The Simple AP® Biology Unit 3 Cheat Sheet

3.1–3.2 Enzyme Structure & Catalysis

Structure

Enzyme = biological catalyst (usually a protein). Speeds up a rxn; NOT used up.
Active site: a pocket w/ a specific shape + charge → binds only its matching **substrate**.
Induced fit: substrate binding shifts the active site's shape → a tighter fit → bonds strain.
Specificity: shape & charge must match; shape comes from protein folding (1°→4°).

How Catalysis Works

Activation energy (E_a): energy needed to start a rxn. Enzymes ↓ E_a → rate ↑ a lot.

ΔG unchanged: enzyme doesn't change the energy of reactants or products.
Reused: E + S → ES complex → E + product. The enzyme is freed to work again.

Graph feature	Means
Hump height	E_a
Lower hump	Enzyme present
Products below	Releases energy

Helpers

Cofactors (metal ions like Mg^{2+}) and **coenzymes** (vitamin-based, e.g., NAD^+) help enzymes work.
Fast: one enzyme can handle thousands of substrate molecules every second.

⚠ Enzymes lower Ea but never change ΔG.

✓ Enzyme curve on an energy graph: lower peak, but the same start & end heights.

3.3 Environmental Impacts on Enzymes

Temp & pH

Temp ↑ → more collisions → rate ↑ up to the **optimum**. Too hot → shape lost (**denatured**).
Cold: slower (fewer collisions), but the shape stays intact → works again when warmed.
pH: off the optimum → R-group charges shift → the active site's shape is lost (pepsin ~2).
Optimums differ: stomach pepsin ~pH 2; human enzymes ~37 °C; hot-spring microbes 70 °C+.

Concentration

More substrate → rate ↑ until all active sites are busy (the **saturation** plateau on a graph).
More enzyme → a higher max rate (as long as there's plenty of substrate to go around).

Inhibitors

Type	Binds	More S helps?
Competitive	Active site	Yes
Noncompet.	Other site	No

Competitive: looks like substrate; blocks the active site. Lots of substrate outcompetes it.
Noncompetitive (allosteric): binds elsewhere → shape shifts → max rate ↓ for good.
Feedback inhibition: a pathway's end product shuts off an early enzyme → no overproduction.
Salt: ions disrupt bonds between R groups → the shape shifts → activity ↓, like pH.

⚠ Denaturation = lost 3D shape, not broken peptide bonds. Often permanent.

✓ Inhibitor curve still reaches the same plateau at high [S] → it's a competitive inhibitor.

3.4 Cellular Energy

Energy Rules

1st law: energy is converted from one form to another, never created or destroyed.
2nd law: every transfer loses some energy as heat → disorder (entropy) ↑. Cells need a constant energy input to stay alive & ordered.
Life stays ordered by using energy + releasing heat; total disorder in the universe still goes ↑.

Releasing vs Absorbing

Rxn	ΔG	Example
Exergonic	– (releases)	Cell resp.
Endergonic	+ (absorbs)	Photosyn.

Catabolic = breaks molecules (releases energy).
Anabolic = builds them (needs energy).

ATP & Coupling

ATP (adenine + ribose + 3 phosphates): breaking off a phosphate → ADP + P_i + energy.

Energy coupling: ATP's energy release powers the rxns that need energy (+ΔG) to run.
ATP cycle: cell resp. rebuilds ATP from ADP + P_i.

Phosphorylation: ATP hands a phosphate to a protein → shape shifts (pumps, motors).
Pathways: one rxn's product = the next rxn's substrate; each step has its own enzyme.

⚠ Energy is never "used up." It changes form, and some is always lost as heat each step.

✓ Coupling: add the ΔGs. A negative total → the paired reactions can proceed.

3.5 Photosynthesis: Light Reactions

Big Picture

Equation: $6CO_2 + 6H_2O$ + light → $C_6H_{12}O_6 + 6O_2$.
Where: light rxns in the **thylakoid membranes**; the Calvin cycle in the **stroma** (the fluid).
First evolved in prokaryotes (cyanobacteria) → put the O_2 in Earth's air → aerobic life.
Overall: light energy → chemical energy in sugar.

Step by Step

1) Photosystem II: light excites e^- in chlorophyll → the e^- leave and enter the ETC (e^- transport chain).
Photosystem: many pigments funnel light energy to one chlorophyll *a* center, like an antenna.
2) Water split: replaces those e^-; releases **O_2**.
3) ETC: pumps H^+ into the **thylakoid space**.
4) Photosystem I: light re-energizes the e^- → they help make **NADPH** for the Calvin cycle.
5) ATP synthase: H^+ flows out → makes ATP.

Input	Output
Light, H_2O	O_2
ADP, $NADP^+$	ATP, NADPH

Chlorophyll absorbs red & blue light best; it reflects green (why leaves look green).
Carotenoids absorb other colors (blue-green) → widen the range of light a plant can use.
Stacked thylakoids → more membrane area → room for more photosystems + ETCs.

⚠ The O_2 released comes from WATER, not CO_2.

✓ H^+ is pumped INTO the thylakoid space, then flows OUT through ATP synthase.

