

Cellular Respiration

Learning objective 3.5.A Describe the processes of aerobic cellular respiration, and explain the role of oxygen in them.

Name:

Date:

Period:

Use the tool **Sugar Into ATP**. Parts 1 and 2 use **Follow the carbon**, Part 3 uses **The ATP account** and Parts 4 and 5 use **Turn off the oxygen**. Two counts carry most of the marks in this topic: where the six carbons go, and where the ATP is actually made.

Part 1 • Where the carbon goes

Step through the four stages on the **Follow the carbon** tab, recording the counters after each one.

After this stage	Where it happened	Carbon left in the pathway	CO ₂ so far
Glycolysis			
Pyruvate oxidation			
Citric acid cycle			
Oxidative phosphorylation			

1. Name the four stages in order and state where in the cell each one takes place.

2. Trace the six carbon atoms of one glucose through the process, stating at which stage each carbon leaves and in what form.

Part 2 · Electron carriers and oxygen

Record the carriers each stage produces, then open **Why does the equation need exactly six O₂?** and complete the last two rows from the table there.

Stage	NADH	FADH ₂	Net ATP made directly
Glycolysis			
Pyruvate oxidation			
Citric acid cycle			
Oxidative phosphorylation			
TOTAL			

3. State the net ATP yield of glycolysis and explain why it differs from the number of ATP glycolysis produces.

4. Describe the role of NADH and FADH₂ in aerobic respiration.

5. Show, by calculation, why exactly six molecules of oxygen are needed to respire one molecule of glucose.

Part 3 · The ATP account

Switch to **The ATP account** and record the four readouts for each convention chip in turn.

Convention	ATP per NADH	ATP per FADH ₂	Made directly	From the gradient	Total
Current estimate					
Older textbooks					

6. State which quantities changed when you switched convention and which did not, and explain what that tells you about where the disagreement between textbooks comes from.

7. Calculate the percentage of the total ATP that comes from oxidative phosphorylation under each convention, and comment on what the two figures have in common.

Part 4 · Take the oxygen away

Switch to **Turn off the oxygen**. Predict each row before you set the switches, then record what happens.

Oxygen	Fermentation	Stages running (predict)	Stages running (actual)	ATP per glucose	CO ₂ released
Available	Yes				
None	Yes				
None	No				

8. Describe the role of oxygen in aerobic respiration and state where in the process it acts.

9. Explain why removing oxygen stops the citric acid cycle, even though the citric acid cycle does not itself use oxygen.

Part 5 · What fermentation is for

Open **It makes no ATP** and complete the table from what you find there.

Kind of fermentation	Who does it	What happens to the pyruvate	ATP it makes
Lactic acid fermentation			
Alcoholic fermentation			

10. A student says that fermentation is how a cell makes ATP without oxygen. Evaluate that statement.

11. A muscle working anaerobically nets 2 ATP per glucose. Calculate how many times more ATP the same glucose would yield aerobically, and explain one consequence of that difference for an athlete.

What the model simplifies

The ATP total per glucose is an estimate, not a constant. It depends on which shuttle carries the electrons from the NADH made in the cytosol into the mitochondrion, and on how leaky the inner membrane happens to be. Figures between 30 and 32 are all defensible with the current per-carrier estimates, and this tool reports 32.

Individual steps, intermediates and enzyme names in glycolysis and the citric acid cycle are outside the course framework, so the tool counts carbon, electron carriers and ATP rather than naming molecules. ATP synthase is the one enzyme name the framework does expect.

The citric acid cycle is shown as making ATP directly. In most cells it makes GTP, which is then converted to ATP; the accounting is the same and the distinction is beyond the course.

Respiration is drawn here as glucose in and carbon dioxide out. Cells also respire fats and amino acids, which enter the same pathway at different points, and the reverse of that — using respiratory intermediates to build molecules — happens constantly.