

UNIT 3: CELLULAR
ENERGETICS

COGNITOEDU.LINK/AP-BIO-U3

Scan for Unit 3 notes

20 AP-style MCQs across topics 3.1 to 3.5. Practice, review, revisit.

WHAT'S INSIDE

- ✓ 20 MCQs, four options each, in the style of the real AP exam
- ✓ Every question tagged to a Unit 3 topic so you know what to revise
- ✓ Full answer key with a short explanation for every question
- ✓ Mix of standalone and stimulus-style stems, matching real AP question formats

HOW TO USE IT

- 1. Untimed pass.** Work through slowly, aiming for around 90 seconds per question. Read every option before you commit.
- 2. Timed pass.** Redo the pack in 30 minutes. That matches AP exam pace (1.5 minutes per MCQ) and builds stamina.
- 3. Review.** Check the answer key and mark every miss. Revise those topics on Cognito, then retry after a week.

TOPICS COVERED

- **3.1** Enzymes
- **3.2** Environmental Impacts on Enzyme Function
- **3.3** Cellular Energy
- **3.4** Photosynthesis
- **3.5** Cellular Respiration

STRUGGLING WITH A TOPIC?



Any topic tricky? Scan the QR to jump straight to the Unit 3 notes on Cognito. For the full AP Biology course (all 8 units, lessons, quizzes, flashcards and past-paper FRQs), head to **cognitoedu.link/ap-bio-notes**. Rework the questions you got wrong a week later to lock the concepts in.

AP EXAM CONTEXT

12-16% 60

UNIT WEIGHT (MCQ
SECTION)

MCQS ON THE REAL EXAM

1.5m

AVERAGE TIME PER MCQ

AP BIOLOGY

Unit 3: Cellular Energetics

SECTION I · MULTIPLE CHOICE

Time—30 minutes

20 Questions

Directions: Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case and mark it clearly on your answer sheet or circle your choice below.

- Two enzymes catalyze the same reaction but have completely different amino acid sequences. A student claims that they must nevertheless have similarly shaped active sites. Which piece of evidence would best support this claim?
 - Both enzymes are inhibited to the same extent by a competitive inhibitor.
 - Both enzymes are made of a single polypeptide of 200 residues.
 - Each enzyme binds the same substrate molecule and releases the same product mixture.
 - Both enzymes function at neutral pH.
- How does an enzyme speed up a reaction?
 - It lowers the activation energy required for the reaction to proceed.
 - It raises the temperature of the surrounding solution.
 - It provides energy that shifts the reaction's equilibrium.
 - It changes the free energy difference between substrate and product, making the reaction more favorable.

Questions 3, 4 refer to the following information.

The activity of a purified enzyme was measured at five different pH values, holding temperature and substrate concentration constant. Activity is expressed as a percentage of the highest observed rate.

Table 1. Enzyme activity vs. pH

pH	Relative activity (%)
2	5
4	22
6	78
7	100
8	72
10	18

- Based on Table 1, what is the approximate pH optimum of this enzyme?
 - 2
 - 4
 - 7
 - 10

- Which claim about this enzyme is best supported by the data in Table 1?
 - At pH 2 the enzyme is permanently degraded into individual amino acids by hydrolysis of every bond.
 - The enzyme functions best in a strongly acidic environment such as the stomach.
 - Extreme pH shifts the ionization of active-site R groups, lowering activity.
 - pH has no effect on the folding of the enzyme, only on the substrate.

Questions 5, 6 refer to the following information.

Catalase catalyzes the reaction $2 \text{H}_2\text{O}_2 \rightarrow 2 \text{H}_2\text{O} + \text{O}_2$. Students measured the initial rate of O_2 production at varying substrate (H_2O_2) concentrations, with and without a fixed concentration of a noncompetitive inhibitor.

