Chapter 12 - Respiration

Learning objectives

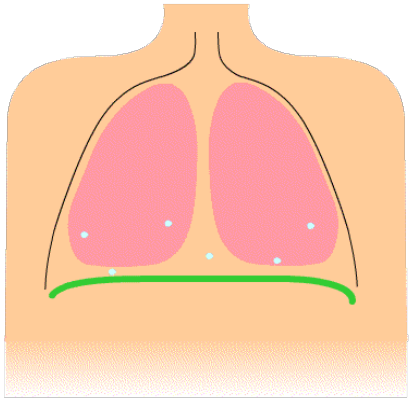
- To define the term 'aerobic respiration' and represent it as a balanced equation
- To describe simply the aerobic respiration of glucose as a two-stage process
- To define the term 'anaerobic respiration' (fermentation) and represent it as a word equation
- To explain how micro-organisms are used in industrial fermentation
- HIGHER To perform a detailed study of respiration, including glycolysis, Krebs cycle and the electron transport chain
- HIGHER To describe ethanol or lactic acid fermentation
- To prepare and test the production of alcohol by yeast.

Chapter 12 - Respiration

External Respiration - is the exchange of gases with the environment.

Internal Respiration - is the controlled release of energy from food.

Respiration is controlled by **enzymes** and traps energy in **ATP** (Adenosine Tri Phosphate).



Aerobic Respiration

This is the controlled release of energy from food using **Oxygen**.
The energy released is stored as **ATP**.
This energy can be saved for when it is needed to power chemical reactions.
40% of energy in glucose is converted to **ATP**.
The other **60%** is released as **heat**.

Glucose + **Oxygen** ⟶ **Energy** + **Carbon Dioxide** + **Water**
Food Breathing in Heat, ATP Breathing out

You must know the word equation above and the balanced chemical equation.

$$C_6H_{12}O_6 + 6\,O_2 \longrightarrow \text{Energy} + 6\,CO_2 + 6\,H_20$$

Aerobic Respiration Stages

Stage 1

This stage is called **Glycolysis**.

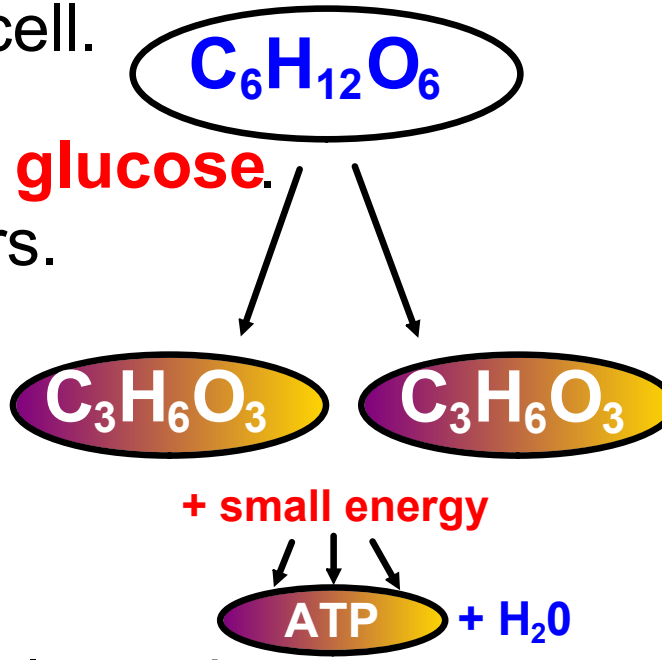
This happens in the **cytosol** of the cell.

(Cytoplasm of the cell with no organelles)

Glycolysis is the **breaking down of glucose**.

It is broken into two **3-carbon** sugars.

These are called **Pyruvate.**



Only a **small** amount of **energy** is released.

