**2.2.5 - H.L 2.2.10 Respiration**

**At the end of ths section you should be able to ….**

|  |  |  |
| --- | --- | --- |
| 1. Define the term: aerobic respiration. |  |  |
| 1. Explain the role of aerobic respiration |  |  |
| 1. Express aerobic respiration by a balanced equation. |  |  |
| 1. Know respiration is a 2 stage process |  |  |
| 1. Know stage 1 does not require oxygen and releases a small amount of energy, occurs in cytosol |  |  |
| 1. Know Stage 2 does require oxygen and releases a large amount of energy, occurs in mitochondrion |  |  |
| 1. Define anaerobic respiration. Know it is a first stage process |  |  |
| 1. State the products of anaerobic respiration |  |  |
| 1. State the cellular location of the first & second stage. |  |  |
| **Contemporary issue**   1. Explain the role of microorganisms in fermentation including bioprocessing with immobilised cells: procedure, advantages and use in bioreactors |  |  |
| **H.L.2.2.10**  11. Know the first stage reaction: Glycolysis |  |  |
| 12. Know the fermentation option: alcohol and carbon dioxide or lactic acid production |  |  |
| 13. Know the second stage process: details of Krebs cycle and electron transport system |  |  |
| **Mandatory activity: Prepare & show the production of alcohol by yeast** |  |  |

**Key words**

**Aerobic respiration, anaerobic respiration, cytosol, fermentation, bioreactor, sodium alginate, calcium chloride, glycolysis, iodoform, potassium iodide, sodium hypochlorite**

* **Definition of aerobic respiration**: Controlled release of energy from food using oxygen.
* **Role** of aerobic respiration:
* Provide energy for cellular activity e.g. protein synthesis, DNA replication, and cell division.
* Provides carbon dioxide for photosynthesis.
* **Balanced equation:**

**C6H12O6 + 6O2 = 6CO2 + 6H2O + energy.**

**Stages of respiration**

Respiration is a **two stage** process:

* The **first stage** does not require oxygen and releases a small amount of energy;
* The **second stage** does require oxygen and releases a large amount of energy.

***Note: Further detail on stages 1 and 2 under higher level P 3***

* **First stage process**

**Anaerobic respiration** may occur in the presence of oxygen but **does not use oxygen**. It is therefore a **first-stage** process.

Anaerobic respiration is also known as **Fermentation.**

The products of Fermentation (anaerobic respiration) are **lactic acid or alcohol** and **carbon dioxide**.

**Fermentation (Anaerobic respiration):**

**Glucose alcohol** **+ carbon dioxide**.

**or**

**Glucose Lactic acid**.

* **Second-stage process**

**Aerobic respiration** **uses oxygen** and is described as a **second-stage** process.

**C6H12O6 + 6O2 = 6CO2 + 6H2O + energy.**

**Cellular location of the first and second stage process:**

* The **first stage process** occurs in the **cytosol** (the cytoplasm minus the organelles).
* The **second stage process** occurs in the **mitochondrion**.

**Contemporary issue:**

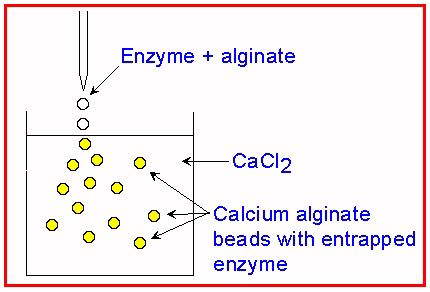
Role of micro-organisms in industrial fermentation

**Industrial fermentation**:

* The use of micro-organisms to make a product e.g. alcohol or bread
* Also known as **bioprocessing**
* Carried out on a large scale in vessels called **bioreactors**.
* Can be carried out using immobilized enzymes (cells). Enzymes are attached to an inert material e.g. sodium alginate

**Procedure**

1. Yeast is mixed with a sodium alginate .
2. Drops of the mixture are added to a calcium chloride solution.
3. Small beads with live, trapped yeast are formed.
4. Nutrients can diffuse through the beads to the live yeast.
5. The product will diffuse from the yeast .



