

Unit 8: Ecology

Unit 8 covers how organisms respond to their environment, how energy moves through ecosystems, how populations grow and interact, and how disruptions reshape ecological communities. CED topics 8.1 through 8.7.

AP Biology

Ecology

About 14 minutes to read

How to use this guide

Read the topics in order the first time. The unit builds from single organisms responding to cues, to energy moving through systems, to the math of population growth, to how species interact, and finally to what breaks ecosystems. Each layer assumes the one before it.

After the first read, use the trap boxes for the pairs the exam confuses most often, especially energy flow versus matter cycling and density-dependent versus density-independent factors. Finish with the practice questions, then do the recall check out loud.

What this unit is worth. Unit 8 is 10 to 15 percent of the AP Biology exam. It also closes the loop on Unit 7. Adaptation and heterozygote advantage are natural selection acting on populations, and the population math here applies the same growth logic to whole communities.

8.1 Responses to the Environment

The unit opens with a simple claim. Organisms detect changes inside and outside themselves, and they respond in ways that tend to improve survival and reproduction. The responses take two forms.

Behavioral responses are things the organism does. **Physiological responses** are things the body does on its own. A plant turning its leaves toward light and an animal shivering in the cold are both responses to environmental cues.

One point the course makes explicit. You are not expected to memorize a list of specific mechanisms. The exam tests whether you recognize the pattern. An organism receives a cue, responds through behavior or physiology, and the response affects its fitness.

Organisms also exchange information. **Communication signals** can be visual, audible, tactile, electrical, or chemical. A signal that changes another organism's behavior can affect who reproduces, which means signaling itself is subject to natural selection.

Behaviors are either **innate** or **learned**. Innate behaviors are inborn and appear without teaching. Learned behaviors are acquired through experience. Both persist for the same reason. Fitness favors whichever behavior raises survival and reproductive success in the environment where it occurs. The course illustrates this with examples like taxis and kinesis in animals, phototropism and photoperiodism in plants, the fight-or-flight response, and schooling or flocking. Treat these as illustrations of the pattern, not as a list to memorize.

Trap. Innate does not mean unchangeable, and learned does not mean optional. Both are shaped by selection. If a question asks why a behavior exists, the answer is fitness, not the label.

8.2 Energy Flow Through Ecosystems

Ecology studies life at four levels. A **population** is one species in an area. A **community** is the interacting populations of different species. An **ecosystem** adds the nonliving environment. A **biome** is a large region defined by climate. Energy flows through these levels. Matter cycles through them. Keep the two verbs separate. Energy enters as sunlight, passes from producers to consumers, and leaves as heat. It does not come back. Matter is different. The same atoms of carbon, nitrogen, phosphorus, and water are reused through biogeochemical cycles.

How an organism handles temperature shapes its **energy budget**. An **endotherm** generates heat through metabolism to hold a steady body temperature. The cost is high. It must eat constantly to fuel the furnace. An **ectotherm** lacks efficient internal temperature control and regulates behaviorally instead, basking in sun or retreating to shade. The cost is low, but activity depends on the environment. A net gain in energy goes to storage, growth, and reproduction. A net loss means shrinking mass, fewer offspring, and eventually death.

The biogeochemical cycles

CYCLE	KEY MOVEMENT	NOTE
Hydrologic	Evaporation, condensation, precipitation, transpiration	Reservoirs include oceans, surface water, the atmosphere, and living organisms
Carbon	Photosynthesis, cellular respiration, decomposition, combustion	Moves between the atmosphere and living things as carbon dioxide and carbohydrates
Nitrogen	Fixation, assimilation, ammonification, nitrification, denitrification	The atmosphere is the largest reservoir. Soil microorganisms run the steps
Phosphorus	Weathering of rock releases phosphate, producers absorb it, consumers pass it on, decomposition returns it	No significant atmospheric component, unlike carbon and nitrogen