Table 2. Initial rate of O_2 production ($\mu\text{mol}\cdot\text{s}^{-1}$)

$[\text{H}_2\text{O}_2]$ (mM)	No inhibitor	With noncompetitive inhibitor
1	12	6
3	28	14
5	40	20
10	56	28
20	60	30

- Which pattern in Table 2 is most consistent with noncompetitive inhibition of catalase?
 - The inhibitor's effect on the rate disappears completely at high substrate concentration.
 - The inhibitor increases the maximum rate reached at high substrate.
 - The inhibitor has no effect at any substrate concentration tested.
 - The inhibitor halves the rate at every substrate concentration tested here.

AP BIOLOGY · Unit 3: Cellular Energetics · Section I (continued)

6. A student predicts that doubling the enzyme concentration in the 'with inhibitor' assay would restore the reaction rate to near the no-inhibitor value at 20 mM H_2O_2 . Which piece of reasoning best supports this prediction?
- (A) Doubling enzyme doubles the maximum rate, offsetting the halving caused by the inhibitor.
 - (B) More enzyme outcompetes the inhibitor for the active site.
 - (C) More enzyme raises the pH of the assay solution, which inactivates the inhibitor.
 - (D) Doubling enzyme increases the affinity of each active site for H_2O_2 .
7. Why can ATP release usable energy for cellular work?
- (A) The adenine base of ATP absorbs sunlight and re-emits that light directly as usable chemical energy.
 - (B) Hydrolysis of its terminal phosphate releases free energy that cells can direct into other reactions.
 - (C) It contains four phosphate groups, and removing one releases usable chemical energy.
 - (D) It builds long chains that break down into monomers to release energy.
8. In muscle cells, the Na^+/K^+ ATPase pumps 3 Na^+ out of the cell and 2 K^+ in against their concentration gradients, using the hydrolysis of one ATP molecule. Which term best describes this arrangement?
- (A) Facilitated diffusion of Na^+ and K^+ driven by their existing electrochemical gradients.
 - (B) Energy coupling that links ATP hydrolysis to an unfavorable transport step.
 - (C) An equilibrium reaction requiring no net energy input.
 - (D) A spontaneous reaction that releases heat instead of doing work.

Questions 9, 10 refer to the following information.

The action spectrum for photosynthesis in a green alga (rate of O_2 evolution) and the absorption spectrum of chlorophyll a were both measured at the same wavelengths of light. Each column is expressed as a percentage of that column's own maximum.

Table 3. Chlorophyll a absorption and photosynthetic rate vs. wavelength (each as % of its own maximum)

Wavelength (nm)	Color	Chlorophyll a absorption (relative)	Rate of photosynthesis (relative)
430	Violet-blue	100	95
500	Blue-green	8	24
550	Green	5	15
600	Orange	23	43
680	Red	93	100

9. Which statement is best supported by comparing the two columns of Table 3?
- (A) Photosynthesis uses only the wavelengths that chlorophyll a absorbs; other wavelengths of light are useless to the alga.
 - (B) Chlorophyll a absorbs most strongly in green light, which drives most photosynthesis.
 - (C) Photosynthetic rate tracks chlorophyll a absorption but shows extra activity in wavelengths chlorophyll a absorbs poorly.
 - (D) The action spectrum and the absorption spectrum are identical at every wavelength tested.
10. The chloroplasts of the alga contain both chlorophyll a and carotenoids. Which additional experiment would most directly test whether carotenoids transfer light energy to the photosynthetic machinery?
- (A) Measure carotenoid concentration in the leaves of a land plant such as a bean or maize seedling.
 - (B) Grow the alga in the dark for 48 hours and then measure O_2 release.
 - (C) Repeat the experiment using far-red light beyond 700 nm.
 - (D) Isolate carotenoids, measure their absorption spectrum, and compare it to the action-spectrum bump.

AP BIOLOGY · Unit 3: Cellular Energetics · Section I (continued)

Questions 11, 12, 13 refer to the following information.

The oxygen release rate of an aquatic plant (*Elodea*) was measured under white light of increasing intensity, at two different CO₂ concentrations, at constant temperature (25°C).

