AP BIOLOGY

UNIT 8

Ecology

10–15%
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 8

Multiple-choice: ~24 questions
Free-response: 2 questions

- Interpreting and Evaluating Experimental Results with Graphing
- Scientific Investigation

UNIT 8

10–15% AP EXAM WEIGHTING | **~19–21** CLASS PERIODS

Ecology

BIG IDEA 1
Evolution
- How does diversity among and between species in a biological system affect the evolution of species within the system?

BIG IDEA 2
Energetics
- How does the acquisition of energy relate to the health of a biological system?
- How do communities and ecosystems change, for better or worse, due to biological disruption?

BIG IDEA 3
Information Storage and Transmission
- How does a disruption of a biological system affect genetic information storage and transmission?

BIG IDEA 4
Systems Interactions
- How do organisms use energy or conserve energy to respond to environmental stimuli?

Developing Understanding

The content in Unit 8 brings together student learning from all previous units as it shows how a system's interactions are directly related to the system's available energy and its ability to evolve and respond to changes in its environment. When highly complex living systems interact, communities and ecosystems change based on those interactions. The more biodiversity present in a system, the more likely that system is to maintain its health and success in the face of disruption. Energy flows through systems; the rate of flow determines the success of the species within the systems. By this point in the course, a student should be able to accurately determine what happens within biological systems when disruptions occur.

Building Science Practices

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

Designing research to test biological systems is at the heart of this course. Students need to understand and evaluate experimental plans designed and conducted by others. They should be able to identify the experimental methods, measurements, and data collection methods used and articulate the hypothesis. They should also be able to plan and implement data collection strategies that test biological systems in order to understand and develop solutions to problems within biological systems. An understanding of how to design experiments that test biological systems is demonstrated by the ability to interpret the results of an experiment in relation to a hypothesis. Sometimes, experimental procedures will need to be modified in order to collect appropriate data; be sure students understand how to modify a procedure to collect data and test a hypothesis.

Preparing for the AP Exam

On past exams, when students have been asked to construct a food web from a data table, they have struggled with inferring the correct relationships between the organisms and with translating how a relationship between two organisms resulted in their placement on the food web. Ensure student understanding of the relationship between organisms and their environment by having them construct and analyze food chains, food webs, and trophic diagrams. Another common error is the incorrect placement of the arrows that indicate energy flow. Students should use their knowledge from Unit 3 to explain how energy and carbon are transferred through an ecosystem so that they can predict how changes in the environment can impact an ecosystem, both positively and negatively.

Throughout the course, students should have practiced providing support for their claims about biological systems. Making connections to ecology are fundamental and will help students to build this skill.