Who eats whom

Feeding relationships are organized into **trophic levels**. Producers sit at the base. Above them come primary, secondary, tertiary, and quaternary consumers, with decomposers breaking down dead matter at every level. An **autotroph** captures energy from physical or chemical sources. Photosynthetic autotrophs use sunlight and drive **primary productivity**. Chemosynthetic autotrophs capture energy from small inorganic molecules and can work without oxygen. A **heterotroph** gets energy by consuming organic matter, which covers herbivores, carnivores, omnivores, scavengers, and decomposers. Primary productivity is the rate at which photosynthetic organisms turn sunlight into biomass. It is the energy input the whole ecosystem runs on.

Trap. Questions love swapping the verbs. Energy flows and is lost. Matter cycles and is conserved. Any option that has energy cycling or matter being used up breaks one of those two rules.

8.3 Population Ecology

A **population** is the individuals of one species interacting in an area. Population growth depends on **birth rate and death rate**, and the relationship is a simple equation. $dN/dt = B - D$. The left side is the rate of change in population size. B is the birth rate and D is the death rate. If births exceed deaths, the population grows. If they are equal, it holds steady.

When reproduction faces no constraints, growth is **exponential**. $dN/dt = r_{max} \cdot N$. Here r_{max} is the maximum per capita growth rate and N is the current population size. The larger the population, the faster it grows, because every individual reproduces at the maximum rate. On a graph this is a J-shaped curve.

Trap. dN/dt is a rate, not a size. It tells you how fast the population is changing, not how many individuals exist. A large population can have a growth rate of zero.

8.4 Effect of Density of Populations

Real populations hit limits, and the sustainable maximum is the **carrying capacity**, K. It is set by the total resources the ecosystem can supply.

Limits come in two kinds. **Density-dependent factors** bite harder as crowding increases. Competition for food and the spread of disease are the standard examples. **Density-independent factors** strike regardless of density. A hurricane, a drought, or a hard freeze does not check how crowded the population is first.

When both kinds of limits apply, growth follows the **logistic** equation. $dN/dt = r_{max} \cdot N \cdot ((K-N)/K)$. Read it in pieces. When N is far below K, the $(K-N)/K$ term is near 1 and growth looks exponential. As N approaches K, that term shrinks toward zero and growth slows. At $N = K$, growth stops. The curve is S-shaped.

FACTOR TYPE	HOW IT ACTS	EXAMPLES
Density-dependent	Effect intensifies as population density rises	Competition, disease
Density-independent	Acts regardless of population density	Natural disasters, climate extremes

Trap. The test is always about crowding. Ask whether the factor's impact changes when the population gets denser. Disease spreads faster in a crowd, so it is density-dependent. A volcano does not care, so it is independent.

8.5 Community Ecology

A **community** is the interacting populations of different species in an area, and it changes over time as those interactions play out. Community structure is described in terms of **species composition and diversity**. **Species composition** is which species are present. **Species diversity** covers both how many species there are and how evenly individuals are spread among them.

Simpson's diversity index puts a number on that. Diversity Index = $1 - \sum(n/N)^2$, where n is the count for one species and N is the total count. A higher value means a more diverse community. The index rewards both richness and evenness. A community with ten equally common species scores higher than one with ten species where a single species dominates.

Species interact, and the interactions drive population dynamics. A **predator-prey interaction** links the hunter's numbers to the hunted. A **trophic cascade** happens when a change at the top ripples down. Remove a top predator and herbivores surge, which can strip the producers below them. **Niche partitioning** lets species coexist by dividing resources, so direct competition drops. **Competition** itself is the fight over the same limited resources. **Cooperation** runs the other way: organisms work together, and cooperative behavior tends to increase the fitness of the individual and the survival of the population.

Symbiosis is close, long-term interaction between two species, and it comes in three forms.

