Respiration

Def: Respiration is the release of energy from food

- The food involved in respiration is usually glucose
- Internal respiration is controlled by enzymes which allow energy to be released in small amounts
- The energy is trapped in molecules called ATP

Types of Respiration

- **Aerobic Respiration** – the release of energy from food in the presence of oxygen

- **Anaerobic Respiration** The release of energy from food without requiring the presence of oxygen

Aerobic Respiration

- Most living things get energy from aerobic respiration and are called **AEROBES**
- The energy stored in bonds in glucose is released and used to make ATP
- When ATP breaks down it supplies energy for all the reactions in a cell such as movement of muscles, growth of new cells etc.

Equation for Aerobic Respiration

$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + Energy$

Glucose + Oxygen ⟶ Carbon dioxide + water + energy

- Aerobic respiration is relatively efficient, 40% of the energy in glucose is used to make ATP

- Any energy not used to produce ATP is lost as heat

ENERGY CARRIERS

There are two main groups of Energy Carriers

Group 1

a) ADP

b) ATP

Group 2

a) NAD^+ and NADH

ATP Stores energy and transfers it to where it is needed

Group 1

a) ADP= (**Adenosine diphosphate**) =low energy molecule, found in cells of all organism

b) ATP= (**Adenosine triphosphate**)= high energy molecule, stores and transports energy

Remember ATP is a source of energy for most cell reactions

***Group 2

A) NAD+ Low energy (Nicotinamide Adenine Dinucleotide)

B) NADH- high energy molecule

Reactions:

