

Respiration

IGCSE Biology

Section II.8.1-2
Cornell notes; Cornell notes; SC.g12.L.18.6-10

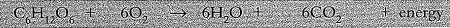
Respiration	Release of energy from food substances in cells
Aerobic respiration	Breakdown of glucose in the presence of oxygen to release energy
Anaerobic respiration	Breakdown of glucose in the absence of oxygen to release energy

Respiration

Respiration is a process carried out in cells (don't confuse it with breathing). For the Core curriculum, you need to be able to write the word equations for respiration. The symbol equations are part of the Extended curriculum. The energy formed during respiration is in the form of ATP (adenosine triphosphate).

Aerobic respiration:

glucose + oxygen → water + carbon dioxide + energy



Anaerobic respiration in muscles:

glucose → lactic acid + energy



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Anaerobic respiration in yeast:

glucose → ethanol + carbon dioxide + energy



Examiner's tips

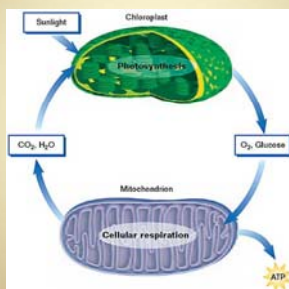
- ▶ If you write a symbol equation, you must make sure the formulae are correct and that the equation is balanced.
- ▶ Anaerobic respiration in muscles does **not** produce carbon dioxide or water.
- ▶ Anaerobic respiration in yeast does **not** produce water.

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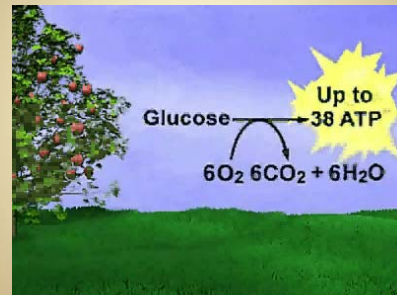
Harvesting Chemical Energy

- **Cellular respiration**
 - process by which cells break down organic compounds to produce ATP.
- Both autotrophs and heterotrophs use cellular respiration to make CO₂ and water from organic compounds and O₂.
- Cellular respiration divided into two stages:
 - glycolysis and aerobic respiration

Photosynthesis-Cellular Respiration Cycle



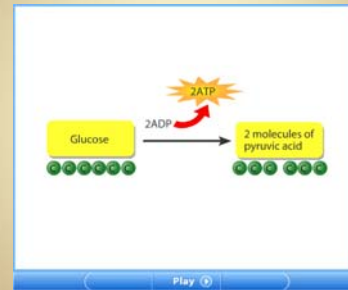
Cellular Respiration



Glycolysis

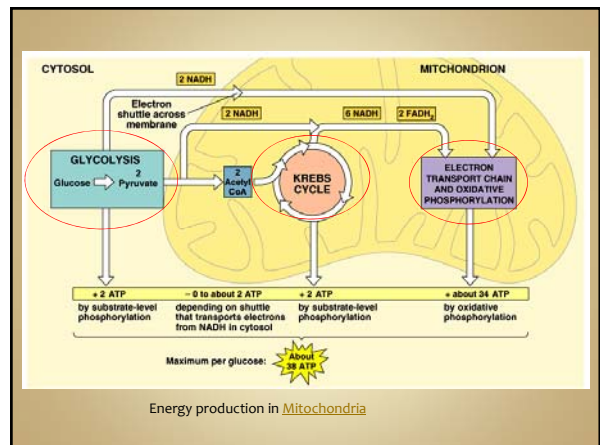
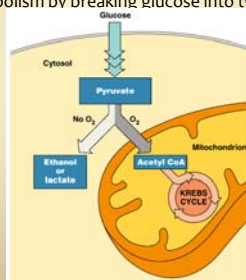
- Cellular respiration begins with glycolysis
 - takes place in the cytosol of cells
- During **glycolysis**, one six-carbon glucose molecule is oxidized to form two three-carbon pyruvic acid molecules.
- A net yield of two ATP molecules is produced for every molecule of glucose that undergoes glycolysis.