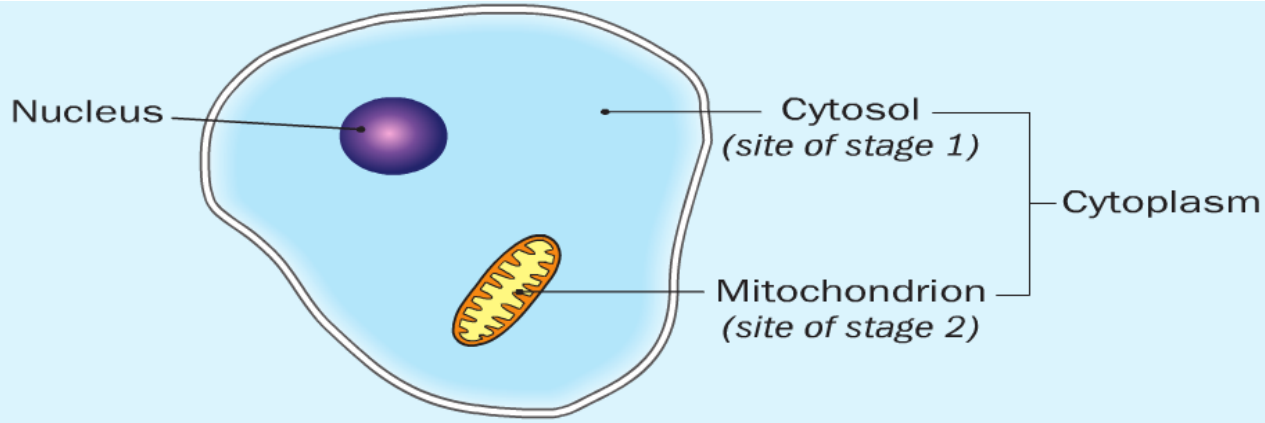
Water is also released when ATP is formed.

This stage does **not** need Oxygen.

Stage 2

This stage **does** need Oxygen.
This happens in the **Mitochondria** of the cell.
The **3-carbon** sugars (**Pyruvate**) are broken down even more.

First, it loses a **carbon dioxide, CO_2** to become **$C_2H_6O_1$**.
This is now called **Acetyl Co-enzyme A**. (Acetyl CoA for short)
This enters the **KREBS CYCLE**, where more carbon dioxide and water are released.
ATP and **NADH** (energy carriers) are both formed during this cycle.
A **large** amount of **energy** is released.