ATP + water → ADP + P + energy

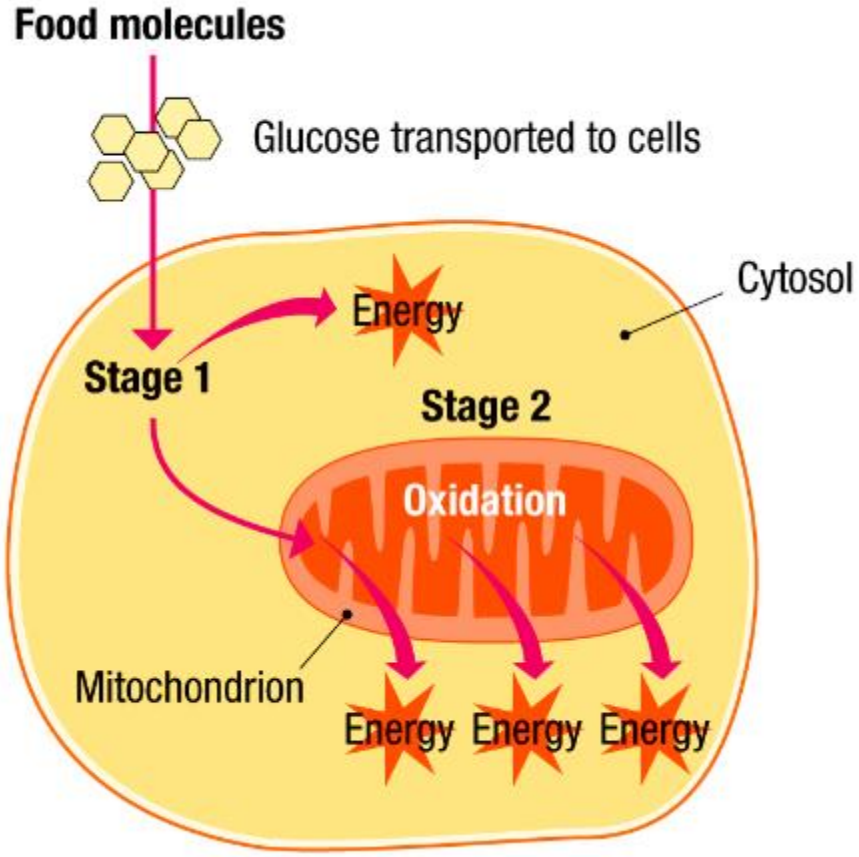
i.e. Respiration

****Phosphorylation is the addition of phosphate to a molecule (+P)***

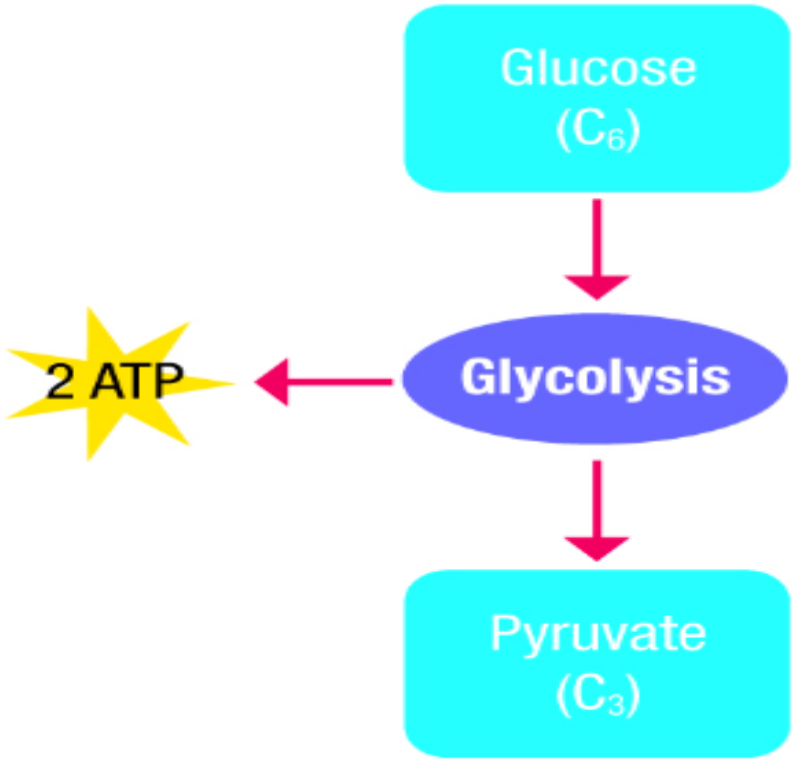
Aerobic Respiration occurs in 2 stages

Stage1 Glycolysis

Stage 2- Krebs Cycle



