

BRIGHT SCHOLARS

AP+

BIOLOGY

A COMPLETE PRACTICE WORKBOOK

for Concepts, Data Analysis, Lab Skills, FRQs, and Exam Readiness

THIS BOOK BELONGS TO

Student Name _____

School / Class _____

Contents

How to Use This Workbook	4
AP+ Biology Skills Self-Assessment	8
Workbook-to-AP Unit Map	11
AP+ Biology Diagnostic Assessment	13
1 How to Think Like an AP+ Biology Student	18
2 Chemistry of Life	20
3 Cell Structure and Function	26
4 Cell Membranes and Transport	32
5 Enzymes and Cellular Energy	38
6 Cellular Respiration and Photosynthesis	44
7 Cell Communication and the Cell Cycle	51
8 Heredity and Meiosis	56
9 Molecular Genetics	61
10 Evolution	65
11 Ecology	69
12 Experimental Design and Lab Skills	75
13 Graphs, Data, and Statistics	80
Current AP Exam Format and Digital Readiness	87
Chapters 14–16: MCQ, FRQ, and Review Strategies	88
AP+ Biology Toolkit	99
Original Practice Question Bank	105
Chapter Open-Response Model Answers and Keys	117
Current-Format Stimulus-Based MCQ Practice	127
Practice Exam 1	131
Practice Exam 2	155
AP+ Biology Vocabulary Builder	179
Unit Practice Worksheets and Extra Data Practice	192
Additional Visual Analysis and Final Reflection	218

AP+ Biology Diagnostic Assessment

Use this diagnostic before beginning the workbook. Complete it without notes, then use the score map to identify the units that need the most attention. This is an original skills check, not an official College Board exam. Section A:

Multiple Choice — 24 Questions

-
- 1 A water molecule forms hydrogen bonds because
- (A) oxygen and hydrogen share electrons equally
 - (B) oxygen is more electronegative than hydrogen
 - (C) water is nonpolar
 - (D) hydrogen atoms carry full negative charges
-
- 2 A protein loses function after a major pH change because the pH change can
- (A) change every amino acid in the primary structure
 - (B) add peptide bonds
 - (C) alter interactions that maintain tertiary structure
 - (D) convert the protein into a lipid
-
- 3 A cell with extensive rough ER and Golgi apparatus is specialized for
- (A) storing DNA
 - (B) photosynthesis
 - (C) digesting glucose in glycolysis
 - (D) secreting proteins
-
- 4 As a cell grows larger, exchange becomes less efficient mainly because
- (A) DNA becomes circular
 - (B) surface area-to-volume ratio decreases
 - (C) ribosomes stop functioning in the larger cytoplasm
 - (D) membranes become impermeable
-
- 5 A membrane protein moves ions against their concentration gradient using ATP. The process is
- (A) osmosis
 - (B) facilitated diffusion
 - (C) active transport
 - (D) simple diffusion
-
- 6 A plant cell placed in a hypotonic solution becomes turgid because
- (A) solutes are pumped out of the cell by active transport
 - (B) water exits the central vacuole into the cytoplasm
 - (C) water enters and the cell wall resists expansion
 - (D) the membrane dissolves
-

CHAPTER

1 How to Think Like an AP+ Biology Student

AP Biology rewards reasoning, not memorization. This chapter builds the habits you need.

What Makes AP+ Biology Different

In AP Biology, success depends on understanding how biological systems work, not memorizing lists of facts.

- Interpret data from experiments you have never seen before
- Design and evaluate experimental procedures
- Explain cause-and-effect relationships between biological processes
- Connect concepts across units
- Write clear, evidence-based scientific explanations

The Five AP+ Biology Habits

Habit	What It Means in Practice
Think in systems	Ask: how do the parts of this biological system interact?
Follow the energy	Trace where energy comes from, where it goes, and what uses it
Follow the information	Track how DNA → RNA → protein → cellular response
Ask cause and effect	For every process, ask: what triggers it? What does it produce?
Look at the data	Never accept a conclusion without examining the evidence

The Claim-Evidence-Reasoning (CER) Framework

Part	Your Job	Starter Phrase
Claim	State what you conclude or predict	"The data suggest that..."
Evidence	Reference specific data or biological facts	"The evidence shows that..."
Reasoning	Explain the biology connecting evidence to claim	"This occurs because..."

i CLAIM-EVIDENCE-REASONING (CER)

A researcher notices that plants placed in a dark room for 48 hours have significantly lower starch levels than plants kept in a lighted room. Use CER to explain this observation.