**Advantages of Immobilised Enzymes**

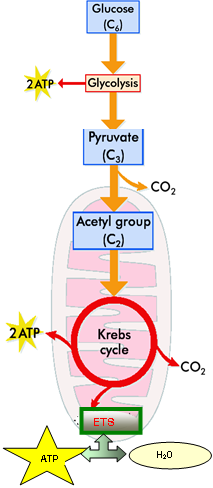
1. Easy recovery of enzymes for reuse.
2. Easy recovery of products (no enzyme contamination).
3. Greater enzyme stability.

Sodium alginate with entrapped enzyme

**Uses of immobilised enzymes (cells)**

* To make alcohol
* To produce glucose
* To make lactose-free milk

**H. 2.2.10 Higher level**



**STAGE 1: GLYCOLYSIS**

* The **first stage** process is referred to as **Glycolysis**
* Converts a **six-carbon carbohydrate (glucose)** to **pyruvate** with the generation of a small amount of **ATP**.

Under **anaerobic** conditions:

* the pyruvate molecule is converted or reduced to **alcohol and carbon dioxide** in most plant cells and yeast.

**or**

* the pyruvate molecule is reduced to **lactic acid** in most animal cells and

many bacteria

**STAGE 2: KREBS CYCLE/ELECTRON TRANSPORT SYSTEM**

In the **second stage** process under **aerobic conditions**, a series of reactions occurs:

* the **pyruvate** molecule enters the mitochondrion and is broken down to one molecule of **carbon dioxide** and a **two-carbon acetyl group, acetyl Co-enzyme A**.
* This **Acetyl Co A** enters a series called **Krebs Cycle** and leaves it later as **CO2 and H2O**.
* During this cycle an electron transport system operates to remove electrons from the substrate intermediates
* Electrons from the cycle are transferred through an electron transport chain (inner membrane of mitochondrion)
* Ultimately these are transferred to oxygen which combines with hydrogen to form water
* The energy released by these electrons through the chain is used in the production of ATP molecules (a large amount of energy is produced).

**Note:** The electron transport system cannot work in the absence of oxygen.

**i) PREPARE AND (ii) SHOW THE PRODUCTION OF ALCOHOL BY YEAST**

**MATERIALS/EQUIPMENT**

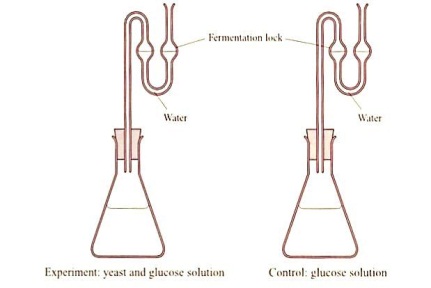
Yeast

Glucose

Sodium hypochlorite solution

Potassium iodide solution

Fermentation locks



**DIAGRAM**

**(i) To prepare alcohol using yeast**

**Yeast and glucose**

**B**

**A**

**Glucose (control)**

P**ROCEDURE**

***(i) To prepare alcohol using yeast***

1. Add yeast and glucose to conical flask A.
2. Add glucose to flask B. This acts as a control .
3. Attach a fermentation lock to each flask.
4. Place both flasks in the incubator at 30 oC overnight.

***(ii) To show the presence of alcohol: Iodoform test for alcohol***

1. Filter the contents of each flask into test tubes.
2. To each test tube, add **potassium iodide** solution

and **sodium hypochlorite** solution.

1. Transfer to a water bath for 4-5 minutes.
2. Allow to cool.
3. Record and compare results.
4. Replicate the investigation.

**Results**

|  |  |  |
| --- | --- | --- |
| **Flask** | **Original colour of filtrate** | **Final colour filtrate** |
| **Yeast and glucose solution** | **Clear** | **Yellow crystals** |
| **Control (no yeast)** | **Clear** | **Clear** |