Bioenergetics

Photosynthesis

- Photosynthesis is a chemical reaction which takes place in plants. It converts **carbon dioxide** and **water** into **glucose** and **oxygen.** It uses light energy to power the reaction which is absorbed by green **chlorophyll.** Because it absorbs energy, it is an **endothermic** reaction.
- The whole reaction occurs inside **chloroplasts** in plant cells.
- Photosynthesis can be represented by the following word and balanced symbol equations

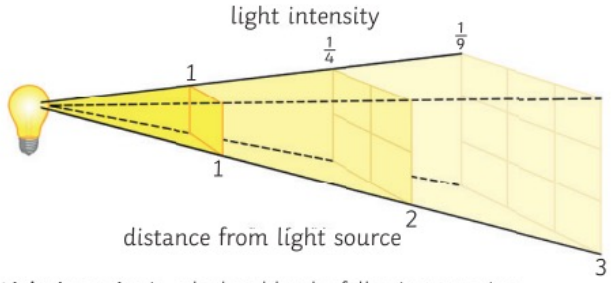
$$\text{carbon dioxide + water} \xrightarrow{\text{light}} \text{glucose + oxygen}$$

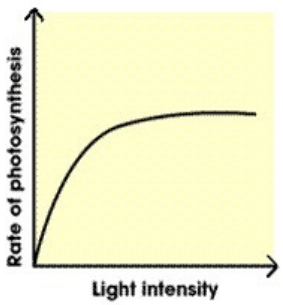
$$6CO_2 + 6H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2$$

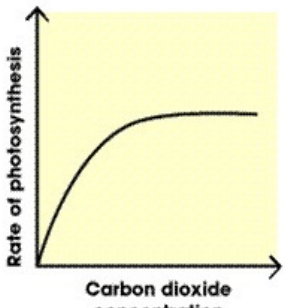
The inverse square law – *[Higher tier]*

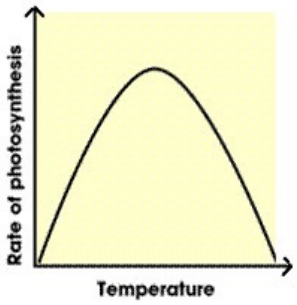
- The inverse square law is used to describe light intensity at different distances from the source. It states that: **the intensity of the light is inversely proportional to the square of the distance from the source.**
- Light intensity is proportional to 1/distance^2
- E.g. if the light source is 0.25m away, the light intensity will be 1/distance^2

So 1/0.0625 = 16 arbitrary units



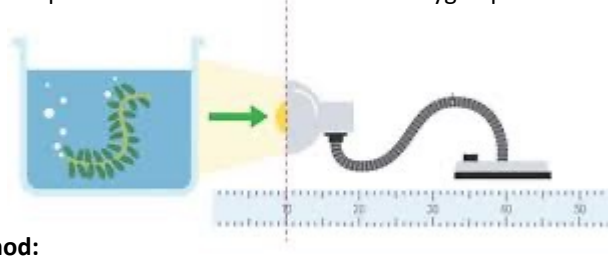






The Rate of Photosynthesis Required Practical

- The rate of photosynthesis can be measured by monitoring the rate that oxygen is produced by plants. To do this we can count bubbles produced by water plants or measure the volume of oxygen produced



Method:

1.Set up a boiling tube containing 45 cm^3 of sodium hydrogencarbonate solution (1%). Allow the tube to stand for a few minutes and shake to disperse any air bubbles that might form.

2.Cut a piece of the pondweed, *Cabomba*. The pondweed should be 8 cm long.

3.Use forceps to place the pondweed in the boiling tube carefully. Make sure that you don't damage the pondweed, or cause the liquid to overflow.

4.Position the boiling tube so that the pondweed is 10 cm away from the light source. Allow the boiling tube to stand for five minutes. Count the number of bubbles emerging from the cut end of the stems in one minute. Repeat the count five times and record your results.

5.Calculate the mean number of bubbles produced per minute. Repeat the experiment at different distances away from the light source.

- Independent variable – distance from the light source/light intensity.
- Dependent variable – the number of bubbles produced per minute.
- Control variables – concentration of sodium hydrogencarbonate solution, temperature, using the same piece of *Cabomba* pondweed each time.