Glycolysis

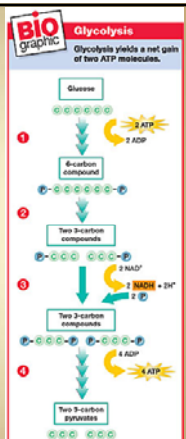
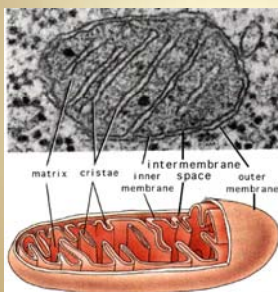


Glycolysis

- occurs in the cytoplasm
 - begins catabolism by breaking glucose into two molecules of pyruvate



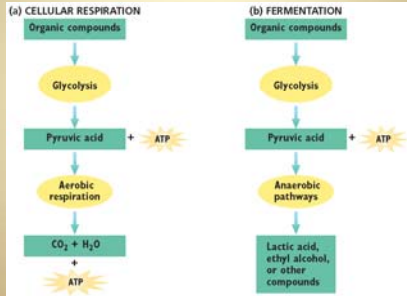
Glycolysis



Fermentation

- If oxygen is not present, some cells can convert pyruvic acid into other compounds through additional biochemical pathways that occur in the cytosol. The combination of glycolysis and these additional pathways is **fermentation**.
- Fermentation does not produce ATP, but it does regenerate NAD⁺, which allows for the continued production of ATP through glycolysis.

Cellular Respiration Vs. Fermentation



Fermentation

- **Lactic Acid Fermentation**
 - In **lactic acid fermentation**, an enzyme converts pyruvic acid into another three-carbon compound called lactic acid

Fermentation

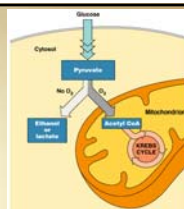


Fermentation

- **Alcoholic Fermentation**
 - Some plants and unicellular organisms, i.e. yeast, use a process called **alcoholic fermentation** to convert pyruvic acid into ethyl alcohol and CO₂

Fermentation

- **Lactic Acid Fermentation**
 - Pyruvic acid accumulates and converts to lactic acid
 - Process regenerates NAD⁺ so glycolysis can continue
 - Produced in muscles during rapid exercise- causes burning
- **Alcoholic Fermentation**
 - Type of fermentation that occurs in yeasts and a few microorganisms
 - Pyruvic acid broken down to produce alcohol and CO₂
 - Important to bakers and brewers



Yeast

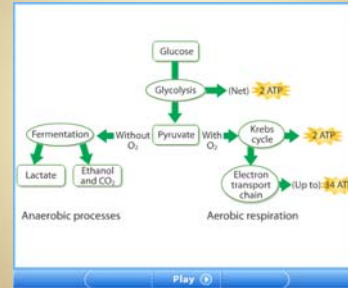
- Used in bread-making and brewing because of the products produced when it respire

Breadmaking – yeast is mixed with water and sugar to activate it. The mixture is added to flour to make dough. This is left in a warm place to rise. The dough rises because the yeast is releasing carbon dioxide, which gets trapped in the dough. A warm temperature is important because respiration is controlled by enzymes (see Topic 8). When the dough is cooked, the high temperature kills the yeast and any ethanol formed evaporates. Air spaces are left where the carbon dioxide was trapped. This gives the bread a light texture.

Brewing – yeast is added to a source of sugar (this may be in fruit juice or in germinated barley grains) and kept in warm conditions. As the yeast respire the sugar – a process called fermentation – ethanol is formed, making the drink alcoholic. The fermenting mixture needs to be kept germ-free to prevent fungi or bacteria converting ethanol to ethanoic acid (vinegar). Carbon dioxide makes the drink fizzy and gives it a slightly sharp flavour, due to its acidity when dissolved in water.

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Aerobic & Anaerobic Respiration



Efficiency of Glycolysis

- Through glycolysis, only about 2 percent of the energy available from the oxidation of glucose is captured as ATP.
- Much of the energy originally contained in glucose is still held in pyruvic acid.
- Glycolysis alone or as part of fermentation is not very efficient at transferring energy from glucose to ATP.