Claim:

Evidence:

Reasoning:

Common AP+ Biology Mistakes to Avoid

! WATCH OUT FOR THESE

Being vague: 'The enzyme doesn't work.' → Instead: 'The enzyme denatures at high pH, losing the shape of its active site.'

Skipping the mechanism: Always explain WHY or HOW, not just what happened.

Ignoring the data: Read graphs and tables before answering data-based questions.

Missing command verbs: 'Describe' and 'Explain' require fundamentally different responses.

CHAPTER REFLECTION

What was the most important concept you learned in this chapter?

What is one question you still have?

Rate your confidence (circle one): 1 2 3 4 5

CHAPTER

2

Chemistry of Life

The molecules of life are not just chemistry - they are biology in action.

Properties of Water

- Polarity: O-H bonds create partial charges, allowing hydrogen bonds between water molecules
- Cohesion: hydrogen bonds hold water molecules together (surface tension, water transport in plants)
- Adhesion: water clings to other polar surfaces
- High specific heat: water absorbs large amounts of heat with minimal temperature rise
- Universal solvent: polar and ionic substances dissolve readily in water
- Ice density: ice is less dense than liquid water - lakes freeze from the top, protecting aquatic life

pH and Buffers

PH SCALE REFERENCE

pH Range	Classification	Biological Example
Below 7	Acidic (higher H ⁺ concentration)	Stomach acid (~pH 2), lysosome (~pH 4.5)
7	Neutral	Pure water
Above 7	Basic / Alkaline	Blood (~pH 7.4), pancreatic fluid (~pH 8)

Buffers resist changes in pH by accepting or releasing H⁺ ions. Blood uses the carbonic acid-bicarbonate buffer system to maintain pH 7.35-7.45.

The Four Macromolecules

MACROMOLECULE COMPARISON TABLE

Macromolecule	Monomer(s)	Key Functions	Indicator Reagent
Carbohydrates	Monosaccharides	Energy storage (starch, glycogen); structural support (cellulose, chitin)	Benedict's reagent; Lugol's iodine
Lipids	Glycerol + fatty acids	Long-term energy storage; membrane structure; hormones	Sudan IV; paper grease test
Proteins	Amino acids (20 types)	Enzymes; structural support; transport; signaling; defense	Biuret reagent (purple-violet)
Nucleic acids	Nucleotides	Genetic information (DNA); protein synthesis (RNA)	Methyl green (DNA stain)

Protein Structure Levels

- Primary: the unique sequence of amino acids in the polypeptide chain
 - Secondary: local folding into alpha helices or beta sheets (hydrogen bonds)
 - Tertiary: overall 3D shape (hydrophobic interactions, ionic bonds, disulfide bridges)
 - Quaternary: two or more polypeptide chains interacting (e.g., hemoglobin)
- Denaturation: loss of protein shape and function due to changes in temperature, pH, or salt concentration.

- 4 A student compares two triglycerides (fats) at room temperature. Triglyceride X is a liquid and Triglyceride Y is a solid. Which structural difference BEST explains this?
- (A) Triglyceride X has more glycerol molecules, which keep it fluid
 - (B) Triglyceride Y has phosphate groups that bond to one another
 - (C) Triglyceride Y has four fused carbon rings that stack rigidly
 - (D) Triglyceride X has kinked unsaturated fatty acids that cannot pack tightly
-
- 5 A mutation replaces a nonpolar leucine buried in the core of a globular enzyme with a charged aspartic acid. Which outcome is MOST likely?
- (A) The enzyme's tertiary structure is disrupted, reducing its activity
 - (B) The enzyme's primary structure is unchanged by the mutation
 - (C) The enzyme gains an extra polypeptide subunit to shield the charge
 - (D) Every peptide bond in the enzyme breaks, freeing its amino acids

i CLAIM-EVIDENCE-REASONING (CER)

A researcher observes slower bacterial growth near a polluted stream at pH 4. Use CER to explain why reduced enzyme activity could account for this observation.

Claim:

[illegible]

Evidence:

Chapter Open-Response Model Answers

Chapter 1 CER

Claim: Plants kept in darkness contain less starch. Evidence: the dark-treated plants have significantly lower starch after 48 hours. Reasoning: without light, the light-dependent reactions do not supply ATP and NADPH for sustained carbon fixation, while cellular respiration continues consuming stored sugars; therefore less glucose is available for starch synthesis.

Chapter 2 FRQ

(a) Solutions 1 and 3 contain reducing sugars because they produce the positive Benedict's result. (b) Hydrochloric acid contributes to low stomach pH; low pH helps denature dietary proteins and supports pepsin activity. (c) Neutral pH and a negative Benedict's test are consistent with pure water but do not prove it; other neutral solutions without reducing sugars would give the same observations.