Limiting Factors

- The rate of photosynthesis is affected by water, temperature, light intensity, carbon dioxide concentration and the amount of chlorophyll. These are referred to as **limiting factors** as if one is in short supply, it will limit the rate of reaction.
- Increasing the light intensity or carbon dioxide concentration increases the rate of photosynthesis but does not do so indefinitely. The rate of photosynthesis will stop increasing as another limiting factor is in short supply.
- Increasing the temperature increases the rate of photosynthesis until an optimum temperature is reached. Before the optimum temperature is reached the rate of photosynthesis is slowed by the particles involved in the chemical reaction, moving slowly. Above the optimum temperature the rate of photosynthesis decreases due to the denaturing of enzymes that act as catalyst for the reaction.

Bioenergetics

Aerobic Respiration

- Cellular respiration is a chemical reaction that takes place in the **mitochondria** of cells of all living organisms in order to release energy from glucose.
- The energy released is used for movement, warmth and building larger molecules for growth and repair.
- Respiration releases energy so it is **exothermic.**
- Respiration can be either aerobic (using oxygen) or anaerobic (without oxygen)
- Aerobic respiration can be represented by the following word and balanced symbol equations :

glucose + oxygen ➔ carbon dioxide + water (+ energy)

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

Anaerobic Respiration

- Anaerobic respiration in animal cells can be represented by the following word equation:

glucose ➔ lactic acid (+ energy)

- Anaerobic respiration is far less efficient than aerobic respiration, because of the incomplete oxidation of glucose, and so releases much less energy.
- Anaerobic respiration in plant and yeast cells can be represented by the following word equation:

glucose ➔ ethanol + carbon dioxide (+ energy)

- The products of anaerobic respiration in plant and yeast cells can be used for baking (carbon dioxide cause bread dough to rise) and producing alcohol (used in alcoholic drinks and biofuels).
- Anaerobic respiration occurs in the cytoplasm of cells, rather than in mitochondria.

Oxygen Debt

- When a period of exercise is over, lactic acid must be removed. The body's tolerance of lactic acid is limited.
- Lactic acid is taken to the liver by the blood, and either:
  - oxidised to carbon dioxide and water, or
  - converted to glucose, then glycogen - glycogen levels in the liver and muscles can then be restored.
- These processes require oxygen. This is why, when the period of activity is over, a person's breathing rate and heart rate do not return to normal straightaway.
- The amount of oxygen required to remove the lactic acid, and replace the body's reserves of oxygen, is called the **oxygen debt**.

Response to Exercise

- When we exercise there is an increased demand for energy. To release this energy there is an increase rate of cellular respiration
- The increased rate of cellular respiration requires an increase in oxygen and glucose to be delivered to cells.
- To increase the oxygen in the body available for cellular respiration the body increases heart rate (to increase blood flow in order to transport oxygen and glucose), breathing rate and breath volume (to increase the intake of oxygen)
- If insufficient oxygen is supplied anaerobic respiration will take place
- Incomplete oxidation of glucose causes a build-up of lactic acid and creates an oxygen debt

Metabolism

- Metabolism is the sum of all the chemical reactions in a cell or in the body.
- The energy transferred by cellular respiration in cells is to make new molecules.
- Important factors contributing to an organism's metabolism include reactions such as:
  - Starch, glycogen and cellulose produced by converting glucose
  - Lipid molecules produced from fatty acids and glycerol
  - Proteins synthesised from glucose and nitrate ions
  - Respiration
  - The breakdown of proteins to form urea.

Uses of Glucose in Plants

The glucose produced by photosynthesis can be used for:

- Respiration (a chemical reaction that releases the energy stored in glucose)
- Converted to insoluble starch for storage
- To produce fats and oils for energy storage (especially in seeds)
- To produce cellulose that strengthens cell walls
- To combine with nitrate ions (NO_3^-) that are absorbed from the soil to produce amino acids for protein synthesis.

Greenhouse Economics – *[Higher tier]*

- A greenhouse creates the most suitable conditions for growing plants.
- Artificial lighting can provide light in darker winter days
- A paraffin heater provides extra warmth and carbon dioxide is given off in combustion.
- These additions can be expensive, but the cost is often outweighed by the additional yield of the crop.