

Biology — Prep & Practice Guide

Topic: Photosynthesis and cellular respiration

How to use this guide. If this material is new to your child, read Part A together first, then do Part B. If it has already been taught, try Part B first — and use Part A afterwards for whatever was missed. Either way, upload the finished Part B pages as a Performance Review with this guide as the prior guide: the answers come back with that review, and it ends with the next practice set.

Part A — Learn

6 short lessons, one for each idea in the practice test that follows. Each says what the idea is in the course's own method, works one example with the reasoning before the answer, and names the mistake to watch for. Each lesson also has a two-minute video, on this guide's page in your Guru portal.

Writing and labeling the overall equations for photosynthesis and cellular respiration

Photosynthesis and cellular respiration each have one overall equation that summarizes many smaller reactions. Photosynthesis takes carbon dioxide, water, and light energy and produces glucose and oxygen. Cellular respiration takes glucose and oxygen and produces carbon dioxide, water, and usable energy in the form of about 30 to 32 ATP. You should be able to write both equations and label which side is reactants and which side is products. Notice that the two equations are mirror images of each other — the products of one are the reactants of the other, which is why the course calls them complementary processes. This idea applies anytime a question asks you to recall, write, or label either equation.

WORKED EXAMPLE

Write the balanced overall equation for photosynthesis and label the reactants and products.

Start with what photosynthesis needs as inputs: carbon dioxide, water, and light energy — these go on the left side as reactants. Then write what it makes as outputs: glucose and oxygen — these go on the right side as products. Use the correct numbers of molecules: 6 CO_2 and 6 H_2O react to form 1 $\text{C}_6\text{H}_{12}\text{O}_6$ and 6 O_2 , so the equation balances in atoms. Label each side clearly since the worksheet asks for labeling, not just the equation.

Answer: $6 \text{CO}_2 + 6 \text{H}_2\text{O} + \text{light energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2$, where CO_2 , H_2O , and light energy are reactants, and glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) and O_2 are products.

WATCH OUT — Students often reverse the equations or mix up which gas is consumed and which is released in each process. Check yourself by asking which process needs light — only photosynthesis does — and make sure CO_2 is a reactant there, not a product.

Locating the light-dependent reactions and Calvin cycle and identifying their inputs/outputs

Photosynthesis happens in the chloroplast in two connected stages, and each stage has its own location and job. The light-dependent reactions happen in the thylakoid membranes, where chlorophyll absorbs light and splits water, producing ATP, NADPH, and oxygen. The Calvin cycle happens in the stroma, the fluid surrounding the thylakoids, and it uses the ATP and NADPH from the light reactions along with CO_2 to build G3P, a 3-carbon sugar that is later used to make glucose. The two stages are linked: the light reactions supply energy carriers that the Calvin cycle spends, and the Calvin cycle returns ADP and NADP^+ for the light reactions to reuse. This matters whenever a question asks where something happens or what goes in and out of each stage.

WORKED EXAMPLE

Where does the Calvin cycle take place, and what two energy carriers does it use, plus what gas does it take in?

Recall that photosynthesis has two stages in two different chloroplast locations. The light reactions happen in the thylakoid membranes, so by elimination the Calvin cycle must happen in the other chloroplast compartment, the stroma. Next, think about what the Calvin cycle needs to build sugar: it needs energy, which comes from ATP, and reducing power, which comes from NADPH — both made in the light reactions. Finally, remember the carbon source: the Calvin cycle pulls in CO_2 from the air to provide the carbon atoms for glucose.

Answer: The Calvin cycle takes place in the stroma. It uses ATP and NADPH as energy carriers, and it takes in carbon dioxide (CO_2).

WATCH OUT — Students often swap the two stages' locations or forget that the Calvin cycle still needs the light reactions even though it doesn't use light directly. Double-check by asking: does this stage make ATP/NADPH (light reactions) or use them (Calvin cycle)?

Explaining the source of photosynthetic oxygen vs. the source of glucose's carbon (correcting the CO_2/O_2 mix-up)

A very common misconception is that the oxygen plants release comes from carbon dioxide. In fact, the oxygen gas released during photosynthesis comes from splitting water molecules in the light-dependent reactions, not from CO_2 . The carbon atoms that end up in glucose come from carbon dioxide, which is fixed during the Calvin cycle by the enzyme rubisco. So water is the source of oxygen, and CO_2 is the source of glucose's carbon — these are two separate jobs done by two separate molecules. This idea applies whenever a question tests whether you understand where atoms actually go during photosynthesis, not just which gases are involved overall.

