AP BIOLOGY

UNIT 7

Natural Selection

13–20%
AP EXAM WEIGHTING

~19–21
CLASS PERIODS

Remember to go to **AP Classroom** to assign students the online **Progress Checks** for this unit.

Whether assigned as homework or completed in class, the **Progress Checks** provide each student with immediate feedback related to this unit's topic and skills.

Progress Check 7

Multiple-choice: ~48 questions (2 parts)

Free-response: 2 questions

- Interpreting and Evaluating Experimental Results with Graphing
- Analyze Data

UNIT 7

13–20% AP EXAM WEIGHTING | **~19–21** CLASS PERIODS

Natural Selection

BIG IDEA 1
Evolution
- What conditions in a population make it more or less likely to evolve?
- Scientifically defend the theory of evolution.

BIG IDEA 4
Systems Interactions
- How does species interaction encourage or slow changes in species?

Developing Understanding

The concepts in Unit 7 build on foundational content from previous units as students discover natural selection—a mechanism of evolution. Natural selection is 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. The biological principles studied here and in previous units will carry over into Unit 8, which focuses on ecology.

Building Science Practices

1.B 1.C 2.A 2.B 2.D 3.B 3.D 4.B 5.A 6.C 6.E

By now, students should be accustomed to using visual models and representations to explain or illustrate biological processes. This unit provides students the opportunity to gain proficiency in describing a given model by communicating the biological meaning it represents. Mastery is demonstrated when students can create or use models such as cladograms and phylogenetic trees to analyze and discuss biological phenomena or solve new problems.

Hardy–Weinberg equations are used with respect to a specific gene. When teaching students how to use the equations, be careful to distinguish between allele and genotype frequencies. The Hardy–Weinberg principle clarifies the factors that alter allele frequency, but it does not imply that allele frequencies are static. This is an important understanding that students need in order to make predictions about a change in a population and to justify the reasoning for their predictions.

Preparing for the AP Exam

The principle of natural selection and its components appear 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 Unit 5 in order to demonstrate the understanding that genetic variation is necessary for natural selection and to 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. Students should be given opportunities to work with different models of isolation mechanisms to gain a better understanding.

UNIT AT A GLANCE

Topic	Suggested Skills	Class Periods ~19–21 CLASS PERIODS
7.1 Introduction to Natural Selection	2.A Describe characteristics of visual representations of biological concepts and processes.	
7.2 Natural Selection	1.B Explain biological concepts and processes.	
7.3 Artificial Selection	4.B Describe data from a table or graph, including: i. identifying specific data points ii. describing trends and patterns in the data iii. describing relationships between variables	
7.4 Population Genetics	3.B State the null hypothesis or predict the results of an experiment.	
7.5 Hardy–Weinberg Equilibrium	1.C Explain biological concepts and processes in applied contexts. 5.A Perform mathematical calculations, including: i. mathematical equations in the curriculum ii. means iii. rates iv. ratios v. percentages and percent changes	
7.6 Evidence of Evolution	4.B Describe data from a table or graph, including: i. identifying specific data points ii. describing trends and patterns in the data iii. describing relationships between variables	

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UNIT AT A GLANCE *(cont'd)*

Topic	Suggested Skills	Class Periods ~19–21 CLASS PERIODS
7.7 Common Ancestry	6.E Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.	
7.8 Continuing Evolution	3.D Propose a new investigation based on an evaluation of the experimental design or evidence.	
7.9 Phylogeny	2.D Represent relationships within biological models, including mathematical models, diagrams, flowcharts, and systems.	
7.10 Speciation	2.B Explain relationships between characteristics of biological models in both theoretical and applied contexts. 6.E Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.	
7.11 Variations in Populations	6.C Provide reasoning to justify a claim by connecting evidence to biological theories.	
7.12 Origins of Life on Earth	3.B State the null hypothesis or predict the results of an experiment.	
Go to **AP Classroom** to assign the **Progress Check** for Unit 7. Review the results in class to identify and address any student misunderstandings.		

