

BRIGHT SCHOLARS

AP+ EXAM PREP SERIES

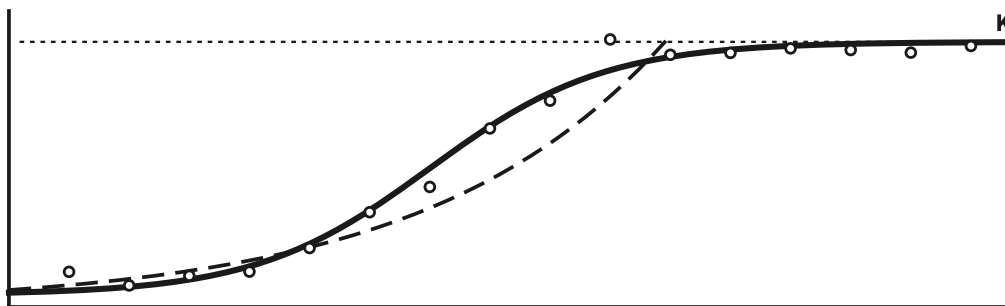
ENVIRONMENTAL SCIENCE

REVIEW WORKBOOK

2027 EXAM

Data Labs • Calculations • Investigations • FRQ Strategy

Read the data. Trace the mechanism. Defend the solution.



Fully digital exam format • Diagnostic test • 9 units • 9 data labs • Full-length practice exam

THIS BOOK BELONGS TO

Name _____

School / Teacher _____

AP exam date _____

Contents

GETTING STARTED

How to Use This Workbook	4
The AP Environmental Science Exam	5
APES Skills Overview	6
8-Week Study Plan and Progress Tracker	7
Diagnostic Test	9

UNITS

1 The Living World: Ecosystems	14
2 The Living World: Biodiversity	23
3 Populations	33
4 Earth Systems and Resources	43
5 Land and Water Use	53
6 Energy Resources and Consumption	63
7 Atmospheric Pollution	73
8 Aquatic and Terrestrial Pollution	83
9 Global Change	93

EXAM PREP

Environmental Laws and Policies	103
Cumulative Calculation and Data Lab	105
Experimental Design Lab	107
Full-Length Practice Exam	108

ANSWERS AND REFERENCE

Answer Key and Model FRQ Responses	128
Calculations Reference	139
Key Terms Glossary	141
Before Exam Day and Final Tracker	143

i KNOW IT

Short concept notes in the margin of every Core Review.

2 FRQ EDGE

Full free-response practice with a labeled work box for each part.

! FIX IT

The mistakes students make most often, named so you can catch them.

UNIT

1 The Living World: Ecosystems

AP EXAM WEIGHT: 6–8% OF THE MULTIPLE-CHOICE SECTION

UNIT QUESTION

Energy enters an ecosystem once, but matter is used again and again. How do those two facts limit what an ecosystem can support?

✓ BY THE END OF THIS UNIT

- ☐ Describe species interactions and how resource partitioning reduces competition.
- ☐ Relate climate to terrestrial biomes, and light, salinity, and nutrients to aquatic biomes.
- ☐ Trace carbon, nitrogen, phosphorus, and water through their reservoirs and processes.
- ☐ Calculate NPP from GPP and respiration.
- ☐ Apply the 10% rule to estimate energy at higher trophic levels.
- ☐ Predict how a change in one species spreads through a food web.

i CED TOPICS IN THIS UNIT

- 1.1 Introduction to Ecosystems
- 1.2 Terrestrial Biomes
- 1.3 Aquatic Biomes
- 1.4 Carbon Cycle
- 1.5 Nitrogen Cycle
- 1.6 Phosphorus Cycle
- 1.7 Hydrologic (Water) Cycle
- 1.8 Primary Productivity
- 1.9 Trophic Levels
- 1.10 Energy Flow and the 10% Rule
- 1.11 Food Chains and Food Webs

BIG IDEA

Energy and matter move through ecosystems in predictable patterns, while species interactions and biome conditions shape ecosystem structure.