WORKED EXAMPLE

A student says, "The oxygen released by plants comes from carbon dioxide." Is the student right? Explain.

First, recall which stage produces oxygen gas — that happens in the light-dependent reactions, in the thylakoid membranes. Next, recall what gets split there: light energy splits water molecules (H_2O), and splitting water releases O_2 as a byproduct. Then consider what CO_2 is used for instead: CO_2 is fixed in the Calvin cycle to build the carbon backbone of glucose, not to make oxygen. Since the student's claim

assigns oxygen's origin to the wrong molecule, the student is incorrect.

Answer: No, the student is not right. The oxygen released by plants comes from the splitting of water in the light-dependent reactions, not from carbon dioxide. CO_2 instead supplies the carbon atoms used to build glucose in the Calvin cycle.

WATCH OUT — Students often assume that because CO_2 goes in and O_2 comes out, the oxygen must come from the CO_2 . Catch this by tracing where each molecule is actually used — water is split for oxygen, and CO_2 is fixed for carbon, in two different stages.

Sequencing the three stages of aerobic cellular respiration by location, oxygen requirement, and ATP yield

Aerobic cellular respiration happens in a fixed order of three stages, each in a different part of the cell, each with a different oxygen requirement and ATP output. Glycolysis happens first, in the cytoplasm, splits glucose into two pyruvate molecules, needs no oxygen, and makes a net 2 ATP. Pyruvate is then converted to acetyl-CoA, which enters the Krebs cycle in the mitochondrial matrix; the Krebs cycle oxidizes acetyl-CoA, releasing CO_2 and making NADH and FADH₂, and produces about 2 more ATP. The electron transport chain happens last, in the inner mitochondrial membrane, requires oxygen as the final electron acceptor to form water, and produces the bulk of the ATP, about 26 to 28. This sequence and the oxygen requirement at each step is what you need to recall whenever a question asks you to order the stages or fill in a table about them.

WORKED EXAMPLE

Complete the table for the three stages of aerobic cellular respiration: location, whether it needs O_2 , and approximate ATP yield.

Start with glycolysis since it's always first — it happens outside the mitochondria, in the cytoplasm, and since it doesn't rely on oxygen directly, mark it as not needing O_2 ; its ATP yield is small, just 2 net ATP. Move to the Krebs cycle next, which happens inside the mitochondria specifically in the matrix, after pyruvate is converted to acetyl-CoA; the Krebs cycle itself doesn't use oxygen directly as a reactant, but it only runs if the cell is in aerobic conditions, and it yields about 2 ATP. Finish with the electron transport chain, located on the inner mitochondrial membrane, which directly requires O_2 as the final electron acceptor, and yields the most ATP, about 26-28.

Answer: Glycolysis: cytoplasm, no O_2 needed, 2 ATP. Krebs cycle: mitochondrial matrix (after pyruvate is converted to acetyl-CoA), no O_2 directly needed (but aerobic conditions required), 2 ATP. Electron transport chain: inner mitochondrial membrane, O_2 needed, about 26-28 ATP.

WATCH OUT — Students often think the Krebs cycle directly uses O_2 since it's aerobic, or they forget glycolysis happens in the cytoplasm, not the mitochondria, or they forget pyruvate must first be converted to acetyl-CoA before entering the Krebs cycle. Check by asking: does this exact step have O_2 as a reactant in its own reaction, or does it just depend on oxygen being available elsewhere?

Interpreting experimental CO_2 data to determine which process (photosynthesis vs. respiration) dominates under given conditions

Plants carry out both photosynthesis and cellular respiration at the same time, all day and night, but you can tell which process is dominating by tracking CO_2 levels. If CO_2 in the air around a plant decreases, photosynthesis — which consumes CO_2 — is happening faster than respiration releases it, so photosynthesis dominates. If CO_2 increases, respiration — which releases CO_2 — is outpacing photosynthesis, which happens in the dark when there's no light to drive the light reactions. This idea applies to experiments where CO_2 concentration is measured over time under different light conditions. Remember that respiration never stops, even in bright light, but photosynthesis only runs when light is available and strong enough to exceed respiration's CO_2 output.

