CELL RESPIRATION

Content Statements:

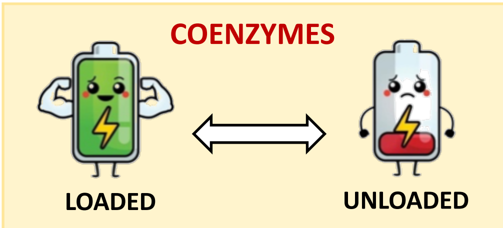
C1.2.1	ATP as the molecule that distributes energy within cells
C1.2.2	Life processes within cells that ATP supplies with energy
C1.2.3	Energy transfers during interconversions between ATP and ADP
C1.2.4	Cellular respiration as a system for producing ATP within the cell using energy released from carbon compounds
C1.2.5	Differences between anaerobic and aerobic cell respiration in humans
C1.2.6	Variables affecting the rate of cell respiration

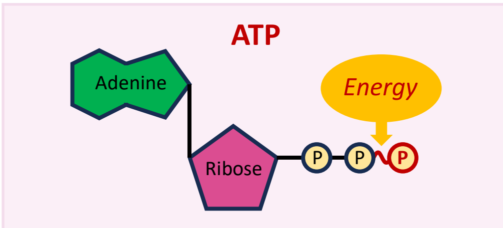
ENERGY

Living organisms need chemical energy to power the metabolic reactions that sustain life processes. These processes include the **biosynthesis** of organic molecules (via anabolism), the **active transport** of materials across a cell membrane and the overall **movement** of cells or cellular components (such as chromosomes).

ADENOSINE TRIPHOSPHATE

A coenzyme is a complex organic molecule that is required for an enzyme's metabolic activity. Coenzymes cycle between two states: a loaded form capable of assisting enzyme activity and an unloaded form (similar to a charged and expended battery). **Adenosine triphosphate** (ATP) is a coenzyme that is used to transport *chemical energy* to metabolic reactions. It functions as an immediate energy source for a cell (i.e. energy currency). ATP possesses three negatively charged phosphates that need increasing amounts of energy to hold together. When the ATP is hydrolysed to **adenosine diphosphate** (ADP) and an inorganic phosphate, the released energy can then be utilised by the cell.





CELL RESPIRATION

Cellular respiration is the controlled release of energy from the breakdown of organic compounds. These compounds are produced by autotrophs (via photosynthesis) or can be synthesised from other pre-existing molecules within the cell (e.g. excess glucose can be converted to fats). Usable carbon compounds include:

- **Carbohydrates:** The main organic molecule used in cell respiration is the monomer **glucose** ($C_6H_{12}O_6$)
- **Triglycerides:** Fats produce more energy per gram than sugars, but are harder to transport and digest
- **Proteins:** Not a primary source as produces nitrogenous by-products (which are toxic if not excreted)

When the organic compounds are broken down in cell respiration, the chemical energy that is released is used to generate ATP (from ADP + Pi). In this respect, the organic compounds function like a bank (storing high amounts of chemical energy within their covalent bonds), while the ATP is usable money. The function of cell respiration is to convert the inaccessible chemical energy into an available form that cells can use.

TYPES OF CELL RESPIRATION

Cellular respiration can involve one of two reaction pathways: anaerobic respiration or aerobic respiration

ANAEROBIC RESPIRATION	AEROBIC RESPIRATION
Partial breakdown of glucose	**Complete** breakdown of glucose
Oxygen is **not** required for a **small** ATP yield	Oxygen **is** required for a **large** ATP yield
Occurs entirely in the **cytosol**	Occurs in the **mitochondria**
Involves glycolysis and fermentation	Involves glycolysis, Krebs cycle and ETC
Products: Lactic acid / Ethanol + CO_2	**Products:** Carbon dioxide and water

ANAEROBIC RESPIRATION

Anaerobic respiration involves the *partial breakdown* of carbohydrates (glucose) in the *absence of oxygen*. It occurs in the *cytosol* and results in a *low yield* of ATP (net production = 2 ATP). The glucose can either be converted into **lactic acid** (animals) or **ethanol** and **carbon dioxide** (plants and yeast). The production of lactic acid in humans is used to maximise the power of muscle contractions when levels of oxygen are low.

Glucose → Lactic Acid + 2 ATP

AEROBIC RESPIRATION

Aerobic respiration involves the *complete breakdown* of carbohydrates (glucose) in the *presence of oxygen*. It occurs in the *mitochondria* and results in a *high yield* of ATP (net production = 30 ATP). The oxygen is used to complete the digestion of glucose, resulting in the formation of **carbon dioxide** and **water**. While sugars like glucose can be digested via either respiratory pathway, triglycerides can only be digested aerobically.

Glucose + Oxygen → Carbon Dioxide + Water + 30 ATP

MITOCHONDRIA

The mitochondrion is an organelle in eukaryotic cells that is responsible for aerobic respiration. It is believed to have evolved via endosymbiosis, when an aerobic bacterium was engulfed by another prokaryotic cell. Evidence for this endosymbiotic origin includes the fact that the mitochondrion possesses circular DNA, 70S ribosomes has a double membrane. In terms of structure, the central region is called the **matrix**, while the inner membrane is highly folded into **cristae**. By folding this membrane, the SA:Vol ratio is increased. This optimises the structure of the mitochondria to allow aerobic respiration to occur more rapidly and in greater amounts (maximising total ATP yield).

Mitochondrion

FACTORS AFFECTING RESPIRATION RATE

The rate of respiration can be measured by either the consumption of inputs (glucose and oxygen) or the formation of product (carbon dioxide). However, these conditions may be affected by the pathway used. Factors that affect aerobic respiration include temperature and pH (which will alter enzyme functionality), as well as glucose concentration and oxygen availability (both of which function as respiratory substrates).