Efficiency

	Cytosol	Mitochondrial matrix	Electron transport	Total
Glycolysis	2 ATP		→ 2 ATP	2 ATP
	2 NADH		→ 6 ATP	6 ATP
Respiration	Pyruvic acid to acetyl CoA	2 × (1 NADH)	→ 2 × (3 ATP)	6 ATP
	Krebs cycle	2 × (1 ATP)	→ 2 ATP	2 ATP
		2 × (3 NADH)	→ 2 × (9 ATP)	18 ATP
		2 × (1 FADH ₂)	→ 2 × (2 ATP)	4 ATP
		TOTAL	38 ATP	

Krebs Cycle

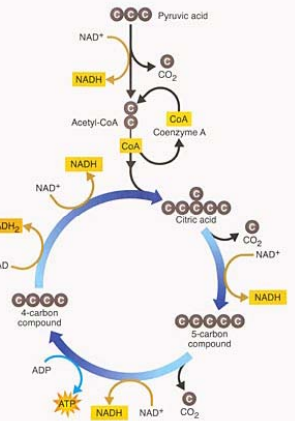


Krebs Cycle



Krebs Cycle

- Occurs in the mitochondrial matrix
 - degrades pyruvate to carbon dioxide
- Several steps in glycolysis and the Krebs cycle transfer electrons from substrates to NAD^+ , forming NADH
 - NADH passes electrons to the electron transport chain

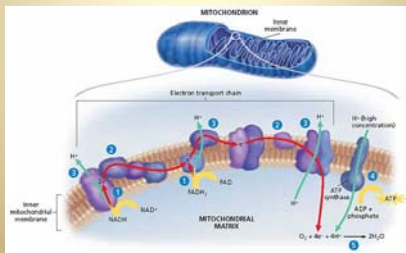


The Krebs Cycle

- Pyruvic acid produced in glycolysis reacts with coenzyme A to form **acetyl CoA**
- Then, acetyl CoA enters the Krebs cycle
- One glucose molecule is completely broken down in two turns of the Krebs cycle.
 - These two turns produce four CO_2 molecules, two ATP molecules, and hydrogen atoms that are used to make six NADH and two FADH_2 molecules.

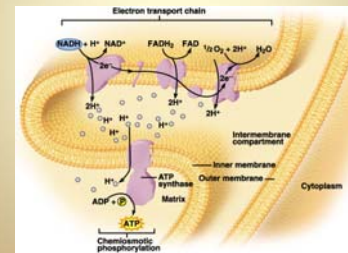
Electron Transport Chain and Chemiosmosis

- High-energy electrons in hydrogen atoms from NADH and FADH_2 are passed from molecule to molecule in the electron transport chain along the inner mitochondrial membrane.

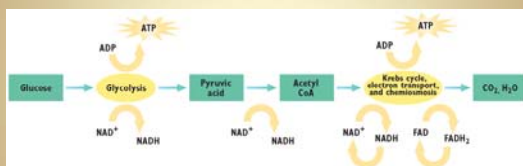


Electron Transport Chain

- Embedded in the inner mitochondrial membrane
 - Most ETC molecules are proteins
- Primary ATP generating pathway



Summary of Cellular Respiration



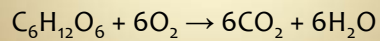
Cellular Respiration



8.1 Aerobic respiration

Core

- Define *aerobic respiration* as the release of a relatively large amount of energy in cells by the breakdown of food substances in the presence of oxygen
- State the equation for aerobic respiration using symbols



8.2 Anaerobic respiration

Core

- Define *anaerobic respiration* as the release of a relatively small amount of energy by the breakdown of food substances in the absence of oxygen
- State the word equation for anaerobic respiration in muscles during hard exercise (glucose → lactic acid) and the microorganism yeast (glucose → alcohol + carbon dioxide)
- Describe the role of anaerobic respiration in yeast during brewing and bread-making
- Compare aerobic respiration and anaerobic respiration in terms of relative amounts of energy released

Resources

Campbell et.al. (2004) *Biology: Exploring Life. Prentice Hall*

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