UNIT AT A GLANCE

Topic	Suggested Skill	Class Periods ~19–21 CLASS PERIODS
8.1 Responses to the Environment	3.C Identify experimental procedures that align with the question, including: i. identifying dependent and independent variables ii. identifying appropriate controls iii. justifying appropriate controls	
8.2 Energy Flow Through Ecosystems	6.D Explain the relationship between experimental results and larger biological concepts, processes, or theories.	
8.3 Population Ecology	4.A Construct a graph to represent the data, including: x-y graphs (bar, histogram, line, log scale, dual y), scatter plot, box and whisker plot, and pie chart. The graph should include the following components: i. type of graph appropriate for the data ii. axis labeling, including appropriate units and legend iii. scaling iv. accurately plotted data (including error bars when appropriate) v. trend line (when appropriate)	
8.4 Effect of Density on Populations	5.A Perform mathematical calculations, including: i. mathematical equations in the curriculum ii. means iii. rates iv. ratios v. percentages and percent changes	
8.5 Community Ecology	5.B Use confidence intervals and error bars to estimate whether sample means are statistically different.	
8.6 Biodiversity	6.E Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.	
8.7 Disruptions in Ecosystems	5.D Use data to evaluate a hypothesis or prediction, including rejecting or failing to reject the null hypothesis.	
Go to **AP Classroom** to assign the **Progress Check** for Unit 8. 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	8.1	**Construct an Argument** Have students perform an animal behavior lab using pill bugs. They should use choice chambers to study the responses of pill bugs to the levels of moisture in the given chambers, creating different environments on either side of the choice chamber and placing the same number of pill bugs on both sides. Have them count the number of pill bugs on both sides of the choice chamber at regular intervals for a defined period of time. Chi-square can be used to evaluate the null hypothesis. Once a hypothesis is evaluated, students can construct arguments in support of ways to keep pill bugs out of places where they are unwanted.
2	8.5	**Graph and Switch** Ask students to read about the moose and wolves of Isle Royale to obtain background information on the two organisms. Then have them download a data spreadsheet from the internet and use it to graph data about the two populations. They should use their graph to make and justify predictions about how the two populations can change relative to each other.
3	8.6	**Index Card Summaries/Questions** To facilitate the hula hoop diversity activity, divide students into groups and give each group a hula hoop and a magnifying glass. Ask students to place their hula hoops in a grassy, woodsy, or garden area and make observations and collect a variety of data about the plants, animals, and abiotic factors inside the hula hoop area. They should record their observations, collected data, and any questions on index cards. Once students have collected all their data and made their observations, have them predict what will happen to organisms in an ecosystem when its biodiversity changes. As a class, discuss the relationship between biodiversity and species endangerment, and predict what changes might occur in an ecosystem when a biotic or abiotic factor changes.

SUGGESTED SKILL

Questions and Methods

3.C

Identify experimental procedures that align with the question, including:

i. identifying dependent and independent variables

ii. identifying appropriate controls

iii. justifying appropriate controls

AVAILABLE RESOURCES

- AP Central > AP Biology Lab Manual > Transpiration Lab
- AP Central > AP Biology Lab Manual > Fruit Fly Behavior Lab
- AP Central > Classroom Resources > Visualizing Information
- AP Central > Classroom Resources > Quantitative Skills in the AP Sciences (2018)

ILLUSTRATIVE EXAMPLES

EK 8.1.A.1

- Photoperiodism and phototropism in plants
- Taxis and kinesis in animals
- Nocturnal and diurnal activity

EK 8.1.A.2

- Fight-or-flight response
- Predator warnings
- Plant responses to herbivory

EK 8.1.B.1

- Territorial marking in mammals
- Coloration in flowering plants and animals
- Bird songs
- Pack behaviors in animals
- Predatory warnings

TOPIC 8.1
Responses to the Environment

Required Course Content

BIG IDEA 2

Energetics: Biological systems use energy and molecular building blocks to grow, reproduce, and maintain dynamic homeostasis.

LEARNING OBJECTIVE

8.1.A

Explain how the behavioral and physiological response of an organism is related to changes in internal or external environment.

ESSENTIAL KNOWLEDGE

8.1.A.1

Organisms respond to changes in their environment through behavioral and physiological mechanisms.

EXCLUSION STATEMENT—*Knowledge of specific behavioral or physiological mechanisms is beyond the scope of the AP Exam.*

8.1.A.2

Organisms exchange information with one another in response to internal changes and external cues, which can change behavior.

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BIG IDEA 3

Information Storage and Transmission: Living systems store, retrieve, transmit, and respond to information essential to life processes.

LEARNING OBJECTIVE

8.1.B

Explain how the behavioral responses of organisms affect their overall fitness and may contribute to the success of a population.

ESSENTIAL KNOWLEDGE

8.1.B.1

Organisms communicate through various mechanisms (visual, audible, tactile, electrical, and/or chemical signals).

i. Organisms have a variety of signaling behaviors that produce changes in the behavior of other organisms and can result in differential reproductive success.

ii. Animals use signals to indicate dominance, find food, establish territory, and ensure reproductive success.

EXCLUSION STATEMENT—*Knowledge of specific mechanisms of communication is beyond the scope of the AP Exam.*

8.1.B.2

Responses to information and communication of information are vital to natural selection and evolution.

i. Fitness favors innate and learned behaviors that increase survival and reproductive success.

ii. Cooperative behavior tends to increase the fitness of the individual and the survival of the population.