Chapter 2 Data Skill: Enzyme Activity vs. pH

- pH 2.
- At pH 2, far from its optimum of pH 8, trypsin's ionic and hydrogen bonds are disrupted. The enzyme denatures: its active site changes shape, it can no longer bind substrate well, and it loses activity.
- At pH 8, pepsin (optimum pH 2) denatures, so its active site no longer fits its substrate. Pepsin is adapted to the acidic stomach, not the basic small intestine.
- The claim is not supported. The data give only each enzyme's peak, not its activity at pH 5. Although pH 5 is 3 units from each optimum, the two activity curves need not be the same shape, so equal activity would have to be measured, not assumed.

Chapter 2 CER

Claim: The acidic water (pH 4) slows bacterial growth by reducing enzyme activity. Evidence: bacteria grow more slowly near the polluted stream, where the pH is 4, than in water closer to the near-neutral pH at which most bacterial enzymes work best. Reasoning: excess H^+ ions disrupt the ionic and hydrogen bonds that hold enzymes in their tertiary structure. The enzymes partly denature, their active sites change shape and bind substrate less effectively, and the reactions that supply ATP and build cell parts slow down, so the cells divide less often.

Chapter 3 SA:V

For side lengths 2, 4, and 8 μm : surface areas are 24, 96, and 384 μm^2 ; volumes are 8, 64, and 512 μm^3 ; SA:V ratios are 3.0, 1.5, and 0.75. The ratio decreases as size increases.

Chapter 3 FRQ

(a) Liver cells carry out energy-demanding work: synthesizing proteins (for example, blood plasma proteins) and glycogen, detoxifying drugs and alcohol, and active transport. Mitochondria make most of the cell's ATP by aerobic respiration, so many mitochondria are needed to supply this ATP. (b) Benefit: more internal space for hemoglobin and greater flexibility; limitation: no nucleus/organelles means no

protein synthesis or repair. (c) The claim is incorrect. First, the mature red blood cell develops from a nucleated eukaryotic precursor cell in the bone marrow and loses its nucleus and organelles during maturation, so the missing nucleus reflects differentiation, not a prokaryotic origin. Second, it is part of a multicellular eukaryotic organism and cannot live or divide independently; a prokaryote is an independent single-celled organism with its own circular DNA in a nucleoid, 70S ribosomes, and (in most bacteria) a cell wall, and it reproduces by binary fission. The red blood cell has no DNA, no ribosomes, no cell wall, and cannot divide.

Chapter 4 Osmosis

Percent mass change = 34%. Water moved into the bag because the bag solution had lower water potential than distilled water. In 50% external sucrose, water would leave the 30% bag because the external solution would have lower water potential. A variable to control is temperature (or bag size, volume of external water, or time), because it changes the rate of water movement; if it differed between trials, the mass change could not be attributed to the sucrose gradient alone.

Chapter 4 FRQ

(a) A is hypotonic: its solute concentration is lower (water potential higher) than inside the RBCs, so water moves into the cells by osmosis; the cells swell and some lyse. B is isotonic: solute concentrations are equal, so there is no net water movement and the cells keep their normal shape. C is hypertonic: its solute concentration is higher (water potential lower), so water moves out of the cells by osmosis and they shrink (crenate). (b) Water also enters a plant cell in a hypotonic solution, but as the central vacuole swells, the rigid cellulose cell wall pushes back. This turgor pressure raises the cell's water potential until net water entry stops, so the cell becomes turgid instead of bursting; an animal cell has no wall, so water keeps entering until it lyses. (c) Place potato cores of equal size and mass in sucrose solutions from 0.0 to 1.0 M for 24 hours. IV: sucrose concentration; DV: percent change in mass; constant: temperature (or core size, solution volume, time); use several cores per concentration. Predicted outcome: cores gain mass in low concentrations and lose mass in high concentrations; on a graph of percent mass change vs. concentration, the point where the line crosses 0% estimates the osmotic concentration of the potato cells.

Chapter 5 Data/Lab

1. Graph: x-axis, substrate concentration (mM); y-axis, reaction rate (units/min). The curve rises steeply at low substrate concentrations, then levels off near 53 units/min. 2. The rate plateaus because nearly all enzyme active sites are occupied (saturated), so the amount of enzyme, not substrate, limits the rate. 3. The rate at 4 mM would fall below 38 units/min: the inhibitor occupies some active sites, so fewer enzyme-substrate complexes form. Adding more substrate can partly overcome this inhibition. 4. At 75°C the rate would drop sharply: heat disrupts the hydrogen and ionic bonds that maintain the enzyme's tertiary structure, so the active site changes shape