Table 4. O₂ release rate (bubbles per minute)

Light intensity (lux)	Low CO ₂ (0.03%)	High CO ₂ (1.0%)
0	0	0
500	8	9
1,000	16	18
2,000	22	40
4,000	22	55
8,000	22	60

11. Which variable is limiting the photosynthetic rate at 4,000 lux in the low-CO₂ treatment in Table 4?
- (A) Light intensity
(B) CO₂ concentration
(C) Water availability
(D) Temperature
12. Which prediction about the plants in this experiment is best supported by Table 4?
- (A) In the low-CO₂ trial, doubling light intensity from 8,000 to 16,000 lux would double the O₂ release rate.
(B) At 16,000 lux with high CO₂, the O₂ release rate would rise sharply above 60 bubbles/min.
(C) In the high-CO₂ trial, the O₂ release rate would plateau close to 60 bubbles/min at 16,000 lux.
(D) Removing all CO₂ would leave the O₂ release rate unchanged in either trial.
13. Which best explains why the high-CO₂ trial reaches a much higher plateau rate than the low-CO₂ trial?
- (A) Higher CO₂ speeds the light-dependent reactions in the thylakoids by absorbing more photons directly.
(B) Higher CO₂ shifts water into O₂ more efficiently in photosystem II.
(C) Higher CO₂ lowers the activation energy of chlorophyll excitation.
(D) Higher CO₂ raises the maximum rate at which the Calvin cycle fixes carbon.
14. A researcher claims that oxidative phosphorylation produces more ATP per glucose than any other stage of eukaryotic aerobic respiration. Which piece of evidence best supports this claim?
- (A) Glycolysis in the cytoplasm can proceed in the absence of oxygen, unlike the mitochondrial steps of respiration.
(B) The Krebs cycle produces CO₂ as a waste product.
(C) Substrate-level phosphorylation in glycolysis plus the Krebs cycle yields about 4 ATP per glucose, while the electron transport chain and ATP synthase generate the rest.
(D) Pyruvate is oxidized in the mitochondrial matrix.

AP BIOLOGY · Unit 3: Cellular Energetics · Section I (continued)

Questions 15, 16 refer to the following information.

Isolated mitochondria were provided with pyruvate, O_2 , ADP, and inorganic phosphate (Pi). At time 0, various treatments were added and the rate of O_2 consumption was measured over the next 5 minutes.

Table 5. Mitochondrial O_2 consumption under different treatments

Treatment	O_2 consumption ($nmol \cdot min^{-1}$)
Control (buffer only)	220
Cyanide (blocks Complex IV)	5
Oligomycin (blocks ATP synthase)	40
DNP (proton ionophore, uncoupler)	410
No pyruvate	18

15. Which conclusion about the electron transport chain is best supported by the cyanide treatment in Table 5?
- (A) Oxygen is consumed at a normal rate even when the electron transport chain is fully blocked.
- (B) Cyanide accelerates electron flow but blocks ATP synthesis.
- (C) Cyanide uncouples oxidation from phosphorylation, raising O_2 use.
- (D) Cyanide prevents electrons from reaching O_2 , so O_2 consumption drops.
16. Which claim about DNP is best supported by the data in Table 5?
- (A) DNP directly blocks Complex IV of the electron transport chain, so mitochondrial O_2 consumption falls to near zero.
- (B) DNP lets protons re-enter the matrix bypassing ATP synthase, so ETC speeds up while ATP synthesis falls.
- (C) DNP inhibits pyruvate uptake, mimicking the 'no pyruvate' condition.
- (D) DNP has no effect because oxygen supply is limiting.

Question 17 refers to the following information.

Yeast were provided with equal masses of three different sugars in a sealed chamber, and the rate of CO_2 production from fermentation was measured under identical anaerobic conditions.