SAMPLE INSTRUCTIONAL ACTIVITIES

The sample activities on this page are optional ways to incorporate varied instructional approaches in the teaching of this course. You do not need to use these activities or instructional approaches and are encouraged to adapt the activities to best support students in your classroom. The following examples were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 171 for more examples of activities and strategies.

Activity	Topic	Sample Activity
1	7.2	**Misconception Check** Using one of many available online resources, have students learn about the work of Peter and Rosemary Grant. Using data from the Grants' work, help students to build their graphing and statistical analysis skills. This is a good opportunity for students to practice explaining trends in data and supporting their claims with evidence. Through their work of supporting their claims, misconceptions will come up and can be corrected.
2	7.3	**Graph and Switch** Place students into groups of 3–5 and have them perform a brine shrimp lab, placing groups of brine shrimp eggs in petri dishes with various concentrations of salt in the water. They should monitor the number of eggs and swimming shrimp in the petri dishes at regular time intervals over a period of 2–3 days. Ask students to then calculate the hatching viability in each petri dish and graph their data. Chi-square can be used to analyze the null hypothesis. Have students then switch graphs with classmates to compare findings.
3	7.5	**Construct an Argument** Have students use one of the Rock Pocket Mice activities available online to learn the principles of the Hardy–Weinberg equilibrium and to calculate allele frequencies in a population. Once students have completed their calculations, have them construct an argument about whether and how the mice populations are evolving.
4	7.10	**Ask the Expert** Show students a cartoon image of an isolating mechanism that leads to speciation. Discuss with them what is happening in the cartoon and how it relates to speciation. Place students into groups and have them conduct research on other isolating mechanisms and draw their own cartoons to illustrate what they learned. Ask students to move around to other groups, sharing their cartoons and answering any questions from their classmates.

TOPIC 7.1
Introduction to Natural Selection

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of visual representations of biological concepts and processes.

AVAILABLE RESOURCES

- AP Central > Classroom Resources > Visualizing Information
- AP Central > Classroom Resources > Evolution and Change

Required Course Content

BIG IDEA 1

Evolution: The process of evolution drives the diversity and unity of life.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
7.1.A Describe the causes of natural selection.	**7.1.A.1** Natural selection is a major mechanism of evolution.
	7.1.A.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 on those favorable traits to subsequent generations.
7.1.B Explain how natural selection affects populations.	**7.1.B.1** Evolutionary fitness is measured by reproductive success.
	7.1.B.2 Biotic and abiotic environments can fluctuate, affecting the rate and direction of evolution. Different genetic variations can be selected in each generation.

SUGGESTED SKILL

Concept Explanation

1.B

Explain biological concepts and processes.

AVAILABLE RESOURCE

- AP Central > Classroom Resources > Evolution and Change

ILLUSTRATIVE EXAMPLES

EK 7.2.A.2

- Flowering time in relation to global climate change

EK 7.2.A.3

- Sickle cell anemia
- DDT resistance in insects

TOPIC 7.2
Natural Selection

Required Course Content

BIG IDEA 1

Evolution: The process of evolution drives the diversity and unity of life.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
7.2.A Describe the importance of phenotypic variation in a population.	**7.2.A.1** Natural selection acts on phenotypic variations in populations. **7.2.A.2** Environments change and apply selective pressures to populations. **7.2.A.3** Some phenotypic variations can increase or decrease the fitness of an organism in particular environments.
7.2.B Explain how variation in molecules within cells connects to the fitness of an organism.	**7.2.B.1** Variation in the number and types of molecules within cells can provide populations a greater ability to survive and reproduce in different environments.

TOPIC 7.3
Artificial Selection

Required Course Content

BIG IDEA 1

Evolution: The process of evolution drives the diversity and unity of life.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
7.3.A Explain how humans can affect diversity within a population.	7.3.A.1 Through artificial selection, humans affect variation in other species.