EXCLUSION STATEMENT—*The details of the various communications and community behavioral systems are beyond the scope of the AP Exam.*

ILLUSTRATIVE EXAMPLES

EK 8.1.B.2.i

- Parent and offspring interactions
- Courtship and mating behaviors
- Foraging by bees and other animals

EK 8.1.B.2.ii

- Pack behavior in animals
- Herd, flock, and schooling behavior in animals
- Predator warnings
- Colony and swarming behavior in insects
- Kin selection

SUGGESTED SKILL

Argumentation

6.D

Explain the relationship between experimental results and larger biological concepts, processes, or theories.

AVAILABLE RESOURCES

- AP Central > AP Biology Lab Manual > Energy Dynamics Lab
- AP Central > Classroom Resources > Visualizing Information

ILLUSTRATIVE EXAMPLES

LO 8.2.A

- Seasonal reproduction in animals and plants
- Life-history strategy (biennial plants, reproductive diapause)

EK 8.2.C.1

- Food chains/webs
- Trophic pyramids/ diagrams

TOPIC 8.2
Energy Flow Through Ecosystems

Required Course Content

BIG IDEA 2

Energetics: Biological systems use energy and molecular building blocks to grow, reproduce, and maintain dynamic homeostasis.

LEARNING OBJECTIVE

8.2.A

Describe the strategies organisms use to acquire and use energy.

ESSENTIAL KNOWLEDGE

8.2.A.1

Organisms use energy to organize, grow, reproduce, and maintain homeostasis.

i. Organisms use different strategies to regulate body temperature and metabolism. Endotherms use thermal energy generated by metabolism to maintain homeostatic body temperatures. Ectotherms lack efficient internal mechanisms for maintaining body temperature, although they may regulate their temperature behaviorally by moving into the sun or shade or by aggregating with other individuals.

ii. A net gain in energy results in energy storage, the growth of an organism, and increased reproductive output.

iii. A net loss of energy results in loss of mass, a decrease in reproductive output, and, eventually, the death of an organism.

8.2.A.2

Different organisms use various reproductive strategies in response to energy availability. Some organisms alternate between asexual and sexual reproduction in response to energy availability.

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LEARNING OBJECTIVE

8.2.B

Explain how energy flows and matter cycles through trophic levels.

ESSENTIAL KNOWLEDGE

8.2.B.1

Ecological levels of organization include populations, communities, ecosystems, and biomes.

8.2.B.2

Energy flows through ecosystems, while matter and nutrients cycle between the environment and organisms via biogeochemical cycles. The cycles are essential for life, and each cycle demonstrates the conservation of matter. The cycles are interdependent.

8.2.B.3

Biogeochemical cycles include abiotic and biotic reservoirs, as well as processes that cycle matter between reservoirs.

8.2.B.4

The hydrologic (water) cycle involves water movement and storage within the hydrosphere. Reservoirs include oceans, surface water, the atmosphere, and living organisms. Processes include evaporation, condensation, precipitation, and transpiration.

8.2.B.5

The carbon cycle involves recycling carbon atoms through Earth's biosphere into organisms as carbohydrates and back into the atmosphere as carbon dioxide (CO_2). At the highest levels of organization, the carbon cycle can be simplified into four parts: photosynthesis, cellular respiration, decomposition, and combustion.

8.2.B.6

The nitrogen cycle involves several steps, including nitrogen fixation, assimilation, ammonification, nitrification, and denitrification. These steps are performed by microorganisms in the soil. The largest reservoir of nitrogen is the atmosphere. In nitrogen fixation, nitrogen gas (N_2) is fixed into ammonia (NH_3), which ionizes to ammonium (NH_4^+) by acquiring hydrogen ions from the soil solution.