TYPE	WHO BENEFITS	PATTERN
Parasitism	One benefits, the other is harmed	A tick feeding on a mammal
Mutualism	Both benefit	Bees pollinating flowers while gathering nectar
Commensalism	One benefits, the other is unaffected	Barnacles riding on a whale

Trap. Commensalism and mutualism blur because both look friendly. The question is always about the second organism. Helped means mutualism. Unaffected means commensalism. If the second organism is harmed, it is parasitism, which is a long-term relationship rather than a hunt.

8.6 Biodiversity

Biodiversity is not decoration. **Ecosystem resilience** depends on it. Natural and artificial ecosystems with fewer component parts, and with little diversity among the parts, are less resilient to changes in the environment. When a disturbance hits a simple system, there are fewer alternative pathways to absorb it.

Some species matter out of proportion to their numbers. A **keystone species** has effects far larger than its abundance would suggest, and its removal often collapses the ecosystem. Keystone species, producers, and essential abiotic and biotic factors all contribute to maintaining ecosystem diversity.

Trap. If a question describes the most abundant producer in a system, that is not automatically the keystone species. Look for disproportionate effect, not head count.

8.7 Disruptions to Ecosystems

An **adaptation** is a genetic variation favored by selection that gives its bearer an advantage in a particular environment. Note the requirements. It is genetic, not acquired in a lifetime, and it spreads because selection favored it. **Heterozygote advantage** is a special case. The heterozygous genotype has higher fitness than either homozygote, so selection maintains both alleles in the population instead of fixing one.

Disruptions break the systems described above. An **invasive species** is introduced, intentionally or not, into a new area where it finds no predators or competitors, or where it simply outcompetes natives. Kudzu and zebra mussels are the course's examples. Because the invader faces none of the checks from its home range, it can reshape the whole community.

Human activity drives two chemical disruptions that students constantly mix up. **Biomagnification** is the rising concentration of a toxin at successively higher trophic levels. A pollutant present in tiny amounts in producers becomes concentrated in top predators. **Eutrophication** is nutrient enrichment of water, often from fertilizer runoff. The nutrients feed algal blooms, the algae die, decomposers multiply, oxygen drops, and fish die. Both can cause extinctions. They are different processes with different culprits, toxins versus nutrients.

Biogeography is the study of where species live. The geographic distribution of species records the history of habitat change, showing how geological and meteorological events like continental drift or El Niño have moved ecosystems around. The course's other disruption examples include disease, such as Dutch elm disease and potato blight, and human activities like logging, urbanization, and monocropping.

Trap. Biomagnification and eutrophication are the pair to drill. Toxins climb the food chain in biomagnification. Nutrients feed blooms in eutrophication. If the scenario mentions fertilizer runoff and dead fish, it is eutrophication. If it mentions a pollutant concentrated in top predators, it is biomagnification.

Confusions That Cost Points

Most missed questions in this unit come from a short list of pairs that look alike under time pressure. Review each pair carefully so you can tell them apart when you see them in a question.

PAIR	HOW TO SEPARATE THEM
Energy flow vs matter cycling	Energy flows one way and is lost as heat. Matter cycles and is conserved. Swapping the verbs is the most common wrong answer in 8.2.
Endotherm vs ectotherm	Endotherms burn food to make heat and pay a high energy cost. Ectotherms adjust behaviorally and pay little, but depend on the environment.
Exponential vs logistic growth	Exponential has no constraints and makes a J curve. Logistic includes K and makes an S curve. The $(K-N)/K$ term is the difference.
Density-dependent vs density-independent	Ask whether crowding changes the impact. Disease spreads faster in a crowd. A hurricane does not care.
Parasitism vs mutualism vs commensalism	Plus/minus, plus/plus, plus/zero. Judge by what happens to the second organism.
Biomagnification vs eutrophication	Toxins concentrated up the food chain versus nutrients causing blooms and oxygen loss.
Keystone vs most abundant	Keystone means disproportionate effect. Abundance alone never identifies one.
Innate vs learned behavior	Inborn versus acquired through experience. Both are explained by fitness.
dN/dt vs N	A rate versus a size. A growth rate of zero does not mean an empty population.
Niche partitioning vs competition	Partitioning divides resources to reduce competition. Competition is the contest itself.