SUGGESTED SKILL

Representing and Describing Data

4.B

Describe data from a table or graph, including:

i. identifying specific data points

ii. describing trends and patterns in the data

iii. describing relationships between variables

AVAILABLE RESOURCES

- AP Central > Classroom Resources > Evolution and Change
- AP Central > AP Biology Lab Manual > Artificial Selection Lab

SUGGESTED SKILL

Questions and Methods

3.B

State the null hypothesis or predict the results of an experiment.

AVAILABLE RESOURCE

- AP Central > Classroom Resources > Evolution and Change

TOPIC 7.4
Population Genetics

Required Course Content

BIG IDEA 1

Evolution: The process of evolution drives the diversity and unity of life.

LEARNING OBJECTIVE

7.4.A

Explain how random occurrences affect the genetic makeup of a population.

ESSENTIAL KNOWLEDGE

7.4.A.1

Evolution is also driven by random occurrences.

i. Mutation is a random process that adds new genetic variation to a population.
ii. Genetic drift is a change in allele frequencies attributable to a nonselective process occurring in small populations.
iii. The bottleneck effect is a type of genetic drift that occurs when a population size is reduced to a small number of individuals for at least one generation.
iv. The founder effect is a type of genetic drift that occurs when a population is separated from other members of the population. The frequency of genes and traits will shift based on the genes in this new founder population.
v. Migration can result in gene flow (the addition or removal of alleles from a population).

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LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
7.4.B Describe the role of random processes in the evolution of specific populations.	**7.4.B.1** Random processes can lead to changes in allele frequencies in a population. i. Mutations result in genetic variation, which provides phenotypes on which natural selection acts. ii. Genetic drift can allow a small population to diverge from other populations of the same species. iii. Gene flow between two populations prevents them from diverging into separate species.
7.4.C Describe the change in the genetic makeup of a population over time.	**7.4.C.1** Changes in allele frequencies provide evidence for the occurrence of evolution in a population.

SUGGESTED SKILLS

Concept Explanation

1.C

Explain biological concepts and processes in applied contexts.

Statistical Tests and Data Analysis

5.A

Perform mathematical calculations, including:

i. mathematical equations in the curriculum
ii. means
iii. rates
iv. ratios
v. percentages and percent changes

AVAILABLE RESOURCES

- AP Central > Classroom Resources > Evolution and Change
- AP Central > AP Biology Lab Manual > Mathematical Modeling

ILLUSTRATIVE EXAMPLE

EK 7.5.A.2

- Graphic analysis of allele frequencies in a population

TOPIC 7.5
Hardy–Weinberg Equilibrium

Required Course Content

BIG IDEA 1

Evolution: The process of evolution drives the diversity and unity of life.

LEARNING OBJECTIVE

7.5.A

Describe the conditions under which allele and genotype frequencies will change in populations.

ESSENTIAL KNOWLEDGE

7.5.A.1

The Hardy–Weinberg Equilibrium is a model for describing and predicting allele frequencies in a non-evolving population. Conditions for a population or an allele to be in Hardy–Weinberg equilibrium are:

i. A large population size
ii. No migration
iii. No new mutations
iv. Random mating
v. No natural selection

These conditions are never met, but they provide a valuable null hypothesis.

7.5.A.2

Allele frequencies in a nonevolving population can be calculated from genotype frequencies.

RELEVANT EQUATIONS

Hardy–Weinberg Equation—

$$p^2 + 2pq + q^2 = 1$$

$$p + q = 1,$$

where:

p = frequency of allele 1 in the population

q = frequency of allele 2 in the population

TOPIC 7.6
Evidence of Evolution

Required Course Content

BIG IDEA 1

Evolution: The process of evolution drives the diversity and unity of life.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
7.6.A Describe the types of data that provide evidence for evolution.	**7.6.A.1** Evolution is supported by scientific evidence from many disciplines (geographical, geological, physical, biochemical, and mathematical data).
7.6.B Explain how morphological, biochemical, and geological data provide evidence that organisms have changed over time.	**7.6.B.1** Molecular, morphological, and genetic evidence from extant and extinct organisms adds to our understanding of evolution. i. Fossils can be dated by a variety of methods. These include 1) the age of the rocks where a fossil is found; 2) the rate of decay of isotopes including carbon-14; and 3) geographical data. ii. Morphological homologies, including vestigial structures, provide evidence of common ancestry. **7.6.B.2** A comparison of DNA nucleotide sequences and protein amino acid sequences provides evidence for evolution and common ancestry.