Table 6. CO_2 production by yeast under anaerobic conditions

Substrate	CO_2 ($mL \cdot min^{-1}$)
Glucose	3.8
Sucrose	3.5
Lactose	0.1
No sugar (water)	0.05

17. Which claim about the yeast in Table 6 is best supported by the data?
- (A) The yeast ferments sucrose but cannot take up and/or hydrolyze lactose.
- (B) The yeast prefers lactose to glucose because it produces less CO_2 per minute from lactose in this assay.
- (C) Fermentation of glucose produces no CO_2 ; the CO_2 comes from cell wall breakdown.
- (D) Lactose is toxic to yeast in these conditions.
18. A biologist compares ATP yield per glucose in two conditions: a muscle cell running purely on glycolysis (during a sprint) versus a muscle cell running aerobic respiration to completion. Which comparison is best supported by the biochemistry of cellular respiration?
- (A) Both conditions yield the same ATP because a molecule of glucose stores the same total energy in every cell.
- (B) The sprinting cell yields ~2 ATP per glucose; the aerobic cell yields ~30–32 ATP.
- (C) The sprinting cell yields more ATP because fermentation regenerates NAD^+ faster than the electron transport chain.
- (D) The sprinting cell yields zero ATP because no O_2 is available.

AP BIOLOGY · Unit 3: Cellular Energetics · Section I (continued)

Questions 19, 20 refer to the following information.

Students measured the rate of a metabolic reaction in three organisms across the same temperature range.

Table 7. Reaction rate vs. temperature (arbitrary units)

Temperature (°C)	Bacterium A	Fungus B	Mammal C
10	5	3	1
20	12	8	2
30	24	16	4
40	42	9	8
50	26	1	0

19. Based on Table 7, which organism's enzymes appear to be most heat-tolerant?
- (A) Fungus B, because its reaction rate reaches its maximum value at 30°C in this dataset.
- (B) Mammal C, because its rate is nonzero at 10°C.
- (C) Bacterium A, because its rate rises to 40°C and is still measurable at 50°C.
- (D) All three organisms show identical heat tolerance.
20. Which claim best explains why the reaction rate in Fungus B falls above 30°C?
- (A) The enzyme is denaturing; heat disrupts the weak interactions that hold the active site in shape.
- (B) Substrate molecules stop moving at high temperatures, so productive collisions with the enzyme become rare in solution.
- (C) ATP is consumed too quickly at high temperatures, so the reaction has no fuel.
- (D) The reaction becomes exergonic only above 50°C, so it slows below that threshold.

Q1. Answer: A

Topic 3.1 · Enzymes

A competitive inhibitor binds the active site itself, so equal inhibition by the same competitive inhibitor is direct evidence that both active sites accept it and therefore have similarly shaped binding pockets. C only restates the stem: catalyzing the same reaction means the same substrate goes in and product comes out, which is given, not evidence. B (same length) says nothing about the fold. D (both work at neutral pH) is a weak match that says nothing specific about active-site shape.

Q2. Answer: A

Topic 3.1 · Enzymes

Enzymes stabilize the transition state, which lowers activation energy so a larger fraction of substrate molecules have enough energy to react at a given temperature. Enzymes do not add heat (B) or energy (C), and they do not change ΔG or the position of equilibrium (D); they only change how fast equilibrium is reached.

Q3. Answer: C

Topic 3.2 · Environmental Impacts on Enzym...

Activity peaks at pH 7 (100% relative activity) and drops on either side (78 at pH 6, 72 at pH 8, then further at 4 and 10). This is the pH optimum for this enzyme. Very low pH (2, 4) and high pH (10) all show much lower activity because they disrupt the ionization of R groups in the active site, changing the enzyme's shape.

Q4. Answer: C

Topic 3.2 · Environmental Impacts on Enzym...

Activity drops sharply on both sides of pH 7. Extreme H^+ or OH^- concentrations change the charge state of ionizable R groups (Asp, Glu, Lys, His, etc.), altering hydrogen bonding and ionic interactions that hold the active site in shape. A overstates the damage: without a test returning the enzyme to pH 7, the data can't show the damage is permanent. B contradicts the pH 2 activity. D ignores that pH affects the enzyme's own structure.