3.5 Photosynthesis: Calvin Cycle

Three Phases (Stroma)

1) Carbon fixation: the enzyme **rubisco** attaches CO_2 to RuBP (a 5-C sugar) in the stroma.
2) Reduction: ATP + NADPH turn the product into **G3P** (a 3-C sugar) that can leave the cycle.
3) Regeneration: most G3P rebuilds RuBP so the cycle can keep going & fix more CO_2.
Count: 3 CO_2 → 1 G3P. 2 G3P → 1 glucose.
Needs light rxns: uses their ATP & NADPH → stops soon after it gets dark outside.
"Light-independent" ≠ "happens in the dark".

Light Rxns vs Calvin

	Light	Calvin
Where	Thylakoid	Stroma
Uses	Light, H_2O	CO_2, ATP
Makes	ATP, O_2	Sugar (G3P)

Predict the Effect

No light → ATP & NADPH run out → the Calvin cycle stops making sugar within minutes.
No CO_2 → no carbon fixation → no sugar made.
Measure rate by O_2 made, CO_2 used, or how fast punched leaf disks float up in solution.
DCPIP lab: blue dye turns clear as it takes e^- → faster fade = faster photosynthesis.

⚠ Plants also do cellular respiration, day and night, in every living cell of the plant.

✓ FRQ: link the light rxn products (ATP, NADPH) to the Calvin cycle's inputs, step by step.

3.6 Respiration: Glycolysis → Krebs

Big Picture

Equation: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + ATP.
NADH & $FADH_2$: carry e^- (energy) to the ETC.
Exergonic: glucose loses e^- (oxidized); O_2 gains them (reduced) → forms water at the end.

Stage	Where	Makes
Glycolysis	Cytosol	2 ATP, NADH
Krebs	Matrix	2 ATP, NADH, CO_2
ETC	Inner memb.	~26–28 ATP

Glycolysis

Glucose → 2 pyruvate. Net 2 ATP. No O_2 needed.
In nearly all life → evidence of common ancestry.
Uses 2 ATP, makes 4 → net 2 ATP + 2 NADH.

Pyruvate Oxidation & Krebs

Pyruvate oxidation: pyruvate → acetyl-CoA + CO_2 + NADH in the mitochondrial matrix.
Krebs cycle: acetyl-CoA broken down → CO_2 + NADH + $FADH_2$ + a little ATP (2 per glucose).
Carbons: all 6 glucose carbons leave as CO_2.
2 turns of Krebs per glucose (one per pyruvate).
Other fuels: fats & proteins also feed into Krebs.
Regulation: lots of ATP slows glycolysis down (feedback inhibition of an early enzyme, PFK).

⚠ The CO_2 you exhale comes from glucose. The O_2 you breathe ends up in water.

✓ After Krebs, most of the energy is still held in NADH & $FADH_2$, not in ATP yet.

3.6 ETC, Chemiosmosis & Fermentation

Electron Transport Chain

NADH, $FADH_2$ drop off their e^- at proteins in the **inner mito membrane** (cristae folds).
e^- move down the chain → the energy pumps H^+ into the **intermembrane space** (gradient).
O_2 = final e^- acceptor → forms H_2O. No O_2 → the whole chain backs up and stops.
Why O_2: pulls e^- strongly → biggest energy release. **Cyanide** blocks the chain.

Chemiosmosis

H^+ flows back through **ATP synthase** → makes most of the cell's ATP (chemiosmosis).
Uncouplers (brown fat): let H^+ leak back across → heat is made instead of ATP (keeps babies warm).
Prokaryotes: ETC sits in the plasma membrane.

No O_2? Fermentation

Type	Product	Who
Lactic acid	Lactate	Muscle
Alcoholic	Ethanol, CO_2	Yeast

Purpose: recycle NAD^+ from NADH → glycolysis keeps making its 2 ATP per glucose.
Yield: aerobic ~30–32 ATP/glucose vs only 2 for fermentation (~15× more per glucose).
Yeast switch between respiration & fermentation as O_2 levels change (facultative).

⚠ Fermentation makes NO extra ATP. It just recycles NAD^+ for glycolysis to use.

✓ Block the ETC or remove O_2 → no H^+ gradient → ATP synthase stops making ATP.

3.7 Fitness & Unit 3 Exam Strategy

3.7 Variation = Fitness

Molecular variation helps a population survive in more environments → ↑ fitness.
Pigments: different ones absorb different light → more of the light gets used (shade, deep water).
Enzyme variants work at different temps or pH.
Fermentation lets organisms survive low O_2.
Brown fat (uncoupling) makes heat → helps mammals stay warm in the cold.

Photo vs Resp.

	Photo.	Resp.
Organelle	Chloroplast	Mitochond.
e^- from	H_2O	Glucose
e^- end at	$NADP^+$	O_2

Exam Moves

Predict: name the blocked step → what piles up → what runs out → the effect on ATP made.
Graphs: rate = slope. Name the IV, DV and controls (e.g., a boiled enzyme tube, no light).
Math: rate = change in amount ÷ time (mL O_2/min).
Data trap: a plateau can mean saturation, not a broken (denatured) enzyme. Check [S].
Links: Unit 1 protein shape → Unit 2 membranes → Unit 8 energy flow in food webs & ecosystems.

⚠ Both organelles use an ETC + ATP synthase.

✓ Justify with mechanism: "no H^+ gradient → no ATP" beats "less energy" on FRQs.