AP Biology Unit 3: Cellular Energetics Study Guide

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A seedling turns toward sunlight; a runner uses stored food during a race. Both depend on cells transferring energy. Cellular energetics connects enzymes, ATP, cellular respiration and photosynthesis into one useful question: how does a cell obtain energy and use it to do work?

What Unit 3 covers

College Board lists Cellular Energetics as 12%-16% of the multiple-choice section , not a fixed fraction of every exam question. Check the current AP Biology course framework for scope and updates. Begin with membranes, organelles, proteins and the difference between a reactant and a product.

Enzymes speed reactions without supplying the energy

An enzyme is a biological catalyst. Most are proteins; some RNA molecules also catalyze reactions. A substrate is a reactant an enzyme acts on. The enzyme lowers the activation-energy barrier, so a reaction can occur faster. It does not change the reaction’s overall free-energy change or equilibrium position.

Temperature, pH, substrate concentration and inhibitors can affect activity. When you read a graph, identify the variable on each axis and what was held constant. A fall in activity at high temperature can be consistent with an enzyme losing its functional shape; a graph alone does not prove every possible mechanism.

ATP and energy coupling

ATP hydrolysis converts ATP and water into ADP and inorganic phosphate. The overall reaction releases free energy under typical cellular conditions. Breaking a bond alone requires energy; it is misleading to say that energy is released simply because the terminal phosphate bond breaks.

Coupling links an energy-releasing process to one that requires energy, often through transfer of a phosphate group. Think about the combined reaction, not ATP as a tiny battery that works without interacting with another molecule. See OpenStax on ATP and coupling .

Cellular respiration: follow carbon, electrons and protons

Stage in a eukaryotic cell	Location	Main events per glucose
Glycolysis	Cytosol	One glucose becomes two pyruvate; net 2 ATP and 2 NADH.
Pyruvate oxidation	Mitochondrial matrix	Two pyruvate become two acetyl-CoA; CO_2 and NADH are produced.
Citric acid cycle	Mitochondrial matrix	Acetyl groups are oxidized; electron carriers, CO_2 and a small amount of ATP or GTP are produced.
Oxidative phosphorylation	Inner mitochondrial membrane	Electron transfer builds a proton gradient; ATP synthase uses the gradient to make most of the ATP.

NADH and $FADH_2$ carry high-energy electrons. Oxygen is the final electron acceptor in aerobic respiration and is reduced to water. ATP yield varies with the organism, transport costs, proton leak and how intermediates are used; do not treat the old guide's "36-38 ATP" as a universal fixed yield. OpenStax explains these sources of variation .

What changes without oxygen?

Without a functioning aerobic electron-transport chain, cells cannot sustain that route of oxidative phosphorylation. Fermentation regenerates NAD^+ so glycolysis can continue; fermentation itself does not add ATP beyond glycolysis's net two ATP per glucose. Some organisms use other terminal electron acceptors in anaerobic respiration, which is different from fermentation. Avoid reducing the physiology of exercise or muscle discomfort to a single "lactic acid" explanation.

Photosynthesis: two linked stages

Stage	Location in chloroplast	Role
Light-dependent reactions	Thylakoid membrane	Light drives electron transfer, water supplies electrons and oxygen is released; ATP and NADPH form.
Calvin cycle	Stroma	Uses ATP and NADPH to fix CO_2 and produce G3P, a three-carbon molecule used to build sugars and other compounds.

Photosynthesis and respiration connect through matter and energy, but one is not simply the other pathway running backward. Plants perform cellular respiration as well as photosynthesis. C4 and CAM pathways are useful extensions for understanding carbon fixation and water conservation; distinguish extensions from the details required by your course.

Worked example: interpreting an enzyme experiment

A class measures product formation at the same temperature and pH. At low substrate concentration the rate rises as more substrate is added; at high concentration the graph levels off.

1. Identify the response: rate of product formation.

2. Identify the changed condition: substrate concentration.

3. Explain the initial rise: more substrate can encounter available active sites.

4. Explain the plateau: with enzyme amount fixed, active-site availability can limit the rate.

5. Propose a check: increase enzyme concentration while keeping other conditions controlled, then compare the curves.

Practice explaining, then check

Practice: Why does a disrupted proton gradient reduce ATP synthesis?

ATP synthase depends on the electrochemical gradient to drive phosphorylation of ADP. If the gradient dissipates, less potential energy is available through that mechanism even if some electron transfer continues.

Practice: Does an enzyme make an energetically unfavorable reaction favorable?

No. It changes the reaction rate by lowering activation energy. Energy coupling or different conditions can affect overall favorability; the enzyme alone does not change Delta G.

Your study plan

1. Draw the mitochondrion and chloroplast with labelled compartments.

2. Trace carbon atoms, electrons and protons separately.

3. Explain how a change in conditions changes a graph or process.

4. Return to missed ideas after a break and try a new question.

Use our AP Biology subject page to find support. Exam dates change each year; use College Board’s current exam information rather than the date printed in the recovered 2025 article.

References

https://apcentral.collegeboard.org/courses/ap-biology

https://openstax.org/books/biology/pages/6-4-atp-adenosine-triphosphate

https://openstax.org/books/biology-2e/pages/7-4-oxidative-phosphorylation

Read the companion article:
https://refreshkid.com/blog/ap-biology-unit-3-cellular-energetics-explained-key-concepts-and-study-guide-free-pdf/