SUGGESTED SKILL

Representing and Describing Data

4.B

Describe data from a table or graph, including:

i. identifying specific data points

ii. describing trends and patterns in the data

iii. describing relationships between variables

AVAILABLE RESOURCE

- AP Central > Classroom Resources > Evolution and Change

SUGGESTED SKILL

Argumentation

6.E

Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.

AVAILABLE RESOURCE

- AP Central > Classroom Resources > Evolution and Change

TOPIC 7.7
Common Ancestry

Required Course Content

BIG IDEA 1

Evolution: The process of evolution drives the diversity and unity of life.

LEARNING OBJECTIVE

7.7.A

Describe structural and functional evidence on cellular and molecular levels that provides evidence for the common ancestry of all eukaryotes.

ESSENTIAL KNOWLEDGE

7.7.A.1

Structural and functional evidence indicates common ancestry of all eukaryotes. This evidence includes:

i. Membrane-bound organelles
ii. Linear chromosomes
iii. Genes that contain introns

TOPIC 7.8
Continuing Evolution

Required Course Content

BIG IDEA 1

Evolution: The process of evolution drives the diversity and unity of life.

LEARNING OBJECTIVE

7.8.A

Explain how evolution is an ongoing process in all living organisms.

ESSENTIAL KNOWLEDGE

7.8.A.1

All species have evolved and continue to evolve. Examples include:

i. Genomic changes over time
ii. Continuous change in the fossil record
iii. Evolution of resistance to antibiotics, pesticides, herbicides, or chemotherapy drugs
iv. Pathogens evolving and causing emergent diseases

SUGGESTED SKILL

Questions and Methods

3.D

Propose a new investigation based on an evaluation of the experimental design or evidence.

AVAILABLE RESOURCE

- AP Central > Classroom Resources > Evolution and Change

SUGGESTED SKILL

Visual Representations

2.D

Represent relationships within biological models, including mathematical models, diagrams, flowcharts, and systems.

AVAILABLE RESOURCE

- AP Central > Classroom Resources > Evolution and Change

TOPIC 7.9
Phylogeny

Required Course Content

BIG IDEA 1

Evolution: The process of evolution drives the diversity and unity of life.

LEARNING OBJECTIVE

7.9.A

Describe the types of evidence that can be used to infer an evolutionary relationship.

ESSENTIAL KNOWLEDGE

7.9.A.1

Phylogenetic trees and cladograms show hypothetical evolutionary relationships among lineages that can be tested.

7.9.A.2

Phylogenetic trees show the amount of change over time calibrated by fossils or a molecular clock, whereas cladograms do not show time scale or the evolutionary difference between groups.

7.9.A.3

Traits that are either gained or lost during evolution can be used to construct phylogenetic trees and cladograms. The out-group represents the lineage that is least closely related to the remainder of the organisms in the phylogenetic tree or cladogram.

i. Shared derived characters can be present in more than one lineage and indicate common ancestry. These are informative for the construction of phylogenetic trees and cladograms.

ii. Molecular data typically provide more accurate and reliable evidence than morphological traits in the construction of phylogenetic trees or cladograms.

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LEARNING OBJECTIVE

7.9.B

Explain how phylogenetic trees and cladograms can be used to infer evolutionary relatedness.

ESSENTIAL KNOWLEDGE

7.9.B.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.

7.9.B.2

Phylogenetic trees and cladograms can be constructed from morphological similarities of living or fossil species and from DNA and protein sequence similarities.