🎯 QUICK START: 2-MINUTE WARM-UP

Try each one in under a minute.

a. Which biogeochemical cycle has no major atmospheric reservoir?

b. GPP is 1,000 kcal/m²/yr and producer respiration is 400 kcal/m²/yr. What is NPP?

c. Name the process that returns N₂ to the atmosphere.

UNIT 1 | CORE REVIEW

Ecosystems: The Essentials

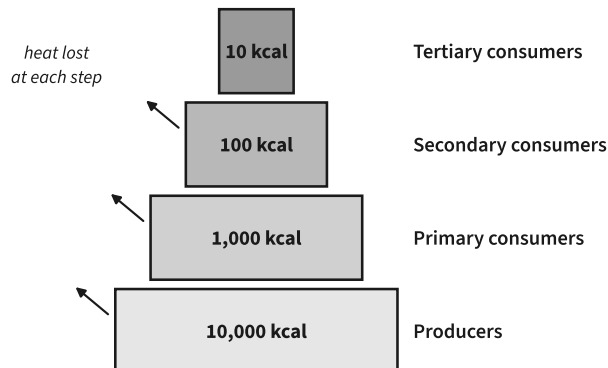
Species interactions. Predation, competition, mutualism, commensalism, and parasitism affect survival and resource use. Resource partitioning can reduce competition when species use a shared resource in different ways, places, or times.

Terrestrial and aquatic biomes. Climate, especially temperature and precipitation, largely determines terrestrial biome distribution. Salinity, depth, flow, temperature, nutrients, and light structure aquatic systems. Estuaries and wetlands are highly productive; open ocean has low NPP per square meter but enormous area.

Biogeochemical cycles. Carbon moves among atmosphere, organisms, oceans, sediments, and rock. Nitrogen fixation makes atmospheric N_2 biologically available; nitrification, assimilation, ammonification, and denitrification move nitrogen among reservoirs. Phosphorus has no major atmospheric phase. Water cycles through evaporation, transpiration, condensation, precipitation, infiltration, and runoff.

Productivity and energy. GPP is total energy captured by producers; $NPP = GPP - \text{respiration}$. Energy decreases between trophic levels because organisms use energy for metabolism and lose heat. The 10% rule is an approximation, not a fixed law.

Food chains and webs. Food chains show one pathway; food webs show many interacting pathways. Changes in a major producer or predator can propagate through multiple trophic levels.



! KNOW IT

GPP: total energy captured by producers in photosynthesis.

$NPP = GPP - \text{respiration}$: energy stored as new producer biomass, available to consumers.

10% rule: about a tenth of the energy at one trophic level reaches the next.

CYCLE CHECKLIST

Carbon: photosynthesis, respiration, decomposition, combustion; fast and slow reservoirs.

Nitrogen: fixation, nitrification, assimilation, ammonification, denitrification.

Phosphorus: weathering of rock; no major gas phase; often limits freshwater growth.

! FIX IT: ENERGY VS. MATTER

Energy flows through ecosystems and is dissipated as heat; matter cycles. Do not say that energy “cycles” like carbon, nitrogen, phosphorus, or water.

UNIT 1 | GUIDED PRACTICE

Worked Examples and Your Turn

EXAM TIP

On calculation questions, write the formula, substitute the values with units, and label the answer. An NPP or energy-transfer answer without $\text{kcal/m}^2/\text{yr}$ is incomplete.

WORKED EXAMPLE 1

A grassland has GPP = 12,000 kcal/m²/yr and producer respiration = 4,500. NPP = 12,000 – 4,500 = 7,500 kcal/m²/yr. The subtraction matters because NPP is the energy stored as new producer biomass after producer respiration.

WORKED EXAMPLE 2

If producers store 8,000 kcal/m²/yr and a simplified 10% transfer is assumed, primary consumers receive about 800 and secondary consumers about 80 kcal/m²/yr. The 10% rule is an approximation; transfer efficiency varies among ecosystems.

 YOUR TURN

- 1** A marsh has GPP of $14,500 \text{ kcal/m}^2/\text{yr}$ and producer respiration of $5,200 \text{ kcal/m}^2/\text{yr}$. Calculate NPP, then estimate energy available to secondary consumers using 10% transfer at each trophic step.

