ATP links respiration to work

Core idea: cells use ATP made using energy from respiration to support energy-requiring processes. ATP is an immediate energy-transfer molecule, not a long-term fuel store.

FOLLOW THE ENERGY TRANSFER

RESPIRATION
Energy transferred from organic molecules

→

ATP
A readily usable link between reactions

→

CELLULAR WORK
Transport, synthesis, movement and division

1. RESPIRATION IS A CHEMICAL PROCESS

Respiration is a series of reactions in cells, not the same as breathing. Energy from the breakdown of organic substances, such as glucose, can be used to make ATP. Energy is transferred, not created.

2. ATP IS USED WHERE WORK IS DONE

ATP-dependent reactions help cells move substances against gradients, build molecules and generate movement. Naming a structure is not enough: connect it to a process and explain why that process needs an energy input.

3. MITOCHONDRIA HELP MEET DEMAND

Mitochondria are major sites of ATP production during aerobic respiration in typical eukaryotic cells. Cells with sustained high ATP demand often have many mitochondria. Not all ATP production occurs in mitochondria; some occurs in the cytoplasm.

4. PLANT CELLS NEED ATP TOO

Root cells use ATP for processes such as active uptake of mineral ions. Photosynthetic cells also respire and need ATP for cellular work. Chloroplasts do not remove the need for mitochondria or respiration.

Cambridge Biology 9700 syllabus: section 1.2, learning outcome 4, p. 16.

ATP is used and regenerated

Supporting explanation: ATP is adenosine triphosphate. Removing one phosphate by hydrolysis forms ADP (adenosine diphosphate) and inorganic phosphate, written P_i.

1. ATP REGENERATION REQUIRES ENERGY

Energy transferred from respiration

$$ADP + P_i \longrightarrow ATP + H_2O$$

Phosphorylation: phosphate is added to ADP.

2. ATP HYDROLYSIS CAN DRIVE CELLULAR WORK

$$ATP + H_2O \longrightarrow ADP + P_i$$

Energy transfer is coupled to an energy-requiring process.

COUPLING MAKES THE TRANSFER USEFUL

An energy-releasing reaction can drive an energy-requiring one when the reactions are linked. For example, ATP-dependent changes in a transport protein can move ions against their electrochemical gradient.

THE MOLECULES CYCLE; ENERGY MUST BE SUPPLIED

ADP and inorganic phosphate can be reused to make ATP. This regeneration needs an energy input. ATP use and regeneration occur continually, so a small ATP pool can support repeated cellular work.

AVOID A MISLEADING SHORTCUT

Breaking a bond alone requires energy. ATP hydrolysis releases energy overall because the full reaction produces products with lower free energy.

Supporting explanation: OpenStax Biology 2e, 6.4 ATP: Adenosine triphosphate.

Which processes need ATP?

Distinguish an energy-requiring mechanism from passive movement. Then link a change in ATP supply to the particular cellular activity being studied.

PROCESS	CONNECTION TO ATP
Active transport	Membrane pumps use ATP directly; some transport is powered indirectly by gradients that ATP-dependent pumps maintain.
Biosynthesis	Building cell components requires energy. ATP supplies energy for steps in synthesis, such as activating amino acids for protein production.
Movement	ATP supports muscle contraction, beating of cilia and movement of cargo along the cytoskeleton.
Cell division	Making new cell material and moving cell structures require energy. ATP supports these activities; division is not just one ATP-driven step.
Diffusion and osmosis	Passive net movement down a concentration or water-potential gradient does not directly use ATP. Maintaining the gradient may still require energy.

INTERPRETING A CHANGE IN ATP SUPPLY

Suppose a treatment lowers ATP availability and ion uptake against a gradient also slows. This is consistent with an energy-dependent uptake mechanism.

REASONING CHAIN

Less ATP available → reduced ATP-dependent pump activity → slower transport against the gradient.

Check that the treatment did not damage membranes or kill cells. The pattern supports the explanation, but does not by itself prove every step.

Cambridge Biology 9700 syllabus: ATP for energy-requiring processes, outcome 1.2.4.