AP BIOLOGY

UNIT 8

Ecology

10–15%
AP EXAM WEIGHTING

~18–21
CLASS PERIODS

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

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

Personal Progress Check 8

Multiple-choice: ~20 questions
Free-response: 2 questions

- Interpreting and Evaluating Experimental Results with Graphing
- Scientific Investigation

UNIT 8

10–15% AP EXAM WEIGHTING | **~18–21** CLASS PERIODS

Ecology

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

BIG IDEA 2
Energetics ENE
- 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 IST
- How does a disruption of a biological system affect genetic information storage and transmission?

BIG IDEA 4
Systems Interactions SYI
- How do species interactions affect the survival of an ecosystem?

Developing Understanding

As a culmination of this course, Unit 8 brings together all other units to show 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 will 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 curriculum, a student should be able to accurately determine what happens within biological systems when disruptions occur.

Building Science Practices

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

Designing research to test biological systems is at the heart of this course. Students should be able 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; students should understand how to modify a procedure to collect data and test a hypothesis.

Preparing for the AP Exam

Students should demonstrate understanding of the relationship between organisms and their environment by constructing and analyzing food chains and food webs and analyzing trophic diagrams. 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. 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 practice providing support for their claims about biological systems. Connections to ecology throughout the course are fundamental and will help students to build this skill.

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods ~18–21 CLASS PERIODS
ENE-3, IST-5	**8.1 Responses to the Environment**	3.C.a Identify experimental procedures that are aligned to the question, including identifying dependent and independent variables.	
ENE-1	**8.2 Energy Flow Through Ecosystems**	6.D Explain the relationship between experimental results and larger biological concepts, processes, or theories.	
SYI-1	**8.3 Population Ecology**	4.A Construct a graph, plot, or chart.	
	8.4 Effect of Density of Populations	5.A.c Perform mathematical calculations, including rates.	
ENE-4	**8.5 Community Ecology**	5.B Use confidence intervals and/or error bars (both determined using standard errors) to determine whether sample means are statistically different.	
SYI-3	**8.6 Biodiversity**	6.E.c Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on data.	
EVO-1, SYI-2	**8.7 Disruptions to Ecosystems**	5.D.a Use data to evaluate a hypothesis (or prediction), including rejecting or failing to reject the null hypothesis. 5.D.b Use data to evaluate a hypothesis (or prediction), including supporting or refuting the alternative hypothesis.	
	Go to **AP Classroom** to assign the **Personal 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 intended to give you ideas of ways to incorporate varied instructional approaches in the teaching of this course. You do not need to use these activities or approaches and are free to alter or edit them in any way you choose. 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	**Error Analysis** Students can perform an animal behavior lab using pill bugs. They can use choice chambers to study the responses of pill bugs to environmental stimuli. Create different environments on either side of the choice chamber. Place the same number of pill bugs on both sides of the choice chamber. 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 analyze the null hypothesis.
2	8.5	**Graph and Switch** Students can read about the moose and wolves of Isle Royale to obtain background information on the two organisms. They can download a data spreadsheet and graph data about the two populations from the Internet. They can 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** Students can perform the "hula hoop diversity" activity. Divide students into groups, and give each group a hula hoop and a magnifying glass. Students should place their hula hoop in a grassy/woodsy area or garden and then make observations and collect a variety of data from their sampling area about the plants, animals, and abiotic factors inside the hula hoop. At the conclusion of the activity, have students predict what will happen to organisms in an ecosystem when its biodiversity changes, discuss the relationship between biodiversity and species endangerment, and predict what changes might occur in an ecosystem when a biotic or abiotic factor changes.

Unit Planning Notes

Use the space below to plan your approach to the unit. Consider how you want to pace your course and your methods of instruction and assessment.

SUGGESTED SKILL

Questions and Methods

3.C.a

Identify experimental procedures that are aligned to the question, including identifying dependent and independent variables.