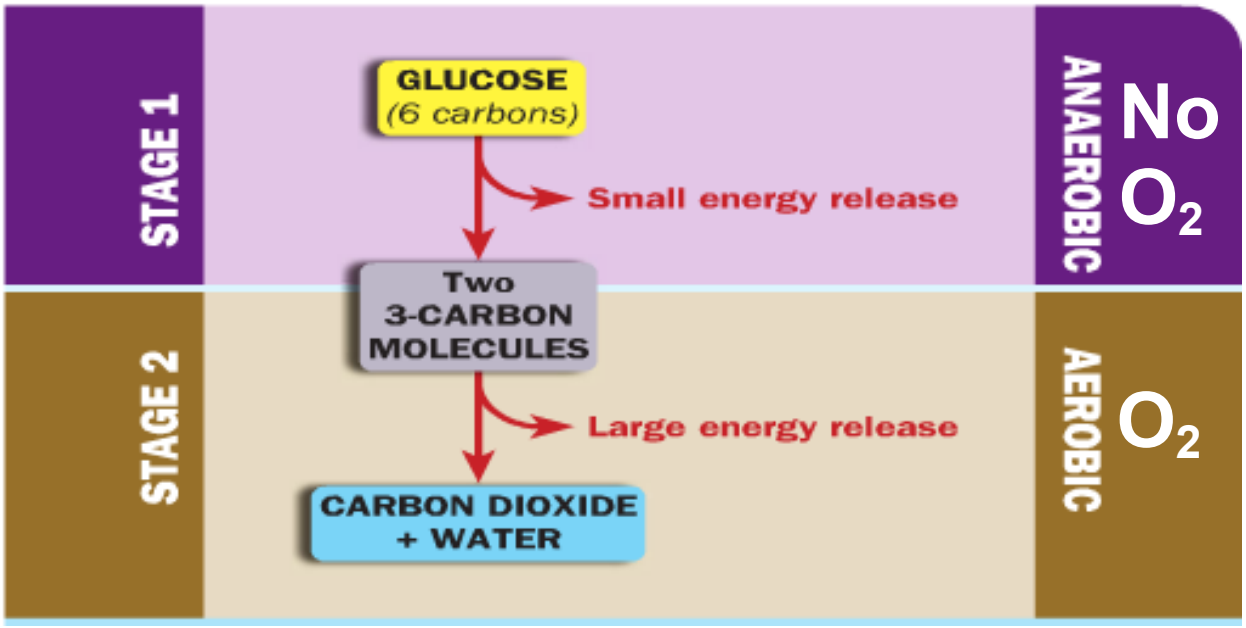
Aerobic Respiration Summary

Glycolysis

In the Cytosol

Stage 2

In the Mitochondria



Anaerobic Respiration

This stage is called **Glycolysis - glucose is broken down.**
It can also be known as **fermentation**.
If there is **No Oxygen** then the Pyruvate can become lactic acid or ethanol.

1. Lactic Acid Fermentation

This happens in muscles when there is not enough oxygen.
The muscle starts to respire anaerobically and glucose is converted into lactic acid. This causes cramp.

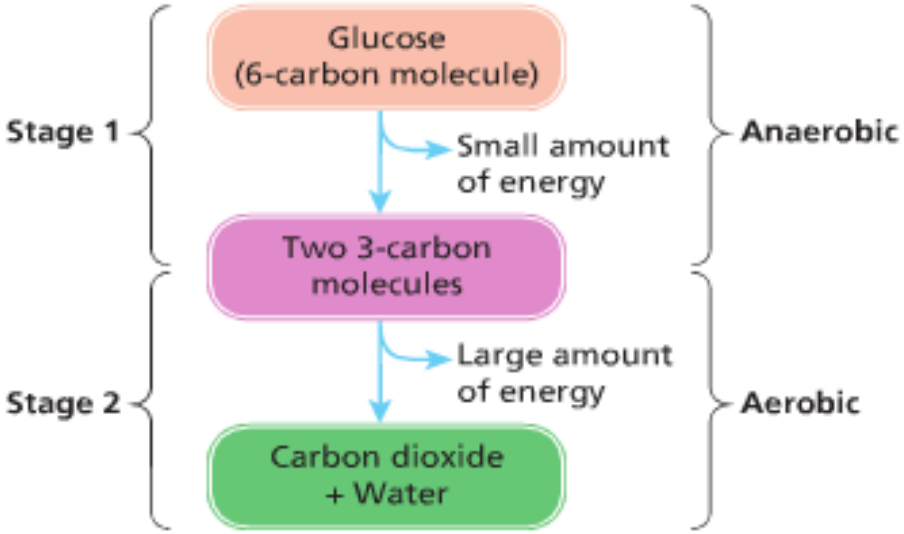
Glucose → 2 lactic acid + a small amount of energy

2. Alcohol fermentation

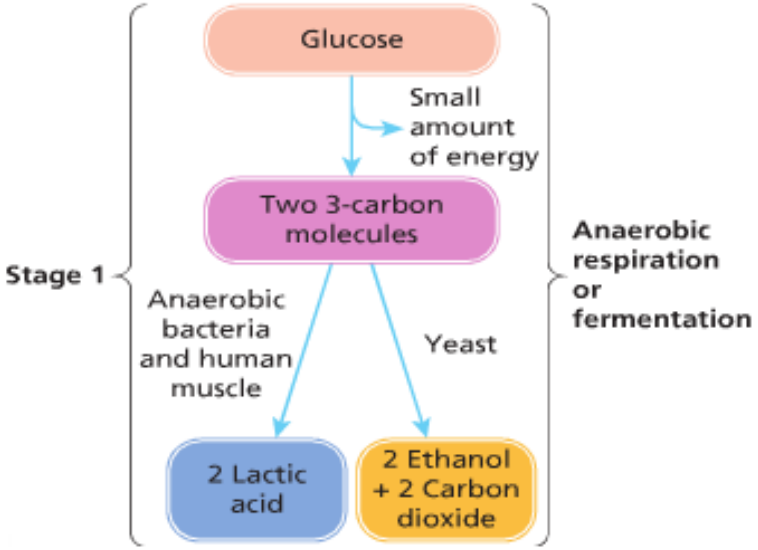
This happens in fungi, bacteria and some plants when there is not enough oxygen.
The organism starts to respire anaerobically and glucose is converted into **alcohol** and **CO_2**.

