment is influenced by genetic diversity. Species and populations with little genetic diversity are at risk of decline or extinction.
b. Genetically diverse populations are more resilient to environmental perturbation because they are more likely to contain individuals who can withstand the environmental pressure.
c. Alleles that are adaptive in one environmental condition may be deleterious in another because of different selective pressures.
ENE-3.D.1 Organisms respond to changes in their environment through behavioral and physiological mechanisms.
X *No specific behavioral or physiological mechanism is required for teaching this concept.*
ENE-3.D.2 Organisms exchange information with one another in response to internal changes and external cues, which can change behavior.
IST-5.A.1 Individuals can act on information and communicate it to others. IST-5.A.2 Communication occurs through various mechanisms—
a. Organisms have a variety of signaling behaviors that produce changes in the behavior of other organisms and can result in differential reproductive success.
b. Animals use visual, audible, tactile, electrical, and chemical signals to indicate dominance, find food, establish territory, and ensure reproductive success.
IST-5.A.3 Responses to information and communication of information are vital to natural selection and evolution—
a. Natural selection favors innate and learned
b. Cooperative behavior tends to increase the fitness of the individual and the survival of the population.
X *The details of the various communications and community behavioral systems are beyond the scope of the course and the AP exam.*
EVO-1.O.1 An adaptation is a genetic variation that is favored by selection and is manifested as a trait that provides an advantage to an organism in a particular environment.
EVO-1.O.2 Mutations are random and are not directed by specific environmental pressures.

Resources

College Board AP Central: https://apcentral.collegeboard.org/courses/ap-biology/course

College Board AP Biology course and exam description manual: https://apcentral.collegeboard.org/pdf/ap-biology-course-and-exam-description-0.pdf

AP Biology Lab Manual:

https://apcentral.collegeboard.org/pdf/ap-biology-teacher-lab-manual-fall-2019.pdf?course=ap-biology

AP Biology Classroom Resources: https://apcentral.collegeboard.org/courses/ap-biology/classroom-resources?course=ap-biology

Khan Academy AP Biology: https://www.khanacademy.org/science/ap-biology

Bozeman Science AP Biology videos: http://www.bozemanscience.com/ap-biology

HHMI Biointeractive: https://www.biointeractive.org/