Stage 1 Glycolysis



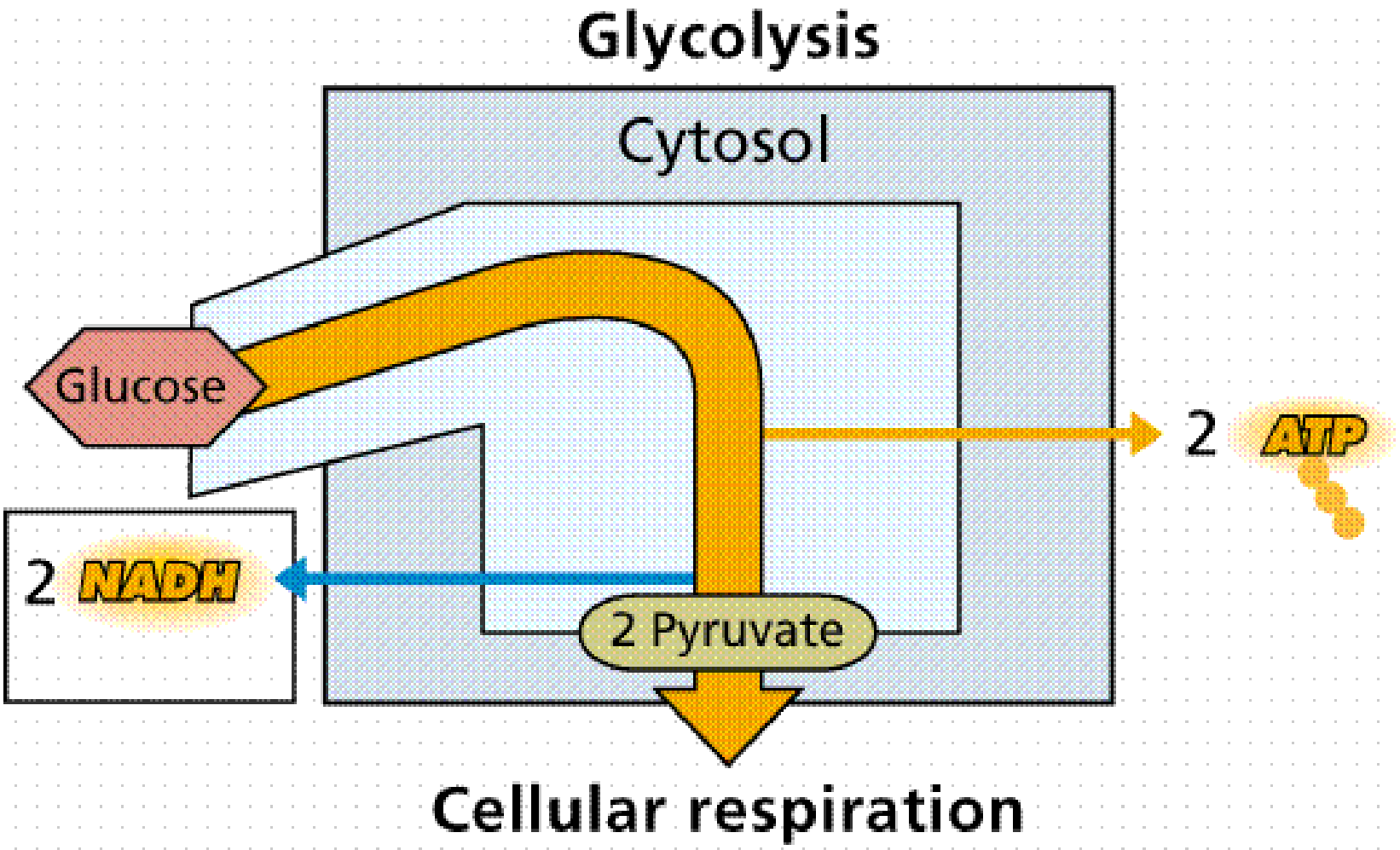
Stage 1 Glycolysis

- Takes place in the cytosol (the cytoplasm without the organelles) as enzymes are found here
- Does not require oxygen
- It only releases small amounts of energy
- Is the same for both aerobic and anaerobic respiration