Q5. Answer: D

Topic 3.2 · Environmental Impacts on Enzym...

A noncompetitive inhibitor binds a site away from the active site, and adding more substrate cannot displace it, so it lowers the maximum rate by the same fraction at every substrate concentration. Table 2 shows the 'with inhibitor' column is exactly half of the 'no inhibitor' column at every $[H_2O_2]$. A describes competitive inhibition, which would show narrowing effect at high substrate; the data show the same halving throughout. B contradicts the data (max rate falls, not rises). C contradicts the data at every concentration.

Q6. Answer: A

Topic 3.2 · Environmental Impacts on Enzym...

The maximum rate is proportional to enzyme concentration. Doubling enzyme doubles the maximum rate the system can reach, so a noncompetitive inhibitor that halves rate is offset. B describes competitive inhibition; a noncompetitive inhibitor binds a separate site, so extra enzyme cannot outcompete it at the active site. C invents a pH change that adding more of the same enzyme protein would not cause. D confuses concentration with affinity: adding more enzyme does not change how tightly each active site binds substrate.

Q7. Answer: B

Topic 3.3 · Cellular Energy

Hydrolysis of ATP to ADP + Pi is strongly exergonic (about -30 kJ/mol), and cells channel that released free energy into reactions that would not proceed on their own, such as muscle contraction and active transport. A is false (light absorption is a photosynthesis pigment role, not ATP's). C is wrong on the structure: ATP has three phosphates, not four. D describes polymer hydrolysis, not ATP.

Q8. Answer: B

Topic 3.3 · Cellular Energy

Coupling links a favorable reaction (ATP hydrolysis, which is spontaneous) to an unfavorable one (moving ions against their gradients) so the total ΔG is negative and the transport step proceeds. This is how ATP powers active transport. A is wrong because facilitated diffusion goes down a gradient without ATP. C ignores that the ions are moved against their gradients, which needs energy input. D contradicts that the released energy is used to do transport work.

Q9. Answer: C

Topic 3.4 · Photosynthesis

Chlorophyll a peaks at 430 and 680 nm (100% and 93% of its own max) and photosynthesis is high there too (95% and 100%). But photosynthesis at 500 and 600 nm is well above what chlorophyll a absorption alone would predict (24% vs 8% at 500 nm; 43% vs 23% at 600 nm), evidence that accessory pigments (carotenoids) absorb light there and pass energy to chlorophyll a. A ignores the 500 nm rate. B contradicts the low absorption at 550 nm (green). D contradicts the mismatch at 500 and 600 nm.

Q10. Answer: D

Topic 3.4 · Photosynthesis

If carotenoids drive the extra photosynthesis at 500 nm, the carotenoid absorption spectrum should peak in that region. Comparing an isolated carotenoid spectrum to the action-spectrum bump would provide the strongest evidence. A is not comparable across species. B measures no pigment property. C tests different wavelengths and cannot explain 500 nm activity.

Q11. Answer: B

Topic 3.4 · Photosynthesis

The low-CO₂ rate plateaued at 22 bubbles/min from 2,000 lux onward; adding more light did not increase rate. At the same intensities, the high-CO₂ trial gave much higher rates (55 at 4,000 lux), showing that CO₂ (not light) is the current bottleneck. Temperature was held constant in the setup, and the aquatic plant is submerged in water, so those are not the limiting variables here.

Q12. Answer: C

Topic 3.4 · Photosynthesis

The high-CO₂ rate is already flattening: 55 at 4,000 lux and 60 at 8,000 lux. Extrapolating that trend, another doubling of light adds little because some factor other than light (for example, Calvin-cycle enzyme capacity) is becoming the bottleneck. A is contradicted by the low-CO₂ plateau from 2,000 lux onward, which shows CO₂ (not light) is the limit there. B contradicts the flattening trend. D is false because O₂ release depends on CO₂ (Calvin cycle needs CO₂ to regenerate substrates).

