ATP and Energy Needs

Essential Question

How do cells get the energy they need from food?

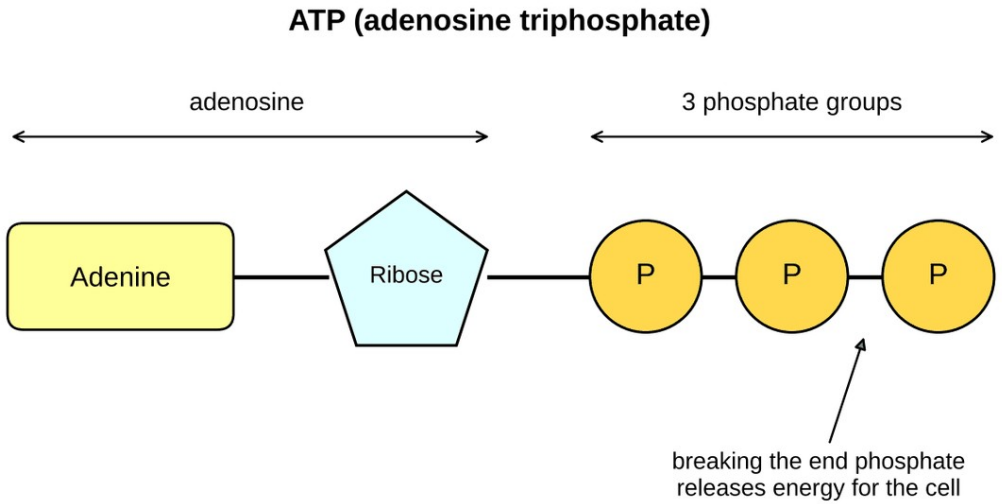
Why Cells Need Energy

- Cells constantly do work
- Examples: moving materials, building molecules, contracting muscles
- Energy comes from the bonds of food molecules
- Cells cannot use that energy directly

Cell work	Example
Building large molecules	Making proteins from amino acids
Moving materials	Pumping ions across a membrane
Movement	Muscle cells contracting
Sending signals	Nerve cells carrying messages

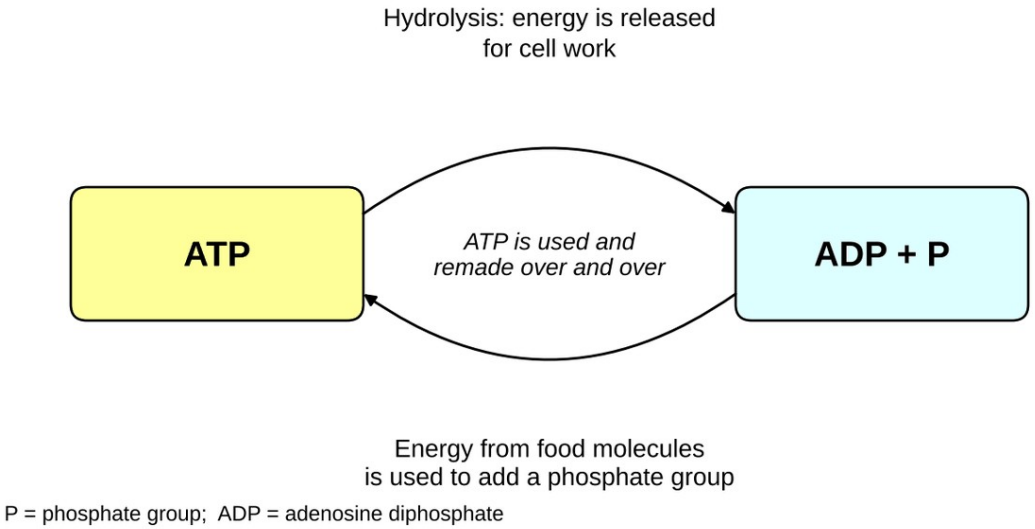
The Structure of ATP

- ATP stands for adenosine triphosphate
- Adenosine = adenine (a base) + ribose (a sugar)
- Three phosphate groups are attached
- ATP is a nucleotide with extra phosphate groups