Glucose → 2 ethanol + 2 carbon dioxide + a small amount of energy

Aerobic Respiration

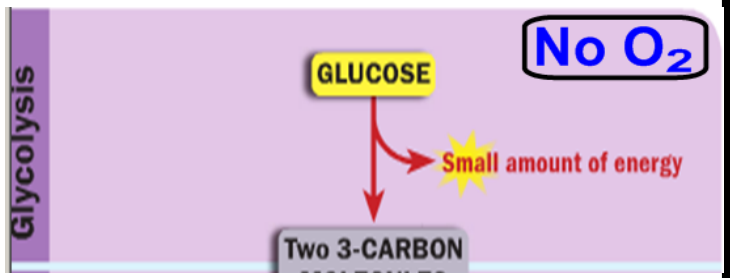


Anaerobic Respiration



Both types of respiration have Glycolysis as the first stage.
This happens in the Cytosol.
Aerobic has a Stage 2 in the Mitochondria - it makes lots of energy using Oxygen.
Anaerobic has no Oxygen and makes either Lactic Acid or Ethanol.

Aerobic Respiration



Stage 2 O_2

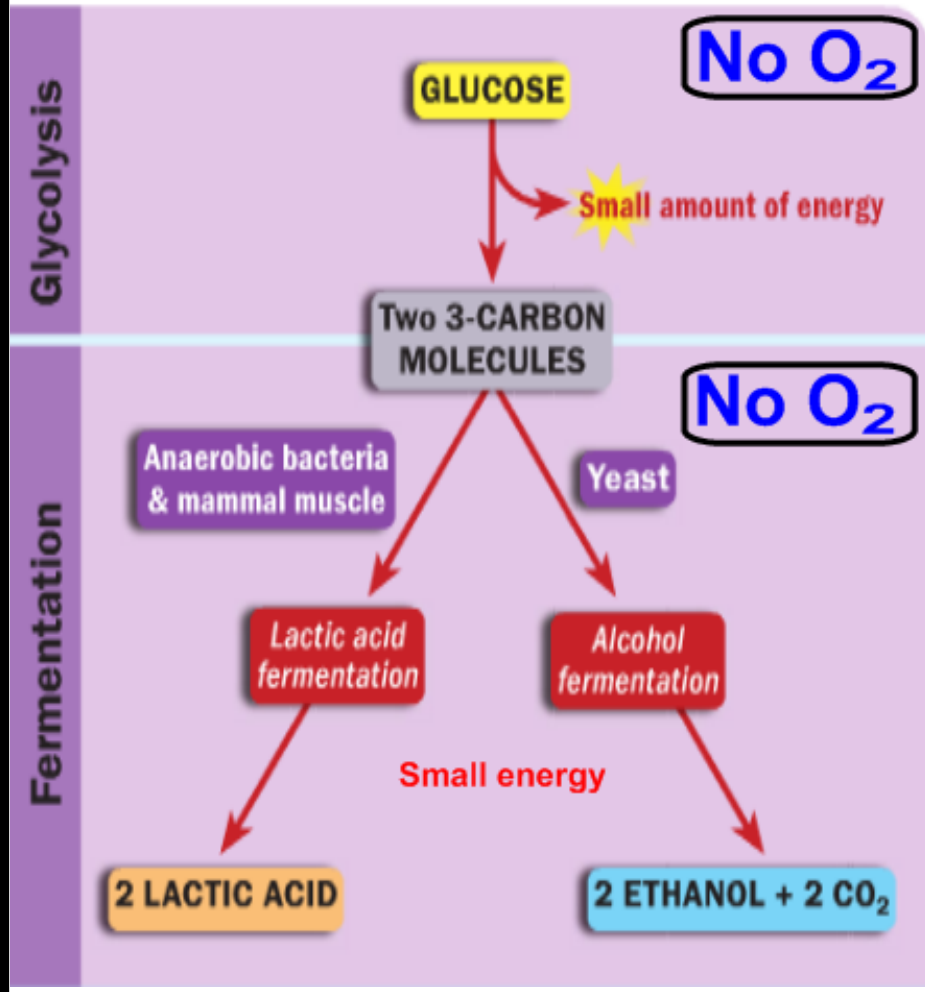
Mitochondria

Krebs Cycle

ATP NADH

Lots of energy!!