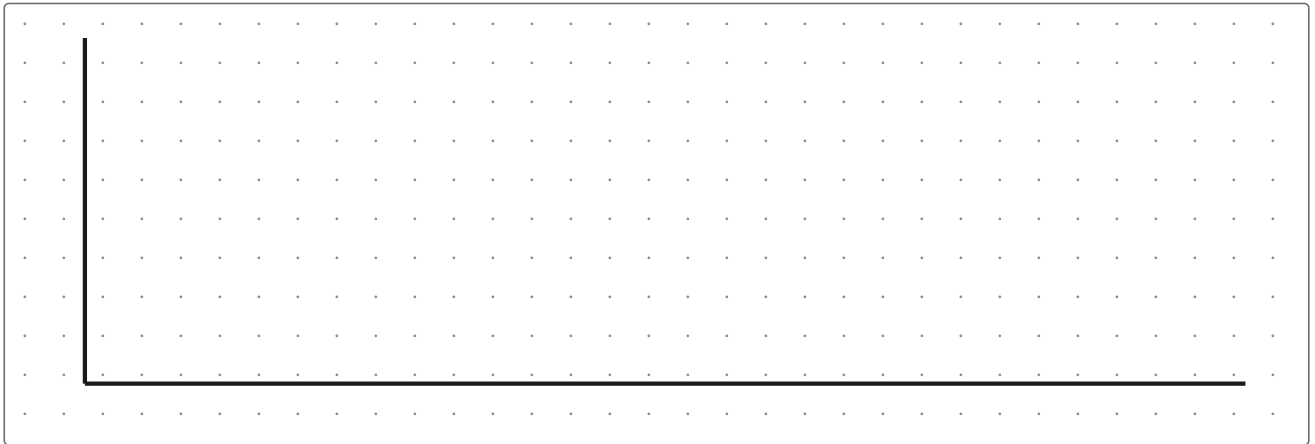
UNIT 1 | DATA LAB

Productivity Across Biomes

Use the fictional annual net primary productivity data to practice graphing, comparison, and causal reasoning.

Biome	Average NPP (g/m ² /yr)
Tropical rainforest	2200
Temperate forest	1250
Grassland	600
Desert	90
Tundra	140
Open ocean	125

- 1 Construct a bar graph of NPP by biome and label both axes with units.



- 2 Identify the biome with the highest NPP and explain TWO environmental conditions that support this productivity.

- 3 Identify the most likely limiting factor responsible for the desert's low NPP.

- 4 A long drought reduces annual rainfall in the grassland by 40%. Predict the most likely change in NPP and justify your prediction.

FRQ EDGE | UNIT 1

Energy Flow in a Grassland

In a temperate grassland, researchers estimate the energy stored each year at four trophic levels: grasses 12,000 kcal/m²/yr; grasshoppers 1,100 kcal/m²/yr; shrews 105 kcal/m²/yr; and owls 9 kcal/m²/yr.

Mastery score: _____ / 4 (1 point per part; a practice score, not an AP score conversion)

A Calculate the percent of energy transferred from grasshoppers to shrews. Show your work.

B Explain why the energy available at each trophic level is less than the energy at the level below it.

FRQ EDGE • UNIT 1 • CONTINUED

C Describe ONE process by which carbon in a shrew's body returns to the atmosphere.

Grid area for response C.

D The grassland is plowed and converted to cropland. Explain ONE effect of this change on carbon storage and on atmospheric CO₂.

Grid area for response D.

✓ READY+ CHECK • SCORE YOURSELF

CONFIDENCE 1 2 3 4

- ☐ I divided shrew energy by grasshopper energy and multiplied by 100.
- ☐ I named a specific process: respiration or decomposition.

- ☐ I named heat lost through respiration, not energy that is "used up."
- ☐ I linked plowing to faster decomposition and more CO₂.

UNIT 1 | REVIEW

Mixed Practice and Exit Ticket

! MIXED SKILL PRACTICE

- 1 Explain why phosphorus can limit freshwater productivity even though organisms also require nitrogen.

- 2 A food web loses its top predator. Predict one plausible trophic cascade.

