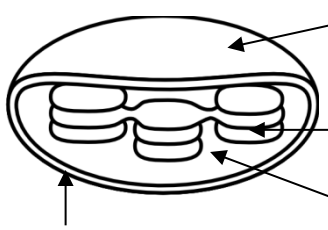
Photosynthesis

Photosynthesis is the process where organisms transform **sunlight energy**, **carbon dioxide** and **water** into chemical potential energy – mainly **glucose/ starch** and produces **oxygen** as a waste product.

$$CO_2 + H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} O_2 + C_6H_{12}O_6$$

Photosynthesis occurs in the **chloroplasts** of autotrophic cells.



Outer membrane

Thylakoids are membranes that contain the chlorophyll – light dependent phase occurs here: a stack of thylakoids = granum (plural: grana)

Stroma – liquid filled interior, where the light independent phase/ Calvin cycle occur.

Inner membrane

Stages of Photosynthesis:

Light dependent stage: the chlorophyll in the thylakoid membrane absorbs solar energy and uses this energy to split the water molecule into hydrogen and oxygen. The oxygen is released from the chloroplast and the hydrogen is carried by NADP to the stroma.

Light independent phase: also called the Calvin cycle - this occurs in the liquid space of chloroplast or stroma. CO_2 and hydrogen enter a biochemical cycle which uses ATP (from the light dependent phase) to produces glucose. The glucose produced is then:

- Used during respiration
- Stored as insoluble starch
- Used to make other organic chemicals that the organism needs e.g. fats, proteins etc.

Factors which affect Photosynthesis:

- **Temperature:** because photosynthesis involves enzymes, as the temperature increases, the rate of photosynthesis increases until it reaches an optimum rate, after which the enzymes are denatured and photosynthesis stops.
- **Light intensity:** increase in light intensity increases the rate of photosynthesis up to a maximum where it levels off, as the light-absorbing pigment is saturated and/or CO_2 becomes limiting, slowing down the Calvin cycle.
- **CO_2 concentration:** increase in CO_2 concentration increases the rate of photosynthesis to a point, where it levels off because the Calvin cycle is saturated and/or light is limited and/or temperature is too low.

Respiration

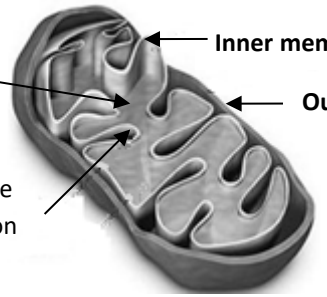
Respiration is the process that occurs in the mitochondria of **all** living organisms, **glucose** being broken down to produce **ATP** (adenosine triphosphate). ATP is the energy molecule used by all organisms to fuel chemical reactions within the cells. Energy is needed by organisms:

- For active transport of materials across membranes
- For chemical reactions in cells to produce molecules e.g. proteins (enzymes)
- To enable the organism to move e.g. muscle contractions, whipping of flagella etc.

$$O_2 + C_6H_{12}O_6 \longrightarrow CO_2 + H_2O + 36\ ATP$$

Respiration occurs in the **cytoplasm** (Glycolysis) and **mitochondria** (transition reaction, Krebs cycle and Electron transport chain) of all living cells.

Matrix: the fluid filled space inside mitochondrion where the Krebs cycle occurs



Inner membrane

Outer membrane

Cristae: folded membrane inside mitochondria where the electron transport chain occurs

Stages of Aerobic Respiration: (respiration in the presence of oxygen).

Glycolysis: occurs in the cytoplasm of the cells. Glucose is broken down into pyruvate; this stage does not require oxygen and produces 2 ATP molecules as well as hydrogen which move to the cristae.

Transition reaction: pyruvate enters the matrix of the mitochondria; CO_2 is removed, producing acetyl coenzyme A and more hydrogen which moves to the cristae.

Krebs cycle: occurs in the matrix. A series of reactions occur, producing CO_2, hydrogen and 2 ATP.

Electron transport chain: occurs on the cristae of the mitochondria. The hydrogens are passed along the electron transport chain, releasing energy which is captured as 34 ATP. Oxygen is required at this stage and water is produced. Each glucose molecule produces 36 ATP during aerobic respiration.

Anaerobic Respiration: (respiration without oxygen)

If oxygen is absent only Glycolysis will occur, producing only 2ATP's: very few organisms can obtain enough energy in the absence of oxygen. However, if it does occur in muscle cells – lactic acid is produced, or in yeast (fermentation) ethanol and CO_2 is produced. In both cases anaerobic respiration is limited by the build up of the toxic products.