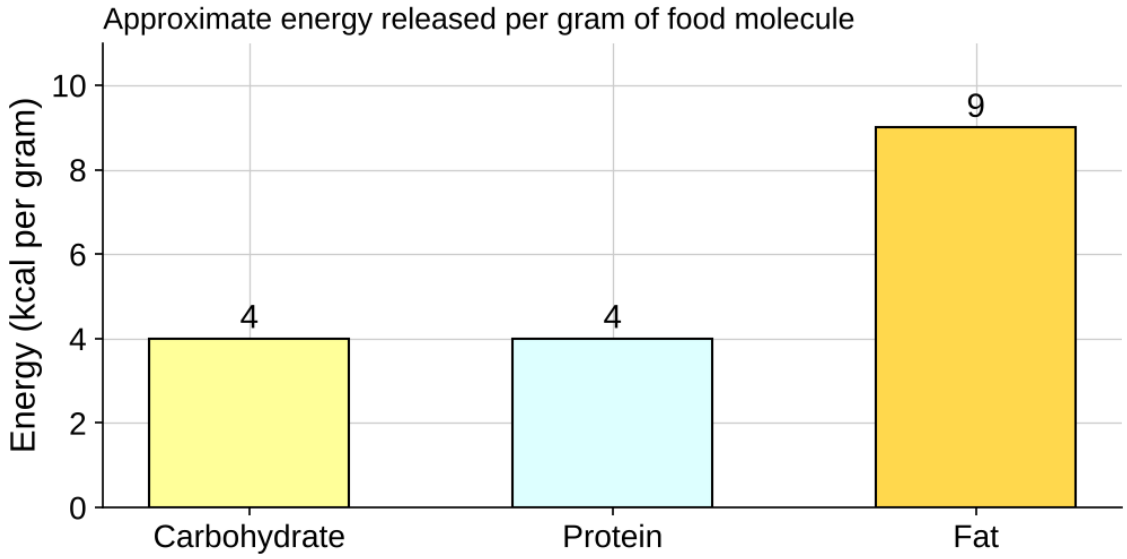
The ATP and ADP Cycle

- Breaking the end phosphate gives ADP plus P
- This releases energy that powers cell work
- Adding a phosphate back to ADP remakes ATP
- Energy from food is used to remake ATP



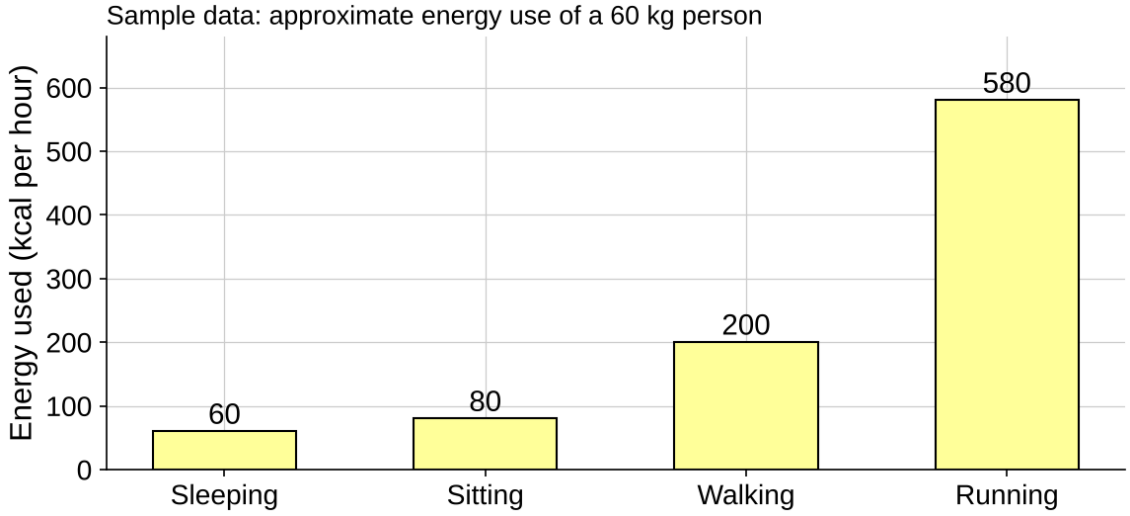
Energy in Food

- Energy in food is measured in kilocalories (kcal)
- The Calories on a food label are kilocalories
- Carbohydrates and proteins give about 4 kcal per gram
- Fats give about 9 kcal per gram



Energy Needs Change with Activity

- A more active cell needs more ATP
- Active muscles need the most
- More ATP means more food molecules broken down
- Energy needs depend on body size and activity