Anaerobic Respiration



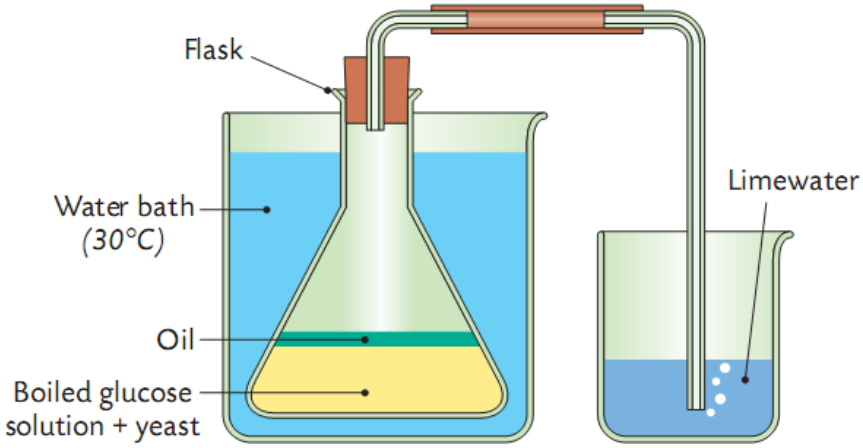
Fermentation

To make alcohol -

We boil water (to remove oxygen).
We add powdered glucose (for food).
The beads/yeast is added when the water cools (so enzyme isn't denatured)
We then add a layer of oil (to block oxygen).
Finally an air-lock is added to stop Oxygen getting in.
The flasks are put in a water bath at 30°C for 3 or 4 days.

Glucose → 2 Ethanol + $2CO_2$

Test for Alcohol - We add potassium dichromate and sulfuric acid and heat.
The solution will change from **orange** to **green** if there is alcohol present.



Biotechnology

Biotechnology refers to the use of living things or their components (especially cells and enzymes) to manufacture useful products or to carry out useful reactions.

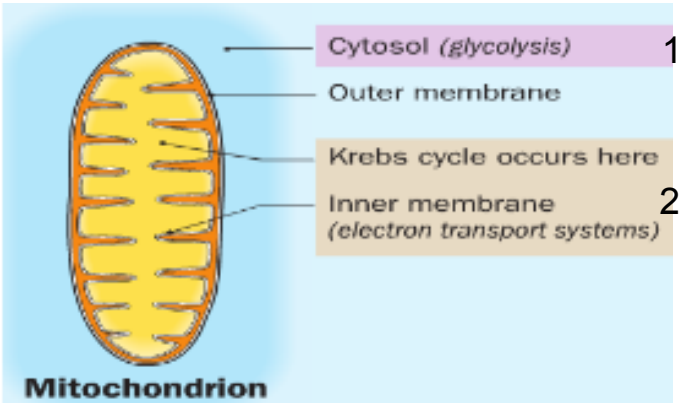
Yeast and bacteria are used in Bioreactors to make various products like cheeses, yoghurts, breads, beers and wines.

Adding yeast to sugar to make alcohol is often messy, makes the beer cloudy and costs more.

Yeast can be trapped or **immobilised** in a gel to stop the beer from getting cloudy.

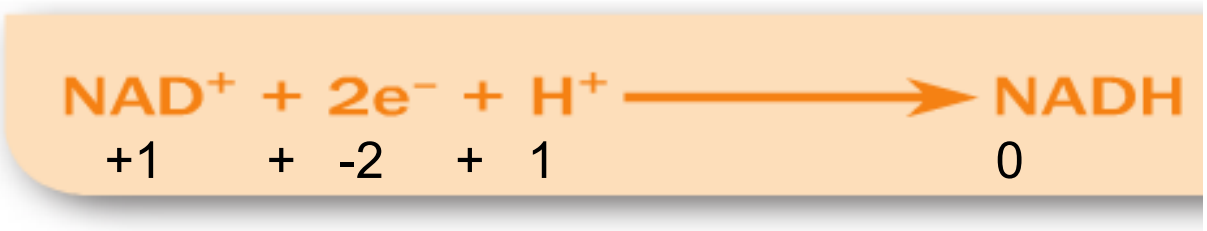
Inside the Mitochondrion

Stage 2 of Aerobic Respiration happens in the Mitochondria of the cell.
The Mitochondria has many foldings on the inside membrane.
This is where ATP and NADH are made.