Q13. Answer: D

Topic 3.4 · Photosynthesis

The Calvin cycle uses rubisco to fix CO₂ onto RuBP. More CO₂ raises the maximum rate at which carbon can enter the cycle, so more Calvin-cycle turnovers demand more ATP and NADPH from the light reactions, raising O₂ output. CO₂ does not absorb light for photosynthesis (A) and is not the substrate of photosystem II (water is) (B). C misassigns activation energy.

Q14. Answer: C

Topic 3.5 · Cellular Respiration

Substrate-level phosphorylation in glycolysis and the Krebs cycle contributes only about 4 ATP per glucose combined. Everything else generated during aerobic respiration comes from the electron transport chain feeding ATP synthase, so oxidative phosphorylation is by far the largest source of ATP per glucose. A, B, and D state true facts but none of them address ATP yield.

Q15. Answer: D

Topic 3.5 · Cellular Respiration

O₂ is the final electron acceptor at Complex IV. Cyanide blocks Complex IV, so electrons cannot reach O₂ and O₂ consumption collapses from 220 to 5 nmol·min⁻¹. A is contradicted by the near-zero rate. B is wrong because blocking Complex IV halts electron flow. C describes DNP, not cyanide.

Q16. Answer: B

Topic 3.5 · Cellular Respiration

DNP is a proton ionophore that shuttles H⁺ across the inner membrane, dissipating the proton gradient. With the gradient's back-pressure removed, electron transport speeds up (consuming more O₂, 410 vs 220 nmol/min), while ATP synthase cannot use the collapsed gradient to make ATP. A is contradicted (O₂ use rose). C would drop O₂ use to the 'no pyruvate' level. D is contradicted by the change from 220 to 410.

Q17. Answer: A

Topic 3.5 · Cellular Respiration

High CO₂ output from glucose and sucrose shows the yeast can ferment both. Sucrose is a disaccharide of glucose and fructose; splitting it with an invertase yields fermentable monomers. Lactose gives essentially no CO₂ (near the water control), so the yeast lacks the ability to take up and/or hydrolyze lactose. B misreads 'less CO₂' as 'prefers.' C contradicts fermentation biochemistry. D is not supported (no toxicity data).

Q18. Answer: B

Topic 3.5 · Cellular Respiration

Glycolysis nets 2 ATP per glucose by substrate-level phosphorylation, and lactic acid fermentation produces no additional ATP; it only regenerates NAD⁺ so glycolysis can continue. When O₂ is available, pyruvate feeds the Krebs cycle and the electron transport chain, and oxidative phosphorylation adds another ~26 to 28 ATP for a total of about 30 to 32 ATP per glucose. A ignores that fermentation leaves most of glucose's chemical energy locked in lactate. C is wrong: fermentation gives fewer ATP per glucose than aerobic respiration. D is wrong: glycolysis itself does not require O₂ and still yields 2 ATP.

Q19. Answer: C

Topic 3.2 · Environmental Impacts on Enzym...

Bacterium A has its highest rate at 40°C and still shows substantial activity at 50°C (26 units), while Fungus B collapses to 1 unit and Mammal C drops to 0 at 50°C. That is direct evidence of heat-tolerant enzymes. A misreads peak temperature as tolerance. B confuses cold performance with heat tolerance. D contradicts the visible spread.

Q20. Answer: A

Topic 3.2 · Environmental Impacts on Enzym...

Heat above an enzyme's tolerance breaks the weak interactions (hydrogen bonds, hydrophobic interactions, ionic interactions) that stabilize tertiary structure. The active site loses its shape and can no longer bind substrate. The classic signature is a rate that rises with temperature, peaks, then falls off steeply as denaturation dominates. Fungus B follows exactly this shape (3, 8, 16, 9, 1 across 10 to 50°C). B is wrong: molecular motion increases with temperature. C is unrelated to substrate binding. D misuses the term exergonic.