Practice Questions

Original questions written for this guide in the style of the AP exam. Answers and explanations are on the next page, so complete the questions before checking them.

- 1.** A lizard spends the early morning basking on a sun-warmed rock, then moves into the shade as the day heats up. The lizard is best described as an
 - A. endotherm
 - B. ectotherm
 - C. autotroph
 - D. decomposer

- 2.** Which statement correctly describes energy and matter in ecosystems?
 - A. Energy cycles between organisms and the environment, while matter flows in one direction
 - B. Both energy and matter cycle indefinitely through ecosystems
 - C. Energy flows through ecosystems and is lost as heat, while matter cycles through biogeochemical cycles
 - D. Matter is used up by producers and must be replaced by new matter from outside the ecosystem

- 3.** In a population, the birth rate exceeds the death rate ($B > D$). Using $dN/dt = B - D$, what must be true?
 - A. The population is shrinking
 - B. The population is growing
 - C. The population has reached carrying capacity
 - D. The growth is exponential

- 4.** A hurricane destroys half the nests in a seabird colony. Crowded sections and sparse sections lose the same fraction of nests. The hurricane is a
 - A. density-dependent factor
 - B. density-independent factor
 - C. carrying capacity
 - D. form of intraspecific competition

- 5.** In logistic growth, $dN/dt = r_{\max} \cdot N \cdot ((K-N)/K)$. As the population size N approaches the carrying capacity K , the growth rate
- A. continues to increase
 - B. approaches zero
 - C. becomes negative immediately
 - D. equals $r_{\max}$
- 6.** Barnacles attach to a whale's skin. The barnacles gain a place to live and access to food-rich water, while the whale is unaffected. This relationship is best described as
- A. mutualism
 - B. parasitism
 - C. commensalism
 - D. competition
- 7.** Wolves are removed from a valley. Within a few years, deer numbers rise sharply and young trees decline. This sequence is an example of
- A. niche partitioning
 - B. a trophic cascade
 - C. biomagnification
 - D. eutrophication
- 8.** Fertilizer runoff enters a lake. Algae grow rapidly, then die. Decomposers multiply, oxygen levels fall, and fish die. This process is
- A. biomagnification
 - B. eutrophication
 - C. nitrogen fixation
 - D. an increase in primary productivity that benefits the ecosystem

Answer Key

- 1. B.** The lizard regulates temperature behaviorally, moving between sun and shade, which is the definition of an ectotherm. A confuses behavioral regulation with internal heat generation. C and D name the wrong categories entirely. How an organism gets its energy and what trophic role it fills are separate questions from how it manages temperature.
- 2. C.** Energy flows one way and leaves as heat. Matter is conserved and cycles. A reverses the two verbs, which is the most common trap in this topic. B ignores heat loss, which is why energy cannot cycle. D violates the conservation of matter that the biogeochemical cycles demonstrate.
- 3. B.** A positive $B - D$ means dN/dt is positive, so the population grows. A reverses the sign of the equation. C confuses growth with carrying capacity. At K the growth rate is zero, not positive. D overclaims. $B > D$ alone does not mean unconstrained maximum-rate growth, which is what exponential requires.
- 4. B.** The storm hits crowded and sparse sections equally, so its effect does not depend on density. A is the trap. It assumes all mortality is density-dependent, but the scenario explicitly removes crowding from the story. C names a population size, not an event. D describes competition, which intensifies with density and is therefore density-dependent itself.
- 5. B.** As N approaches K , the $(K-N)/K$ term shrinks toward zero, so the growth rate approaches zero. A describes the exponential phase, before limits apply. C overshoots. The rate approaches zero from above. It turns negative only if N exceeds K . D confuses the population growth rate with r_{max} , the per capita maximum.
- 6. C.** One organism benefits and the other is unaffected, which is commensalism. A assumes both benefit because the two live together, but nothing in the scenario helps the whale. B assumes attachment means harm, but the whale is explicitly unaffected. D misreads the situation. The two species do not compete for the same resource.
- 7. B.** Removing the top predator ripples down through the trophic levels. Deer rise, then producers fall. That is a trophic cascade. A names resource division, which is not happening here. C and D are the wrong unit topics. They involve toxins and nutrient enrichment, not population change after predator removal.
- 8. B.** Nutrient runoff feeding algal blooms, followed by decomposition and oxygen depletion, is eutrophication. A is the trap. Both processes involve human-driven harm moving through a food web, but biomagnification concentrates toxins up trophic levels while this scenario is about nutrients. C names a real nitrogen cycle step, but fixation makes nitrogen available. It does not kill fish. D is half right and fully wrong. Productivity does rise, but the oxygen crash that follows harms the ecosystem rather than benefiting it.