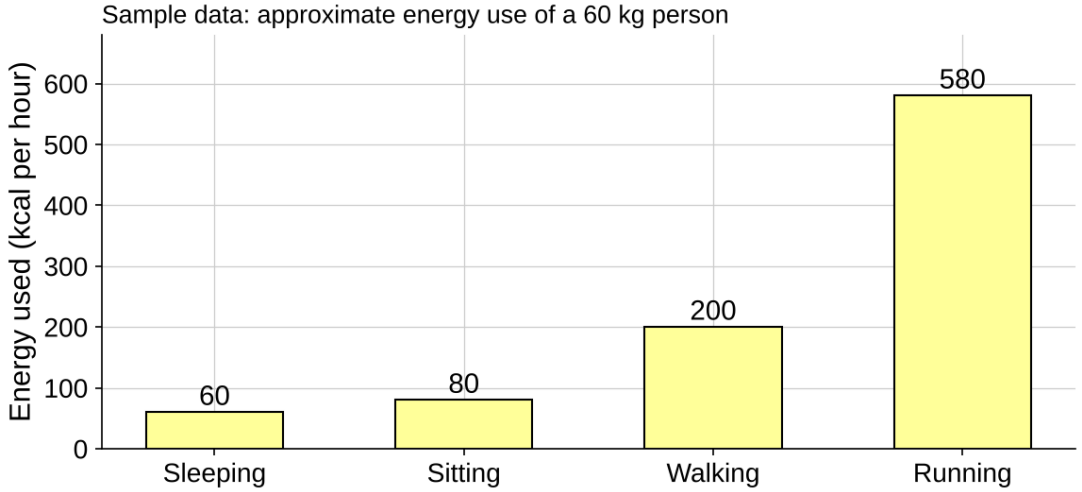
Cells Remake ATP Constantly

- A cell holds only a small supply of ATP at one time
- It is used up within seconds or minutes if it is not replaced
- Cells remake ATP all the time
- Cellular respiration keeps the supply going

Model numbers (not measurements)	Value
ATP molecules in the cell	2,000,000
ATP used each second	40,000
Time the supply would last	50 seconds

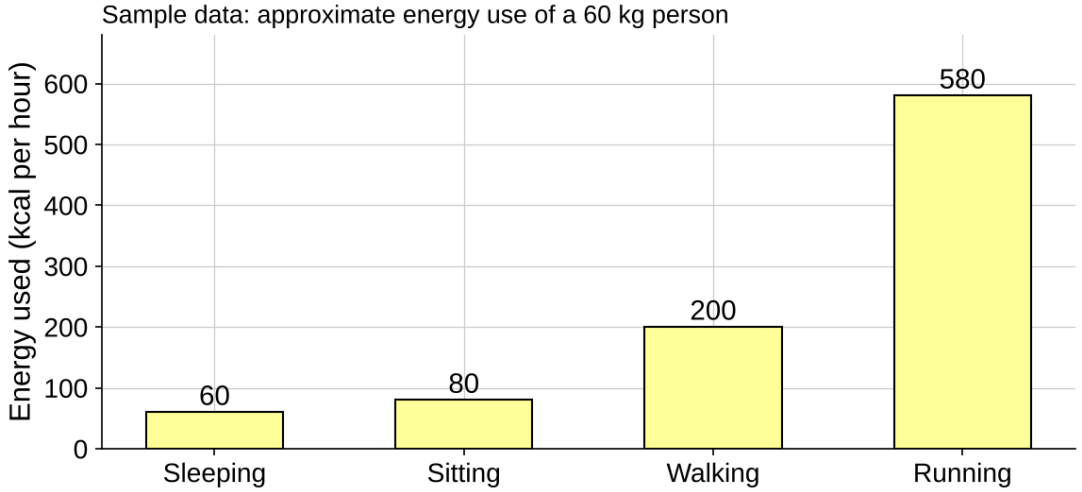
Example: Energy for a Run

A 60 kg person runs for 45 minutes. Use 580 kcal per hour for running, 9 kcal per gram of fat, and 4 kcal per gram of carbohydrate. (a) How much energy is used? (b) What mass of fat holds this much energy? (c) What mass of carbohydrate holds it?



Example: Comparing Activities

Use the graph of energy use for a 60 kg person. (a) How many times more energy per hour does running use than sitting? (b) How much energy is used in 8 hours of sleeping and 2 hours of walking? (c) Explain why running requires more ATP than sitting.



Example: How Long Does the ATP Last?

Use the model numbers: a cell holds 2,000,000 ATP molecules and uses 40,000 per second. (a) How long would the supply last if no ATP were remade? (b) The cell becomes more active and uses ATP 4 times as fast. How long would the supply last now? (c) Explain why this shows that cells must keep making ATP.

ATP and Energy Needs

Big Ideas

- ATP is the molecule cells use to power their work
- Hydrolysis of ATP gives ADP plus a phosphate and releases energy
- Energy from food is used to remake ATP
- Fat holds about 9 kcal per gram; carbohydrate and protein about 4
- More active cells need more ATP