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LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
8.2.B Explain how energy flows and matter cycles through trophic levels.	8.2.B.7 The phosphorus cycle involves weathering rocks releasing phosphate $\left(PO_4^{3-}\right)$ into soil and groundwater. Producers take in phosphate, which is incorporated into biological molecules; consumers eat producers, transferring phosphate to animals. Phosphorus returns to the soil via decomposition of biomass, or excretion. Phosphate can also be incorporated back into the environment via decomposition of decaying organic matter.
8.2.C Explain how changes in energy availability affect populations, communities, and ecosystems.	8.2.C.1 Changes in energy availability can result in changes in population size. 8.2.C.2 Changes in energy availability can result in disruptions to an ecosystem. i. A change in energy resources such as sunlight can affect the number and size of the trophic levels. Trophic levels include producers; primary, secondary, tertiary, and quaternary consumers; and decomposers. ii. A change in the biomass or number of producers in a given geographic area can affect the number and size of other trophic levels.
8.2.D Explain how the activities of autotrophs and heterotrophs enable the flow of energy within an ecosystem.	8.2.D.1 Autotrophs capture energy from physical or chemical sources in the environment. i. Photosynthetic organisms capture energy present in sunlight contributing to primary productivity. ii. Chemosynthetic organisms capture energy from small inorganic molecules present in their environment, which can occur in the absence of oxygen. 8.2.D.2 Heterotrophs, which include carnivores, herbivores, omnivores, decomposers, and scavengers, metabolize carbohydrates, lipids, and proteins as sources of energy. Heterotrophs capture the energy present in carbon compounds by consuming organic matter derived from autotrophs incorporating matter into their tissues.

TOPIC 8.3
Population Ecology

Required Course Content

BIG IDEA 3

Information Storage and Transmission: Living systems store, retrieve, transmit, and respond to information essential to life processes.

LEARNING OBJECTIVE

8.3.A

Describe factors that influence growth dynamics of populations.

ESSENTIAL KNOWLEDGE

8.3.A.1

Populations comprise individual organisms of the same species that interact with one another and with the environment in complex ways.

8.3.A.2

Many adaptations in organisms are related to obtaining and using energy and matter in a particular environment.

i. Population growth dynamics depend on birth rate, death rate, and population size.

RELEVANT EQUATION

Population Growth—

$$\frac{dN}{dt} = B - D$$

where

dt = chage in time

B = birth rate

D = death rate

N = population size

dN = change in population size

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SUGGESTED SKILL

Representing and Describing Data

4.A

Construct a graph to represent the data, including: x-y graphs (bar, histogram, line, log scale, dual y), scatter plot, box and whisker plot, and pie chart. The graph should include the following components:

i. type of graph appropriate for the data

ii. axis labeling, including appropriate units and legend

iii. scaling

iv. accurately plotted data (including error bars when appropriate)

v. trend line (when appropriate)

AVAILABLE RESOURCE

- AP Central > Classroom Resources > Quantitative Skills in the AP Sciences (2018)

LEARNING OBJECTIVE

8.3.A

Describe factors that influence growth dynamics of populations.

ESSENTIAL KNOWLEDGE

ii. Reproduction without constraints results in the exponential growth of a population.

RELEVANT EQUATION

Exponential Growth—

$$\frac{dN}{dt} = r_{max}N$$

where

dt = change in time

N = population size

dN = change in population size

r_{max} = maximum per capita growth rate of population

TOPIC 8.4
Effect of Density on Populations

Required Course Content

BIG IDEA 4

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

LEARNING OBJECTIVE

8.4.A

Explain how the density of a population affects and is determined by resource availability in the environment.

ESSENTIAL KNOWLEDGE

8.4.A.1

Carrying capacity is the sustainable abundance of a species that can be supported by the ecosystem's total available resources.

8.4.A.2

As limits to growth attributable to density-dependent and density-independent factors are imposed, a logistic growth model typically ensues.

RELEVANT EQUATION

Logistical Growth—

$$\frac{dN}{dt} = r_{max} N \left(\frac{K - N}{K} \right)$$

where

dt = change in time

N = population size

dN = change in population size

r_{max} = maximum per capita growth rate of population

K = carrying capacity

SUGGESTED SKILL

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

SUGGESTED SKILL

Statistical Tests and Data Analysis

5.B
Use confidence intervals and error bars to estimate whether sample means are statistically different.