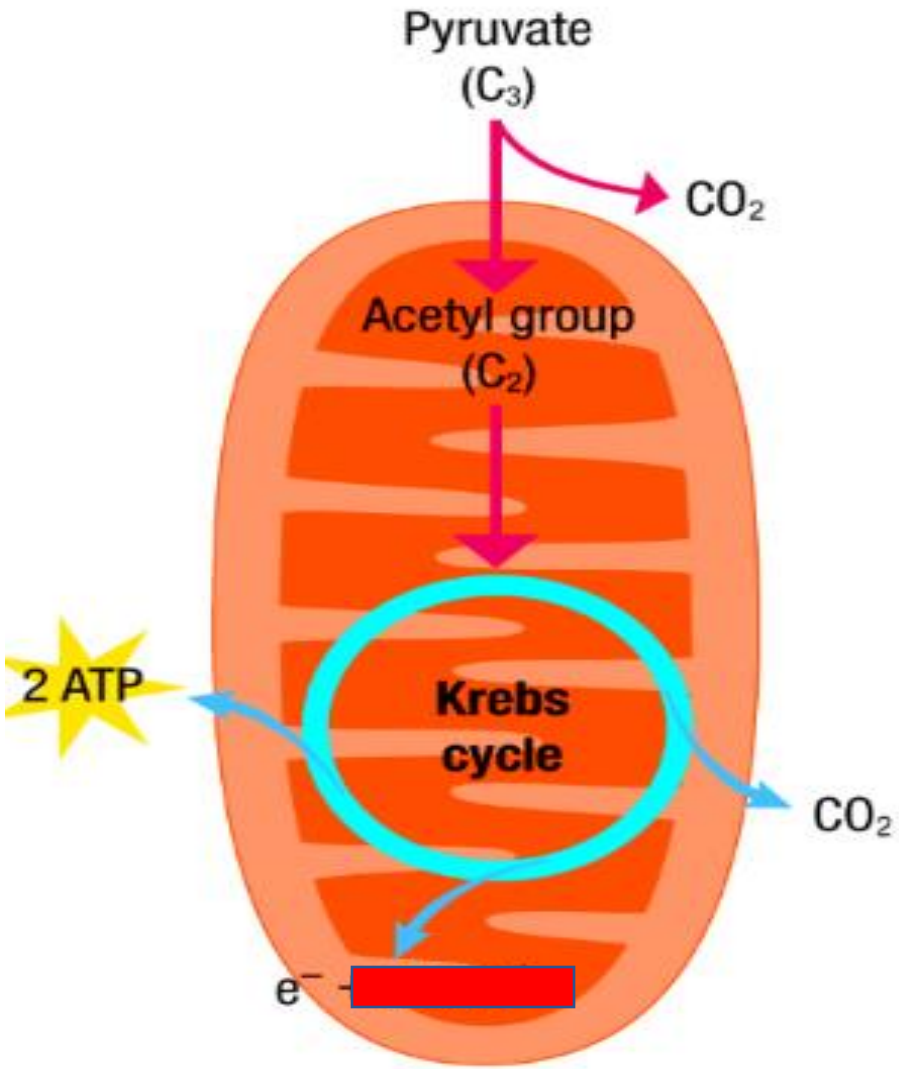
Satge 1 Glycolysis

- A 6 carbon carbohydrate (Glucose) is converted to two 3- carbon molecules with the release of a small amount of energy

- Most of the energy in the glucose molecule remains stored in each 3- carbon molecules


Glycolysis
Cytosol
Glucose
2 ATP
2 NADH
2 Pyruvate
Cellular respiration

STAGE 2



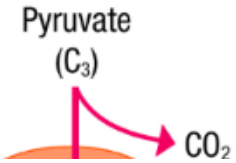
- **Acetyl Co A broken down with release of CO2, protons (H+) and electrone e-
- ADP is converted to ATP

NADH & CO2 (Main products formed)

Stage 2

- In the presence of oxygen the pyruvic acid enters the lumen in the mitochondrion KREBS CYCLE
- It loses a carbon dioxide molecule to form a 2-carbon molecule called Acetyl coenzyme A (Acetyl CoA for short)
- Pyruvic acid also loses 2 high energy electrons that combine with NAD+ and a proton to form NADH
- Each NADH will enter an electron transport system

- The **Krebs cycle** converts the acetyl group into **CO_2** and **hydrogen**.
- The CO_2 is released as a **waste** gas.
- **$NADH^+$** is generated from **NAD** and the **hydrogen**.



Learning Check

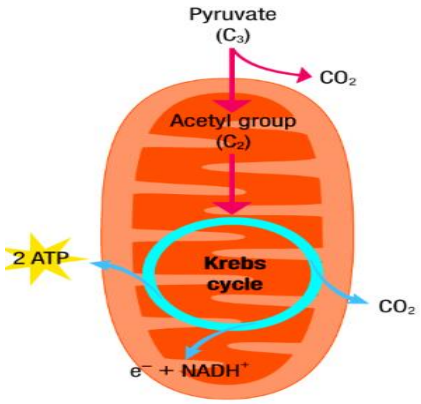
- What happens to the Pyruvic acid if oxygen is present?
- What does the pyruvic acid lose to become Acetyl CoA?
- Pyruvic acid also loses 2 high energy electrons what happens to these?
- What cyclce does the newly form Acetyl CoA enter?
- Where does this take place?
- Is oxygen required?
- What happens to the Acetyl CoA?