AVAILABLE RESOURCES

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

ILLUSTRATIVE EXAMPLES

ENE-3.D.1

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

ENE-3.D.2

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

IST-5.A.2.a

- Territorial marking in mammals
- Coloration in flowers

IST-5.A.2.b

- Bird songs
- Pack behavior in animals
- Predator warnings
- Coloration

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TOPIC 8.1
Responses to the Environment

Required Course Content

ENDURING UNDERSTANDING

ENE-3

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

LEARNING OBJECTIVE

ENE-3.D

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

ESSENTIAL KNOWLEDGE

ENE-3.D.1

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

X EXCLUSION STATEMENT—*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.

ENDURING UNDERSTANDING

IST-5

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

LEARNING OBJECTIVE

IST-5.A

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

ESSENTIAL KNOWLEDGE

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 behaviors that increase survival and reproductive fitness.
b. 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 course and the AP Exam.*

ILLUSTRATIVE EXAMPLES

IST-5.A.3.a

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

IST-5.A.3.b

- Pack behavior in animals
- Herd, flock, and schooling behavior in animals
- Predator warning
- 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 Biology Lab Manual > **Energy Dynamics Lab**
- Classroom Resources > **Visualizing Information**

ILLUSTRATIVE EXAMPLES

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

ENE-1.N.1

- Food chains/webs
- Trophic pyramids/ diagrams

TOPIC 8.2
Energy Flow Through Ecosystems

Required Course Content

ENDURING UNDERSTANDING

ENE-1

The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.

LEARNING OBJECTIVE

ENE-1.M

Describe the strategies organisms use to acquire and use energy.

ESSENTIAL KNOWLEDGE

ENE-1.M.1

Organisms use energy to maintain organization, grow, and reproduce—

a. Organisms use different strategies to regulate body temperature and metabolism.
   i. Endotherms use thermal energy generated by metabolism to maintain homeostatic body temperatures.
   ii. Ectotherms lack efficient internal mechanisms for maintaining body temperature, though they may regulate their temperature behaviorally by moving into the sun or shade or by aggregating with other individuals.
b. Different organisms use various reproductive strategies in response to energy availability.
c. There is a relationship between metabolic rate per unit body mass and the size of multicellular organisms—generally, the smaller the organism, the higher the metabolic rate.
d. A net gain in energy results in energy storage or the growth of an organism.
e. A net loss of energy results in loss of mass and, ultimately, the death of an organism.

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LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ENE-1.N Explain how changes in energy availability affect populations and ecosystems.	**ENE-1.N.1** Changes in energy availability can result in changes in population size. **ENE.1.N.2** Changes in energy availability can result in disruptions to an ecosystem— a. A change in energy resources such as sunlight can affect the number and size of the trophic levels. b. A change in the producer level can affect the number and size of other trophic levels.
ENE-1.O Explain how the activities of autotrophs and heterotrophs enable the flow of energy within an ecosystem.	**ENE-1.O.1** Autotrophs capture energy from physical or chemical sources in the environment— a. Photosynthetic organisms capture energy present in sunlight. b. Chemosynthetic organisms capture energy from small inorganic molecules present in their environment, and this process can occur in the absence of oxygen. **ENE-1. O.2** Heterotrophs capture energy present in carbon compounds produced by other organisms. a. Heterotrophs may metabolize carbohydrates, lipids, and proteins as sources of energy by hydrolysis.

SUGGESTED SKILL

Representing and Describing Data

4.A

Construct a graph, plot, or chart.

AVAILABLE RESOURCES

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

TOPIC 8.3
Population Ecology

Required Course Content

ENDURING UNDERSTANDING

SYI-1

Living systems are organized in a hierarchy of structural levels that interact.

LEARNING OBJECTIVE

SYI-1.G

Describe factors that influence growth dynamics of populations.

ESSENTIAL KNOWLEDGE

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.

RELEVANT EQUATION

Population Growth—

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

where:

dt = chage in time

B = birth rate

D = death rate

N = population size

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

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LEARNING OBJECTIVE

SYI-1.G

Describe factors that influence growth dynamics of populations.

ESSENTIAL KNOWLEDGE

RELEVANT EQUATION

Exponential Growth—

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

where:

dt = change in time

N = population size

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

SUGGESTED SKILL

Statistical Tests and Data Analysis

5.A.c

Perform mathematical calculations, including rates.