- 3 Compare matter cycling with energy flow in one precise sentence.

→ EXIT TICKET

Complete without looking back.

- | | |
|--|---|
| <p>1 What is NPP?</p> | <p>2 Name one terrestrial and one aquatic biome.</p> |
| <p>3 Which cycle lacks a major atmospheric phase?</p> | <p>4 What happens to energy at each trophic transfer?</p> |
| <p>5 Name one species interaction besides predation.</p> | |

✓ READY+ CHECK: UNIT 1

Rate your confidence on each skill before moving on.

SKILL	1	2	3	4
Describe species interactions and how resource partitioning reduces competition	☐	☐	☐	☐
Relate climate to terrestrial biomes, and light, salinity, and nutrients to aquatic biomes	☐	☐	☐	☐
Trace carbon, nitrogen, phosphorus, and water through their reservoirs and processes	☐	☐	☐	☐
Calculate NPP from GPP and respiration	☐	☐	☐	☐
Apply the 10% rule to estimate energy at higher trophic levels	☐	☐	☐	☐
Predict how a change in one species spreads through a food web	☐	☐	☐	☐

1 shaky 2 getting there 3 solid 4 exam-ready

Anything below 3? Reread the Core Review and redo the matching practice before the next unit.

SECTION I • MULTIPLE CHOICE • QUESTIONS 1–80**⌚ 90 MINUTES**

-
- 1** Why is the carbon cycle described as having both a fast and a slow component?
- (A) There is no meaningful difference between the two pools
 - (B) Fast carbon moves through the atmosphere, biosphere, and surface ocean over years to decades, while slow carbon is stored in rock and fossil fuels over millions of years
 - (C) Fast carbon only exists in the ocean
 - (D) Slow carbon is found only in living organisms
-
- 2** Which process returns carbon stored in the slow carbon cycle back to the atmosphere most rapidly?
- (A) Decomposition of leaf litter
 - (B) Photosynthesis
 - (C) Ocean upwelling
 - (D) Combustion of fossil fuels
-
- 3** Timber harvested from a sustainably managed forest is an example of which kind of ecosystem service?
- (A) Provisioning
 - (B) Regulating
 - (C) Cultural
 - (D) Supporting
-
- 4** Habitat fragmentation tends to reduce biodiversity primarily because it:
- (A) Eliminates edge effects
 - (B) Increases the total habitat area available
 - (C) Creates smaller, more isolated populations more vulnerable to local extinction
 - (D) Increases genetic diversity within each fragment
-
- 5** Which condition is necessary for a population to exhibit exponential growth?
- (A) High density-dependent mortality
 - (B) Limited resources and high competition
 - (C) Unlimited resources with no significant limiting factors
 - (D) A carrying capacity has been reached
-
- 6** A population grows at 3.5% per year. Using the rule of 70, its doubling time is about
- (A) 20 years
 - (B) 35 years
 - (C) 245 years
 - (D) 2 years
-
- 7** An age-structure diagram with a very wide base and narrow top most strongly suggests:
- (A) A population with zero birth rate
 - (B) A shrinking population
 - (C) A population in stage 4 of the demographic transition
 - (D) A young, rapidly growing population
-

Answer Key

Answers are grouped by section, with the page number of each set of problems. For free-response questions, the key shows what a strong response includes; credit depends on the correct mechanism, setup, and units, not on matching the wording. Check a whole section at a time, record misses in your error log, and redo anything you missed before reading the explanation.

