

CHAPTER 7.1 – PRODUCTION OF ENERGY THROUGH CELLULAR RESPIRATION

The main substrate in energy production

CELLULAR RESPIRATION

- Cellular respiration is the **oxidation process** of organic molecules through several stages to **release** energy
- Cellular respiration is carried out to generate the energy needed by all living cells
- The main substrate is **glucose**
- Chemical energy **found** in glucose is released to **produce** energy required by cells
- In humans and animals, glucose is **obtained** through **digestion** of **carbohydrates** from the food eaten
- In green plants, **light energy** can be **trapped** by **chlorophyll** for the photosynthesis process to produce glucose

Types of cellular respiration

- ⊞ There are **two** types of cellular respiration
 1. Aerobic respiration
 2. Anaerobic respiration

AEROBIC RESPIRATION

- △ Occurs in the **presence** of oxygen

ANAEROBIC RESPIRATION

- ⊕ Occurs in the **absence** of oxygen

FERMENTATION

- ❖ Fermentation is an **alternative pathway** of obtaining energy besides cellular respiration
- ❖ In fermentation, the **breakdown** of **glucose** is **incomplete** in conditions of limited oxygen or without oxygen



CHAPTER 7.2 – AEROBIC RESPIRATION

Aerobic respiration

- ✚ Aerobic respiration is the **breakdown** of **glucose** involving **oxygen** to produce chemical energy
- ✚ Oxygen is used to **oxidise glucose** to produce
 - 1) Carbon dioxide
 - 2) Water
 - 3) Energy
- ✚ There are two processes through in aerobic respiration
 - A) Glycolysis
 - B) Oxidation of pyruvate

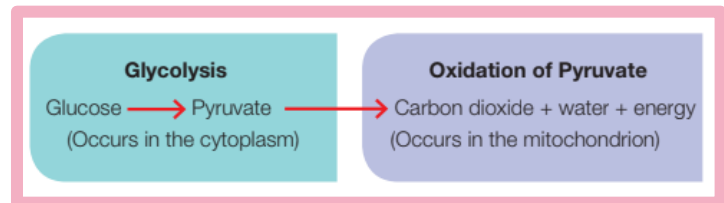
GLYCOLYSIS

- ✓ Glycolysis means the **breakdown** of **glucose** by **enzymes**
- ✓ Occurs in **cytoplasm**
- ✓ One glucose molecule is **broken down** into two pyruvate molecules

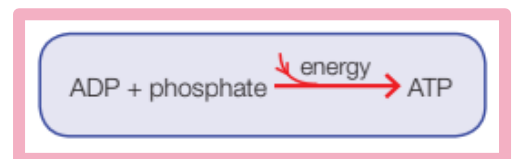
OXIDATION OF PYRUVATE

- Occurs in **mitochondrion**
- Pyruvate produced from glycolysis is then **oxidised** through a series of reactions to produce
 - I Carbon dioxide
 - II Water
 - III Energy

- A large amount of this energy is used to **produce adenosine triphosphate (ATP)** molecules



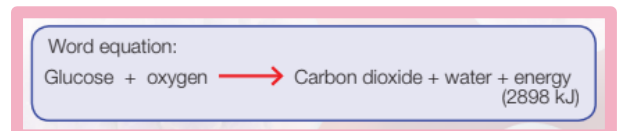
- ✚ The aerobic respiration is simplified as follows:
 - ATP molecules are **produced** when a group of non-organic phosphate is **added** to **adenosine diphosphate (ADP)**



- ATP molecules have **weak** phosphate links
- When the phosphate links on ATP molecules are **broken**, the **energy released** is supplied to cells to help us carry out our daily activities



- ✚ The complete process of glucose oxidation is simplified as follows:



CHAPTER 7.3 – FERMENTATION

Fermentation

- Δ Fermentation is the **incomplete breakdown** of glucose in conditions of **limited oxygen** or **without oxygen**
- Δ Fermentation is **different** from aerobic respiration in its metabolic pathway after the glycolysis stage
- Δ After glycolysis, the pyruvate produced will undergo either
 - a. Alcohol fermentation
 - b. Lactic acid fermentation

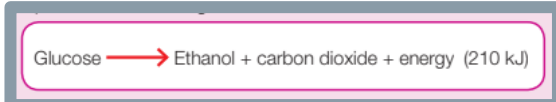
are able to **carry out** alcohol fermentation

- Ethanol **produced** in the tissues during the fermentation process is **toxic** to most plants but the cells of paddy plants have a **higher tolerance** for ethanol compared to other species
- Paddy plants produce **plenty of alcohol dehydrogenase** enzymes that can **break down** ethanol molecules into **non-toxic** carbon dioxide

Alcohol fermentation

→ Alcohol fermentation is the **incomplete breakdown** of glucose to

- 1 Ethanol
- 2 Carbon dioxide
- 3 Energy



→ There are **two** types of alcohol fermentation

- A Yeast
- B Plants

YEAST

- ∨ Ethanol is used in the making of **beer** and **wine**
- ∨ The released carbon dioxide makes bread dough rise

PLANTS

- Paddy plants that grow in **waterlogged areas** with less oxygen

Lactic acid fermentation

➤ Lactic acid is the **breakdown** of glucose into lactic acid and energy



➤ There are **two** types of lactic acid fermentation

- A. Lactobacillus
- B. Human muscle cells

LACTOBACILLUS

- » The bacteria lactobacillus **carries out** milk fermentation to produce yoghurt
- » Lactobacillus acts on the **lactose** (milk sugar) and turns it into **lactic acid**
- » The lactic acid will then **coagulate** casein (milk protein) to produce yoghurt
- » Lactic acid is the source of a sour taste in yoghurt

HUMAN MUSCLE CELLS

- ❑ This process is carried out by the muscle cells during vigorous training
- ❑ During vigorous training, the rate of oxygen used exceeds the oxygen supplied by the blood circulatory system
- ❑ The muscle is in an oxygen-deficiency state and is said to undergo oxygen debt
- ❑ During this process, glucose cannot break down completely
- ❑ For each glucose molecule that is broken down, only two ATP molecules or 150kJ energy will be produced
- ❑ The produced lactic acid accumulates until it reaches a level of concentration that can cause fatigue and muscle cramps
- ❑ Once the vigorous activity stops, the intake of excess oxygen will oxidise the lactic acid into
 - i. Carbon dioxide
 - ii. Water
 - iii. Energy
- ❑ When all the lactic acid has been expelled, the oxygen debt is repaid (refer figure 7.1)

Comparison between aerobic respiration and fermentation

SIMILARITIES

SIMILARITIES BETWEEN AEROBIC RESPRATION AND FERMENTATION	
-	The breakdown process of glucose and its conversion to chemical energy
-	The process begins in the cytoplasm
-	Occurs in yeast, bacteria, animals and plants
-	Produces chemical energy in the form of ATP
-	The process begins with glycolysis when glucose is converted to pyruvate

DIFFERENCES

AEROBIC RESPIRATION	FERMENTATION
The breakdown process of glucose is completed in the presence of oxygen	The breakdown process of glucose is incomplete without oxygen or in limited oxygen conditions
Occurs in cytoplasm and mitochondrion	Occurs in cytoplasm
Produces water	Does not produce water
Glucose is oxidised completely into carbon dioxide and water	Glucose is not oxidised completely into ethanol and carbon dioxide or lactic acid
One molecule of glucose generates 2898 kJ of energy	One molecule of glucose generates 210 kJ (alcohol fermentation) or 150 kJ (lactic acid fermentation) of energy