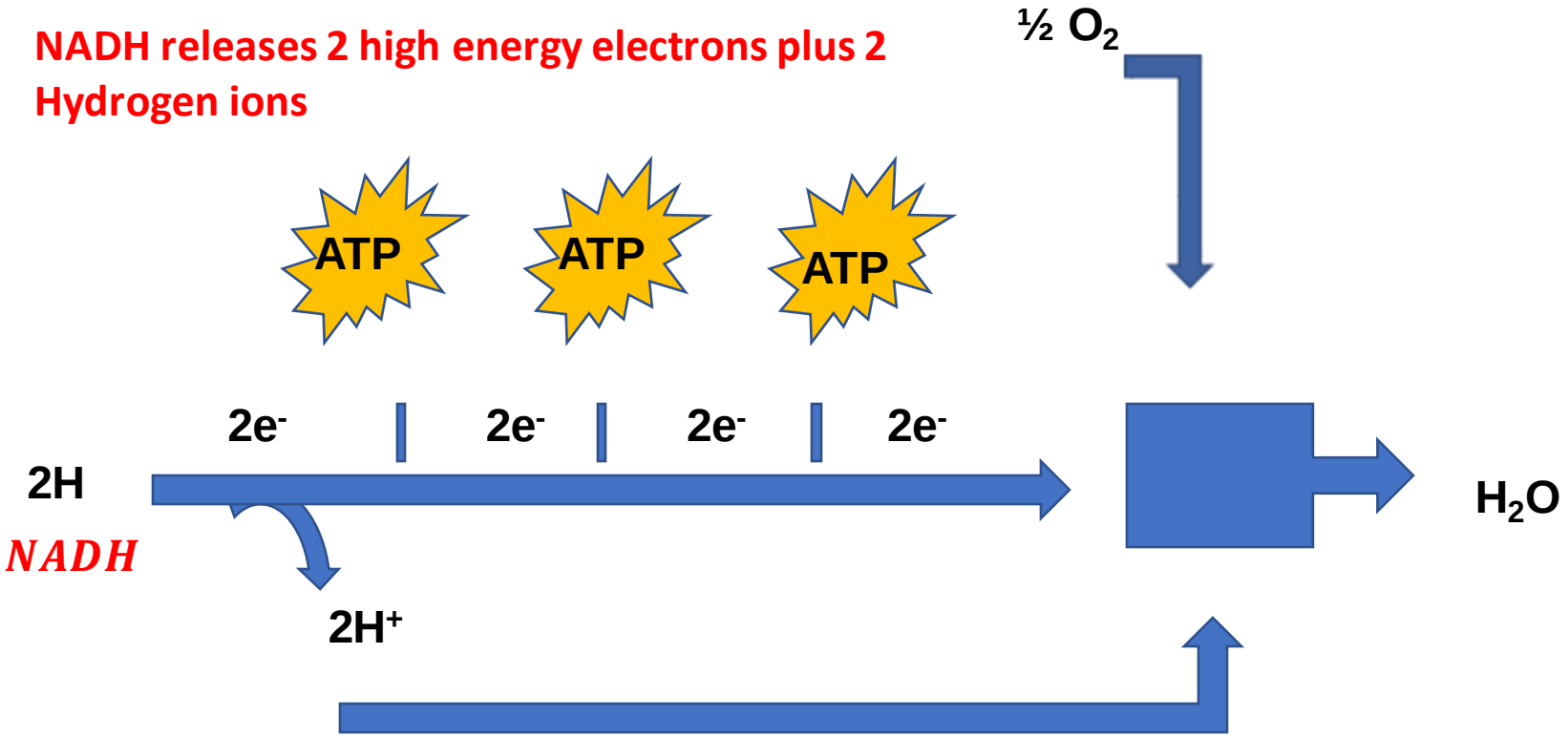
Learning Check

- What happens to the energy released by Acetyl CoA?
- Two products are formed at the end of Krebs cycle what are they?

Electron Transport System

- The NADH enters an electron transport chain made up of protein molecules
- Takes place in the cristae of the mitochondria
- Oxygen is necessary
- The foldings of the cristae increase the number of electron transport systems that can fit in them





Formation of ATP by the electron transport chain

- High energy electrons are passed from NADH to the first of these molecules
- As electrons pass from molecule to molecule they lose some of their energy
- Some of this energy is used to form ATP the rest is lost as heat
- At the end of each system the low energy electron is removed by combining it with oxygen and hydrogen to form water
- The production of ATP by the electron transport system is called **Oxidative Phophorylation** as it requires oxygen + phosphate

Electron Transport System

- The main significance of the electron transport system is that it produces energy rich ATP
- Oxygen is essential as it accepts the low energy electron at the end of the chain
- If oxygen is absent aerobic organisms may die as there is no oxygen to accept the low energy electron and no ATP may be formed