When you check your answers, note which distinction each miss came from. Make a flashcard for that distinction and drill it spaced out over the next few days instead of rereading the whole section. If you missed one of these questions, the same distinction is worth practicing again in Rycal, where the Ecology deck has flashcards for it and more practice questions use the same kinds of traps.

One-Page Recall Check

Say each answer out loud before you look back, and mark the ones you cannot finish. Anything you cannot say out loud yet belongs in your flashcard deck. In Rycal, add those items to the Ecology deck and let spaced review bring them back over the next few days.

- State what the exam expects you to know about animal behavior, and what it explicitly does not require.
- Give one example each of innate and learned behavior, and explain how each can raise fitness.
- Explain how an endotherm and an ectotherm each maintain body temperature, and the energy cost of each strategy.
- State the one-way rule for energy and matter, and give one example of each.
- Walk through the nitrogen cycle's five named steps in order, and name the largest reservoir.
- Explain why phosphorus, unlike carbon and nitrogen, has no significant atmospheric reservoir.
- Use $dN/dt = B - D$ to predict the population trend when births exceed deaths, and when they are equal.
- Sketch the logistic curve and explain what happens to dN/dt as N approaches K .
- Give one density-dependent and one density-independent factor, and explain how you tell them apart.
- Explain what Simpson's diversity index measures, and why both richness and evenness matter.
- Separate parasitism, mutualism, and commensalism using the plus/minus, plus/plus, plus/zero shorthand.
- Explain a trophic cascade in your own words, starting from the removal of a top predator.
- Explain how biomagnification and eutrophication each harm ecosystems, and how they differ.
- Define keystone species and explain why its removal can collapse an ecosystem even though it is not abundant.

Where to go next. Turn every missed item above into flashcards and drill them spaced out over several days rather than in one sitting. In Rycal, open the Ecology deck under AP Biology. The deck covers the terms in this guide, and its practice questions target the same traps named here. If you have a test date, add it in the Test Planner. You can also start your next review with a Brain Dump, then check what you missed against this guide.

Key terms for this unit

Behavioral and physiological response, communication signals, innate behavior, learned behavior, behavior examples, endotherm, ectotherm, energy budget, population, community, ecosystem, biome, biogeochemical cycle, hydrologic cycle, carbon cycle, nitrogen cycle, phosphorus cycle, trophic level, autotroph, heterotroph, primary productivity, birth rate, death rate, birth rate and death rate, exponential growth, carrying capacity, density-dependent factor, density-independent factor, logistic growth, species composition, species diversity, species composition and diversity, Simpson's diversity index, predator-prey interaction, trophic cascade, niche partitioning, competition, cooperation, symbiosis, parasitism, mutualism, commensalism, ecosystem resilience, keystone species, adaptation, heterozygote advantage, invasive species, ecosystem disruption examples, biomagnification, eutrophication, biogeography, energy flow examples, levels of ecological organization, random mutation, reproductive strategies in response to energy availability.