WORKED EXAMPLE

A water plant was sealed in a chamber. In bright light, CO_2 dropped from 400 to 260 ppm over 2 hours. In complete darkness, CO_2 rose from 400 to 470 ppm. Explain why CO_2 fell in light and rose in darkness, and name the process happening in both conditions.

First consider the light condition: since CO_2 decreased, something is consuming CO_2 faster than anything is producing it — that's photosynthesis, which uses CO_2 to build glucose, and it can only run when light is present to power the light reactions. Next consider the dark condition: with no light, photosynthesis cannot occur, but the plant's cells still need ATP, so cellular respiration keeps running and releases CO_2 as a byproduct, causing CO_2 to build up. Finally, recognize that respiration happens in both the light and dark conditions — it's photosynthesis that only occurs in light and that explains the net CO_2 drop by outpacing respiration.

Answer: In bright light, CO_2 fell because photosynthesis was consuming CO_2 faster than respiration was releasing it. In darkness, CO_2 rose because only respiration was occurring, steadily releasing CO_2 with nothing to use it up. Cellular respiration was happening in both conditions.

WATCH OUT — Students often think that in light, only photosynthesis is happening and respiration stops. Catch this by remembering respiration runs continuously in every living cell — the CO_2 data shows which process dominates, not which one is the only one occurring.

Comparing fermentation pathways (lactic acid vs. alcoholic) and their ATP yield to aerobic respiration

When oxygen is not available, the electron transport chain stops working, so cells rely on fermentation to keep glycolysis running by recycling NAD^+ so glycolysis can continue producing a small amount of ATP. Lactic acid fermentation occurs in muscle cells during intense exercise and in some bacteria, converting pyruvate into lactate. Alcoholic fermentation occurs in yeast, converting pyruvate into ethanol and CO_2 , which is why bread dough rises. In both pathways, only the 2 ATP from glycolysis are produced per glucose, which is far less than the 30 to 32 ATP made by aerobic respiration, because without oxygen the Krebs cycle and electron transport chain cannot run. This idea applies whenever a question involves low-oxygen conditions, exercise, yeast, or ATP yield comparisons.

WORKED EXAMPLE

Yeast is placed in a sealed jar of sugar water with no oxygen. Name the process the yeast uses, its two products besides ATP, and how many ATP it makes per glucose.

Since there's no oxygen, the electron transport chain can't run, so the yeast must rely on fermentation to keep making ATP. Yeast specifically performs alcoholic fermentation, not lactic acid fermentation, since that pathway is characteristic of yeast and some bacteria, not muscle cells. The products of alcoholic fermentation, besides ATP, are ethanol and carbon dioxide — the CO_2 is what causes bread dough to rise. Finally, recall that fermentation pathways only yield the ATP made during glycolysis itself, since the later aerobic stages don't run, so the total is 2 ATP per glucose.

Answer: The yeast uses alcoholic fermentation, producing ethanol and carbon dioxide besides ATP, and makes 2 ATP per glucose.

WATCH OUT — Students often mix up which organism uses which fermentation pathway, or they think fermentation produces more ATP because it 'replaces' aerobic respiration. Catch this by remembering fermentation only keeps glycolysis running — it never adds extra ATP beyond glycolysis's 2 ATP, and yeast makes ethanol/ CO_2 while muscle cells make lactate.

Part B — Practice. A practice test on the ideas these pages say matter most at this level. Level: High-school introductory Biology, Unit 5 — Photosynthesis and cellular respiration (bioenergetics).

12 questions across 6 ideas these pages cover — two for each, in the form the course uses. Work them on these pages. **The answers are not printed here: they come back with the review.** When the pages are done, upload them as a Performance Review with this guide as the prior guide, and Guru grades them and says which gaps have closed.

Writing and labeling the overall equations for photosynthesis and cellular respiration

1. Write the balanced overall equation for cellular respiration, and label which substances are the reactants and which are the products.

Answer: _____

2. A student writes the equation for photosynthesis as: $C_6H_{12}O_6 + 6 O_2 \rightarrow 6 CO_2 + 6 H_2O + \text{light energy}$. Identify the error and rewrite the equation correctly, labeling reactants and products.