TOPIC 8.5
Community Ecology

Required Course Content

BIG IDEA 2

Energetics: Biological systems use energy and molecular building blocks to grow, reproduce, and maintain dynamic homeostasis.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
8.5.A Describe the structure of a community according to its species composition and diversity.	**8.5.A.1** The structure of a community is measured and described in terms of species composition and species diversity.
	RELEVANT EQUATION Simpson's Diversity Index— $\text{Diversity Index} = 1 - \sum\left(\frac{n}{N}\right)^2$ where n = total number of organisms of a particular species; N = total number of organisms of all species
8.5.B Explain how interactions within and among populations influence community structure.	**8.5.B.1** Communities are groups of interacting populations of different species that change over time based on the interactions between those populations.
	8.5.B.2 Interactions among populations determine how they access energy and matter within a community.

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LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
8.5.B Explain how interactions within and among populations influence community structure.	**8.5.B.3** Relationships among interacting populations can be characterized by positive and negative effects and can be modeled. Examples include predator/prey interactions, cooperation, trophic cascades, and niche partitioning. **8.5.B.4** Competition, predation, and symbioses, including parasitism, mutualism, and commensalism, can drive population dynamics.

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.

TOPIC 8.6
Biodiversity

Required Course Content

BIG IDEA 4

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

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
8.6.A Describe the relationship between ecosystem diversity and its resilience to changes in the environment.	8.6.A.1 Natural and artificial ecosystems with fewer component parts, and with little diversity among the parts, are often less resilient to changes in the environment. 8.6.A.2 Keystone species, producers, and essential abiotic and biotic factors contribute to maintaining the diversity of an ecosystem.
8.6.B Explain how the addition or removal of any component of an ecosystem will affect its overall short-term and long-term structure.	8.6.B.1 The effects of keystone species on the ecosystem are disproportionate relative to their abundance in the ecosystem. When they are removed from the ecosystem, it often collapses.

TOPIC 8.7
Disruptions in Ecosystems

Required Course Content

BIG IDEA 1

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

LEARNING OBJECTIVE

8.7.A

Explain the interaction between the environment and random or preexisting variations in populations.

ESSENTIAL KNOWLEDGE

8.7.A.1

An adaptation is a genetic variation that is favored by selection and manifests as a trait that provides an advantage to an organism in a particular environment.

8.7.A.2

Heterozygote advantage is when the heterozygous genotype has a higher relative fitness than either the homozygous dominant or homozygous recessive genotype.

8.7.A.3

Mutations are not directed by specific environmental pressures.

BIG IDEA 4

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

LEARNING OBJECTIVE

8.7.B

Explain how invasive species affect ecosystem dynamics.

ESSENTIAL KNOWLEDGE

8.7.B.1

The intentional or unintentional introduction of an invasive species can allow the species to exploit a new niche free of predators or competitors or to outcompete native species for resources.

SUGGESTED SKILL

Statistical Tests and Data Analysis

5.D

Use data to evaluate a hypothesis or prediction, including rejecting or failing to reject the null hypothesis.

ILLUSTRATIVE EXAMPLES

EK 8.7.B.1
- Kudzu
- Zebra mussels

EK 8.7.C.1
- Dutch elm disease
- Potato blight

EK 8.7.D.1
- Global climate change
- Logging
- Urbanization
- Monocropping
- El Nino
- Continental drift
- Meteor impact on dinosaurs

Ecology

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
8.7.C Describe human activities that lead to changes in ecosystem structure and dynamics.	**8.7.C.1** Human impact accelerates changes at local and global levels. These activities can drive changes in ecosystems, such as the following, that cause extinctions to occur: i. Biomagnification ii. Eutrophication
8.7.D Explain how geological and meteorological activity leads to changes in ecosystem structure and dynamics.	**8.7.D.1** Geological and meteorological events affect habitat change and ecosystem distribution. Biogeographical studies illustrate these changes.