TOPIC 8.4
Effect of Density of Populations

Required Course Content

ENDURING UNDERSTANDING

SYI-1

Living systems are organized in a hierarchy of structural levels that interact.

LEARNING OBJECTIVE

SYI-1.H

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

ESSENTIAL KNOWLEDGE

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.

RELEVANT EQUATION

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

where:

dt = change in time

N = population size

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

K = carrying capacity

TOPIC 8.5
Community Ecology

SUGGESTED SKILL

Statistical Tests and Data Analysis

5.B

Use confidence intervals and/or error bars (both determined using standard errors) to determine whether sample means are statistically different.

Required Course Content

ENDURING UNDERSTANDING

ENE-4

Communities and ecosystems change on the basis of interactions among populations and disruptions to the environment.

LEARNING OBJECTIVE

ENE-4.A

Describe the structure of a community according to its species composition and diversity.

ESSENTIAL KNOWLEDGE

ENE-4.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—

$$\text{Diversity Index} = 1 - \Sigma\left(\frac{n}{N}\right)^2$$

n = the total number of organisms of a particular species

N = total number of organisms of all species

ENE-4.B

Explain how interactions within and among populations influence community structure.

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.

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LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ENE-4.B Explain how interactions within and among populations influence community structure.	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.
ENE-4.C Explain how community structure is related to energy availability in the environment.	ENE-4.C.1 Cooperation or coordination between organisms, populations, and species can result in enhanced movement of, or access to, matter and energy.

TOPIC 8.6
Biodiversity

SUGGESTED SKILL

Argumentation

6.E.c

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

Required Course Content

ENDURING UNDERSTANDING

SYI-3

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

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
SYI-3.F Describe the relationship between ecosystem diversity and its resilience to changes in the environment.	SYI-3.F.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. SYI-3.F.2 Keystone species, producers, and essential abiotic and biotic factors contribute to maintaining the diversity of an ecosystem.
SYI-3.G Explain how the addition or removal of any component of an ecosystem will affect its overall short-term and long-term structure.	SYI-3.G.1 The diversity of species within an ecosystem may influence the organization of the ecosystem. SYI-3.G.2 The effects of keystone species on the ecosystem are disproportionate relative to their abundance in the ecosystem, and when they are removed from the ecosystem, the ecosystem often collapses.

SUGGESTED SKILLS

Statistical Tests and Data Analysis

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

5.D.b
Use data to evaluate a hypothesis (or prediction), including supporting or refuting the alternative hypothesis.

ILLUSTRATIVE EXAMPLES

SYI-2.A.2
- Kudzu
- Zebra mussels

SYI-2.B.2.a
- Dutch elm disease
- Potato blight
- Smallpox

SYI-2.B.2.b
- Global climate change
- Logging
- Urbanization
- Mono-cropping

SYI-2.C.1
- El Niño
- Continental drift
- Meteor impact on dinosaurs

TOPIC 8.7
Disruptions to Ecosystems

Required Course Content

ENDURING UNDERSTANDING

EVO-1
Evolution is characterized by change in the genetic make-up of a population over time and is supported by multiple lines of evidence.

LEARNING OBJECTIVE

EVO-1.O
Explain the interaction between the environment and random or preexisting variations in populations.

ESSENTIAL KNOWLEDGE

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.

ENDURING UNDERSTANDING

SYI-2
Competition and cooperation are important aspects of biological systems.

LEARNING OBJECTIVE

SYI-2.A
Explain how invasive species affect ecosystem dynamics.

ESSENTIAL KNOWLEDGE

SYI-2.A.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 other organisms for resources.

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LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
SYI-2.A Explain how invasive species affect ecosystem dynamics.	SYI-2.A.2 The availability of resources can result in uncontrolled population growth and ecological changes.
SYI-2.B Describe human activities that lead to changes in ecosystem structure and/or dynamics.	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— a. The introduction of new diseases can devastate native species. b. Habitat change can occur because of human activity.
SYI-2.C Explain how geological and meteorological activity leads to changes in ecosystem structure and/or dynamics.	SYI-2.C.1 Geological and meteorological events affect habitat change and ecosystem distribution. Biogeographical studies illustrate these changes.