Detailed Steps

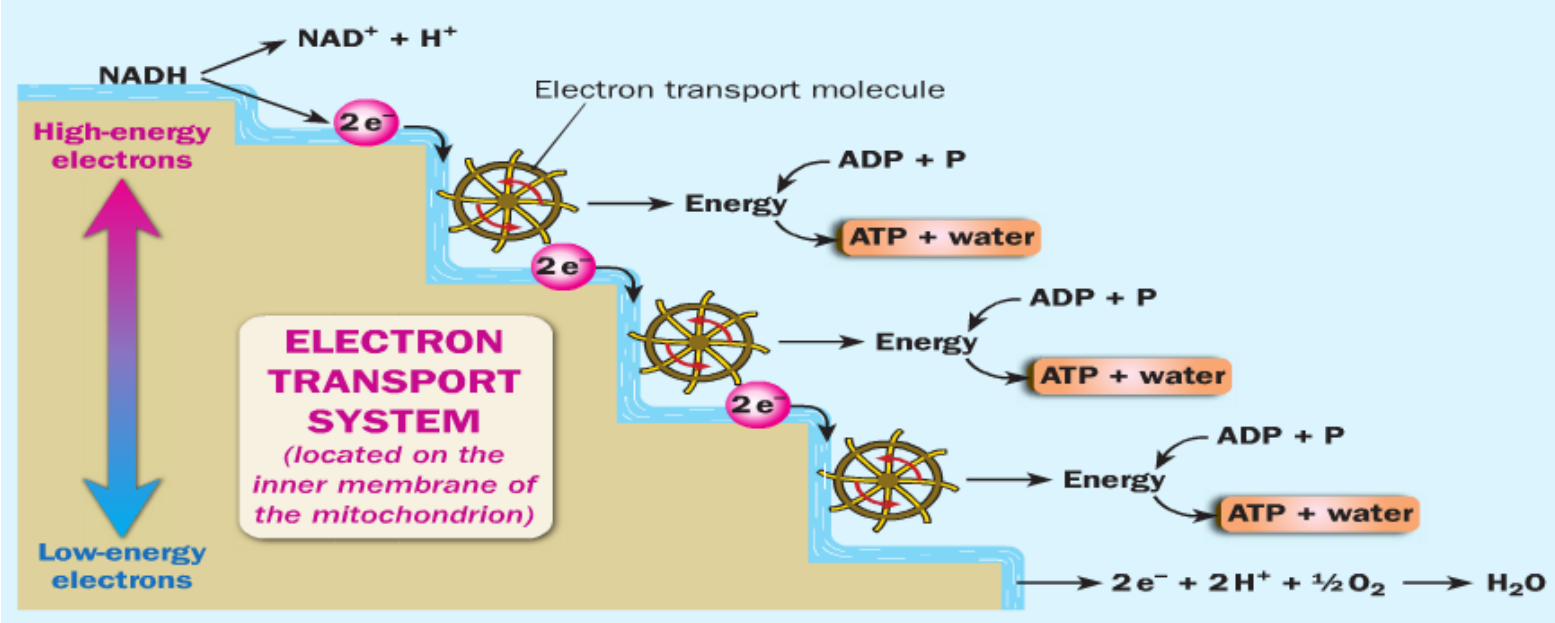
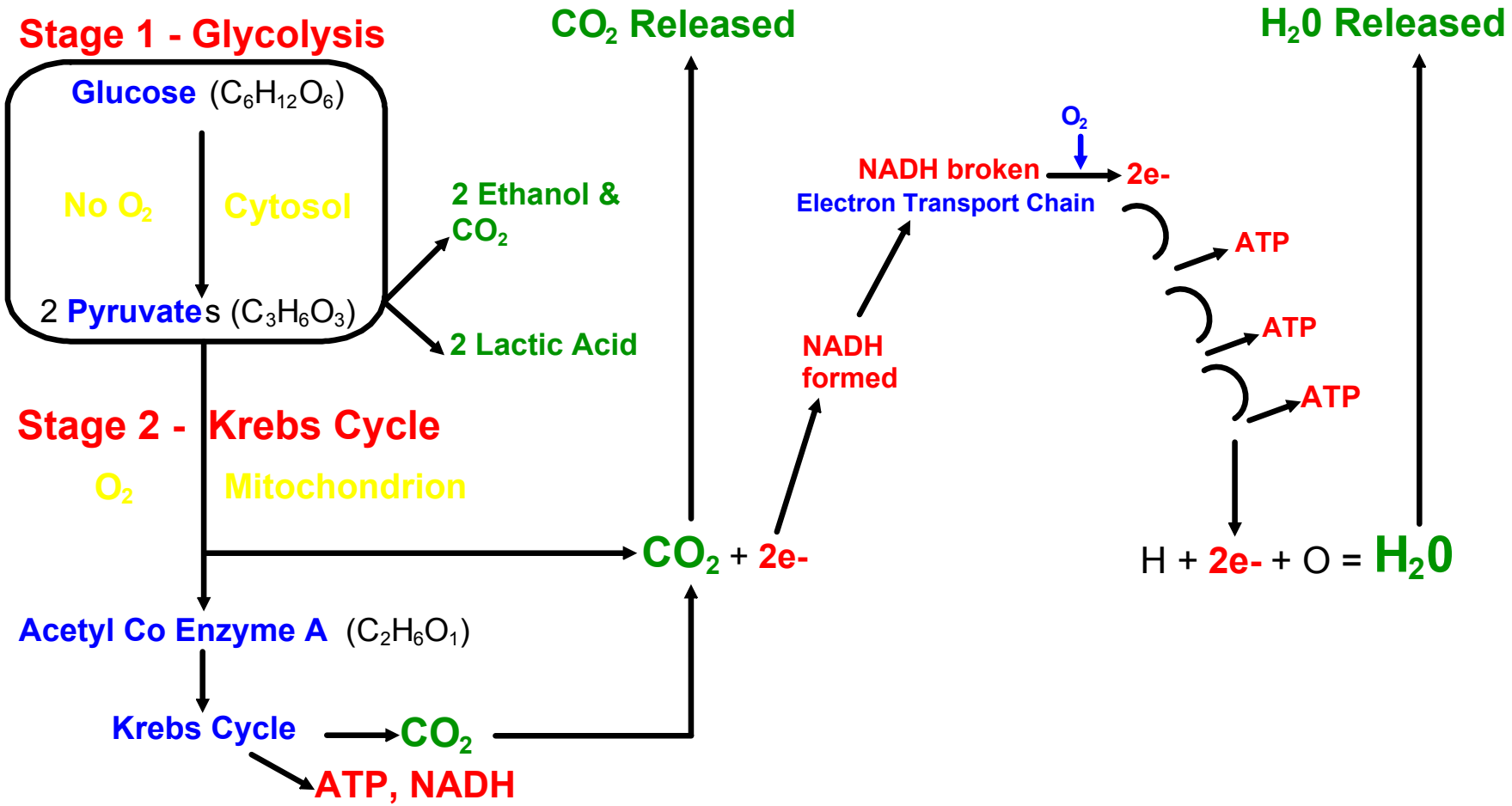
Pyruvate ($C_3H_6O_3$) enters the Mitochondria
It **loses CO_2** and becomes $C_2H_6O_1$
(Acetyl CoEnzyme A).
The Pyruvate also loses **2 electrons** (2 e-)
These combine with NAD+ and a H+ to form **NADH**.



Electron Transport System

These are systems that move energy (electrons) in the inner membrane of the mitochondria. **NADH** that was made earlier from Pyruvate is broken apart and **2 electrons** are released. These set off a chain reaction that makes **3 ATPs**.

At the end of the chain the left over electrons are joined to 2H and O to make **H_20**. This is then released out of the cell.



Respiration Summary