DIAGNOSTIC TEST

Diagnostic Test • Multiple Choice p. 9

- 1 **B.** Removing shade warms the stream; warmer water holds less dissolved oxygen.
- 2 **D.** $20,000 \rightarrow 2,000$ (primary) $\rightarrow 200$ (secondary) $\rightarrow 20$ kcal/ m^2 /yr (tertiary).
- 3 **A.** Pollination is commonly classified as a regulating ecosystem service because it supports ecosystem and agricultural functioning.
- 4 **C.** A narrow tolerance range is characteristic of specialization and can make a species more vulnerable to environmental change.
- 5 **C.** A persistent reduction in a limiting resource lowers the maximum population the environment can sustain.
- 6 **A.** A roughly columnar age structure generally indicates a stable or slowly changing population.
- 7 **B.** Axial tilt changes solar angle and day length through the year.
- 8 **D.** Weaker trade winds reduce the upwelling of cold, nutrient-rich water off western South America.
- 9 **D.** Contour plowing follows the land's contours, reducing runoff velocity and soil loss.
- 10 **C.** Drip systems apply water slowly near roots and generally minimize evaporation and runoff.
- 11 **B.** Hydrogen carries energy but usually must first be produced using electricity or another energy source.
- 12 **A.** Conservation reduces energy use through behavior; efficiency provides the same service with less energy.
- 13 **B.** Electrostatic precipitators charge particles and collect them on oppositely charged plates.
- 14 **D.** Noise pollution can damage hearing and contribute to stress and cardiovascular effects.
- 15 **A.** Secondary treatment relies on microbial decomposition of organic material.
- 16 **C.** Greater response at the same dose indicates greater susceptibility under the experimental conditions.
- 17 **A.** Adaptation reduces vulnerability to climate impacts; the other choices primarily mitigate greenhouse-gas emissions or increase sequestration.
- 18 **B.** Small isolated populations are particularly vulnerable to genetic drift, inbreeding, and random demographic events.

Diagnostic Test • Free Response p. 12

- A** $(27 - 9) \div 10 = 1.8\%$ per year.
- B** $70 \div 1.8 \approx 39$ years.
- C** Late Stage 2 or Stage 3: the death rate has already fallen to a low level while the birth rate is still well above it, so the population grows quickly. Either stage earns credit with this justification.
- D** Examples: expanding education for girls and women, which delays marriage and childbearing and opens other opportunities; or improving access to family planning,

which lets families have the number of children they choose.

UNIT 1 • THE LIVING WORLD: ECOSYSTEMS

Unit 1 Quick Start p. 15

- a** Phosphorus.
- b** $1,000 - 400 = 600$ kcal/ m^2 /yr.
- c** Denitrification.

Unit 1 • Your Turn p. 16

- 1 NPP = 9,300 kcal/ m^2 /yr; primary consumers ≈ 930 ; secondary consumers ≈ 93 kcal/ m^2 /yr.

Unit 1 • Data Lab p. 17

- 1 A correct graph has biome on the x-axis, average NPP (g/ m^2 /yr) on the y-axis, and bars matching the data.
- 2 Tropical rainforest. Warm temperatures, abundant precipitation, and a long growing season support high photosynthetic rates; any two supported factors earn credit.
- 3 Water availability is the most likely limiting factor.
- 4 NPP would generally decrease because less available water limits photosynthesis and plant growth.

Unit 1 Review • Multiple Choice p. 18

- 1 **B.** Impervious surfaces reduce infiltration and route rainfall rapidly to streams as surface runoff.
- 2 **D.** Transpiration releases water vapor from plants to the atmosphere.
- 3 **A.** Added nitrate can stimulate algal growth, which can later increase decomposition and oxygen demand.
- 4 **C.** $NPP = GPP - \text{respiration} = 2,400 - 900 = 1,500$ kcal/ m^2 /yr.
- 5 **C.** Tundra has permafrost, low temperatures, and a short growing season.
- 6 **A.** The shallow littoral zone receives enough light for rooted aquatic vegetation.
- 7 **D.** Denitrifying bacteria convert nitrate to gaseous nitrogen forms.
- 8 **B.** Removing a predator can increase prey abundance and indirectly alter lower trophic levels.
- 9 **D.** Energy is progressively lost as heat (a one-way flow), so each level must contain less energy than the one below it. Biomass, however, can appear inverted in systems like the open ocean where small, fast-reproducing phytoplankton support a larger standing biomass of consumers at any single moment.
- 10 **B.** Nitrogen-fixing bacteria first convert N_2 to ammonia (fixation); nitrifying bacteria then convert ammonia to nitrites and nitrates (nitrification); plants then take up nitrates (assimilation).
- 11 **C.** Ecological (trophic) efficiency averages roughly 10%, meaning each trophic level retains only about a tenth of the energy of the level below, limiting food chain length.