Answer: _____

Locating the light-dependent reactions and Calvin cycle and identifying their inputs/outputs

3. Where in the chloroplast does the Calvin cycle take place, and what two energy carriers from the light-dependent reactions does it use, along with what gas does it take in?

Answer: _____

4. A diagram shows a chloroplast with thylakoid membranes stacked inside a fluid-filled space. Light strikes the thylakoid membranes, and water molecules are shown being split nearby. Based on this, name the two depleted/regenerated molecules that return to the light-dependent reactions after the Calvin cycle uses them, and explain why they must return there.

Answer: _____

Explaining the source of photosynthetic oxygen vs. the source of glucose's carbon (correcting the CO_2/O_2 mix-up)

5. A textbook diagram incorrectly labels an arrow showing ' O_2 released from CO_2 breakdown' during the light-dependent reactions. Which statement correctly identifies and fixes this error?

(A) The label is correct; CO_2 is split in the thylakoid membranes to release O_2 .

(B) The label is incorrect; O_2 actually comes from splitting water (H_2O) during the light-dependent reactions, while CO_2 is used later in the Calvin cycle.

(C) The label is incorrect; O_2 comes from the breakdown of glucose during glycolysis.

(D) The label is correct, but the process should be called the Calvin cycle instead of the light-dependent reactions.

Answer: _____

6. Which statement correctly describes where the carbon atoms in a glucose molecule originally come from during photosynthesis?

(A) From water molecules split in the light-dependent reactions.

(B) From oxygen gas absorbed through the leaf's stomata.

(C) From carbon dioxide fixed into sugar by rubisco during the Calvin cycle.

(D) From ATP generated in the mitochondria.

Answer: _____

Sequencing the three stages of aerobic cellular respiration by location, oxygen requirement, and ATP yield

7. Complete the following description for each stage of aerobic cellular respiration, stating its location in the cell, whether it requires oxygen directly, and its approximate ATP yield: (a) Glycolysis, (b) Krebs cycle, (c) Electron transport chain.

Answer: _____

8. A student lists the stages of respiration in this order: Krebs cycle → Electron transport chain → Glycolysis. Identify the correct order these stages actually occur in a cell, and briefly justify the sequence using oxygen use and location.

Answer: _____

Interpreting experimental CO_2 data to determine which process (photosynthesis vs. respiration) dominates under given conditions

9. A sealed terrarium with a leafy plant showed O_2 levels rise from 21% to 26% over 3 hours under bright light, but fall from 21% to 17% over 3 hours in total darkness. (a) Explain why O_2 rose in light. (b) Explain why it fell in darkness. (c) Which process was occurring in both conditions?

Answer: _____

10. An aquatic plant was placed in a sealed flask and CO_2 was measured under dim light: it fell slightly from 400 ppm to 380 ppm over an hour. Under the same dim light but with the plant removed and only pond water with bacteria, CO_2 rose from 400 ppm to 430 ppm. (a) Explain why CO_2 barely fell with the plant present. (b)

Explain why CO_2 rose with the plant removed. (c) What does the small CO_2 drop with the plant suggest about the balance between photosynthesis and respiration in dim light?

Answer: _____

Comparing fermentation pathways (lactic acid vs. alcoholic) and their ATP yield to aerobic respiration

11. Bread dough left to rise contains yeast that produces bubbles of gas and a slight alcoholic smell, even though the dough is sealed with minimal airflow. Which best explains this?

- (A) The yeast performs aerobic respiration faster, producing CO_2 and ethanol as final products.
- (B) Without enough oxygen, yeast performs alcoholic fermentation, converting pyruvate to ethanol and CO_2 to regenerate NAD^+ for glycolysis to continue.
- (C) The yeast switches to the Calvin cycle to fix CO_2 into sugar, releasing ethanol as a byproduct.
- (D) The yeast's mitochondria produce ethanol directly during the electron transport chain.

Answer: _____

12. Compare the ATP yield of lactic acid fermentation versus aerobic cellular respiration per molecule of glucose, and explain why a sprinting muscle cell might rely on fermentation despite its lower ATP output.

Answer: _____

Built from: the ideas these pages say matter most at this level. Guru Seal: every question and its kept answer key were independently checked by separate AI systems; 0 item(s) were dropped in that check.