7.9.B.3

Phylogenetic trees and cladograms represent hypotheses that are constantly being revised based on evidence.

SUGGESTED SKILLS

Visual Representations

2.B

Explain relationships between characteristics of biological models in both theoretical and applied contexts.

Argumentation

6.E

Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.

AVAILABLE RESOURCE

- AP Central > Classroom Resources > Evolution and Change

ILLUSTRATIVE EXAMPLES

LO 7.10.C

- Hawaiian *Drosophila*
- Caribbean *Anolis*
- Apple maggot *Rhagoletis*

TOPIC 7.10
Speciation

Required Course Content

BIG IDEA 1

Evolution: The process of evolution drives the diversity and unity of life.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
7.10.A Describe the conditions under which new species may arise.	**7.10.A.1** Speciation occurs when two populations become reproductively isolated from each other. **7.10.A.2** The biological species concept provides a commonly used definition of a 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.
7.10.B Describe the rate of evolution and speciation under different ecological conditions.	**7.10.B.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. **7.10.B.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. **7.10.B.3** Convergent evolution occurs when similar selective pressures result in similar phenotypic adaptations in different populations or species.

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Natural Selection

LEARNING OBJECTIVE

7.10.C

Explain the processes and mechanisms that drive speciation.

ESSENTIAL KNOWLEDGE

7.10.C.1

Sympatric speciation occurs in populations with geographic overlap. Allopatric speciation occurs in populations that are geographically isolated.

7.10.C.2

Various pre-zygotic and post-zygotic mechanisms can maintain reproductive isolation and prevent gene flow between populations.

SUGGESTED SKILL

Argumentation

6.C

Provide reasoning to justify a claim by connecting evidence to biological theories.

AVAILABLE RESOURCE

- AP Central > Classroom Resources > Evolution and Change

ILLUSTRATIVE EXAMPLES

EK 7.11.A.1

- California condors
- Black-footed ferrets
- Prairie chickens
- Potato blight
- Corn rust
- Genetic diversity and selective pressures
- Antibiotic resistance in bacteria (not all individuals in a diverse population are susceptible to a disease outbreak)

TOPIC 7.11
Variations in Populations

Required Course Content

BIG IDEA 4

Systems Interactions: Biological systems interact, and these systems and their interactions exhibit complex properties.

LEARNING OBJECTIVE

7.11.A

Explain how the genetic diversity of a species or population affects its ability to withstand environmental pressures.

ESSENTIAL KNOWLEDGE

7.11.A.1

The level of variation in a population affects population dynamics.

i. The ability of a population 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.

ii. Genetically diverse populations are more resilient to environmental perturbation because they are more likely to contain individuals that can withstand the environmental pressure.

iii. Alleles that are adaptive in one environmental condition may be deleterious in another because of different selective pressures.

TOPIC 7.12
Origins of Life on Earth

SUGGESTED SKILL

Questions and Methods

3.B

State the null hypothesis or predict the results of an experiment.

AVAILABLE RESOURCE

- AP Central > Classroom Resources > Evolution and Change

Required Course Content

BIG IDEA 4

Systems Interactions: Biological systems interact, and these systems and their interactions exhibit complex properties.

LEARNING OBJECTIVE

7.12.A

Describe the scientific evidence that supports models of the origin of life on Earth.

ESSENTIAL KNOWLEDGE

7.12.A.1

The origin of life on Earth is supported by scientific evidence.

i. Geological evidence reinforces models of the origin of life on Earth.

ii. Earth formed approximately 4.6 billion years ago (bya). The environment was too hostile for life until about 3.9 bya, and the earliest fossil evidence for life dates to 3.5 bya. Taken together, this evidence provides a plausible range of dates for the origin of life.

7.12.A.2

The RNA world hypothesis proposes that RNA could have been the earliest genetic material. There are three assumptions:

i. At some point in time, genetic continuity was assured by the replication of RNA.

ii. Base-pairing is necessary for replication.

iii. Genetically encoded proteins were not involved as catalysts.