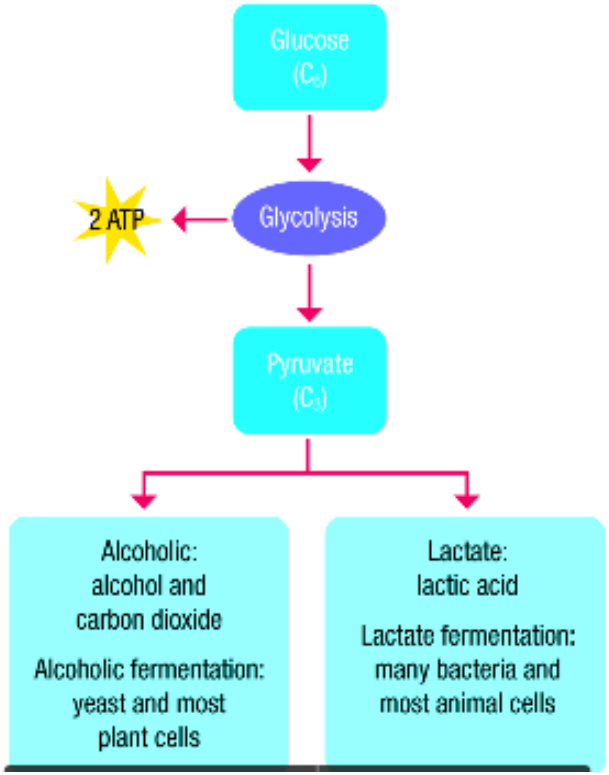
Learning Check

- What molecule formed in Krebs cycle enters the electron transport system?
- The electron transport system is made up of a series of molecules mainly p.....
- The electron transport systems are found on the c..... of the mitochondria
- What does the NADH provide for the electron transport system?
- What happens to the energy provided by the high energy electrons?
- What is the main significant product of the electron transport system
- What happens to the electron at the end of the system when it has become a low energy electron?
- Why is Oxygen essential?

Anaerobic respiration: First stage

(HL ONLY)

If oxygen is not present, the pyruvic acid (pyruvate) is converted into either lactic acid or ethanol and CO_2.



Anaerobic Respiration =Fermentation

As only stage 1 is involved in anaerobic respiration it only occurs in the cytosol

Learning Check

- Where does anaerobic respiration occur?
- What are the 2 possible products from the reduction of pyruvic acid?
- Is any energy produced in this process?

Anaerobic Respiration(also known as fermentation)

- Anaerobic respiration can occur in the presence of oxygen but it does not need to use it
- In anaerobic respiration Glycolysis occurs this means glucose is broken into two 3-carbon molecules
- A small amount of energy is released this way

Lactic Acid Fermentation

- This occurs in some anaerobic bacteria and fungi and in animal muscles when there is not enough oxygen

- In this fermentation Lactic acid is produced

- Glucose → 2Lactic Acid + small amount of energy

Industrial Fermentation

- **Biotechnology** refers to the use of living things (such as microorganisms and enzymes) to carry our useful reactions

- In industrial fermentation the microorganisms are placed in a container with a suitable substrate on which they can react

- The vessel in which biological reactions can take place is called a **Bioreactor**

Advantages of Immobilised Cells

- Immobilisation is gentle it does not damage cells
- Immobilised cells can be easily recovered
- Immobilised cells reduce the need for filtration at the end of bioprocessing
- Immobilised cells can be reused reducing costs

Differences between Aerobic and Anaerobic Respiration

	Aerobic	**Anaerobic**
Location	Cytoplasm and Lumen and Cristae of mitochondria	Cytoplasm
Oxygen Requirements	Uses O_2	Does not use O_2
End Products	$CO_2 + H_2O$	Ethanol +CO_2 or Lactic acid
Energy Produced	Lots of energy (38 ATP)	Little energy (2 ATP)

Syllabus Can You?....

- Definition of the term: aerobic respiration.
- Explain the role of aerobic respiration – what does it do for organisms?
- Express aerobic respiration by a balanced equation.
- State the nature of respiration from syllabus – what stages are involved, where do these take place, what happens?
- Definition of the term: anaerobic respiration.
- Express anaerobic respiration by a balanced equation.
- State the nature and role of fermentation.
- State the cellular location of the first & second stage.
- Explain the role of microorganisms in fermentation.
- Explain the role of microorganisms including bioprocessing and Bioreactors