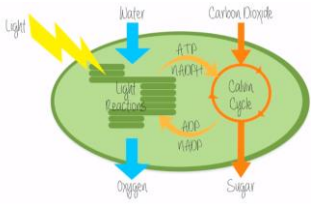
science biology

A-Level Energy Transfers in and between organisms

Photosynthesis

Photosynthesis is the process in plants from which energy from sunlight is used to convert inorganic molecules into organic molecules.



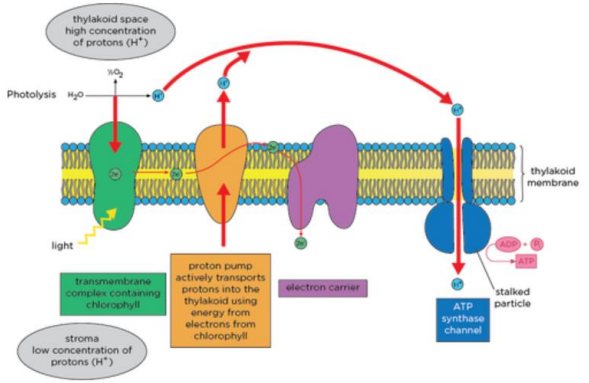
The light-dependent reaction

The light-dependent reaction occurs in the thylakoids of the grana in chloroplasts.

- Photolysis of water requires light energy to break the bonds between oxygen and hydrogen atoms.

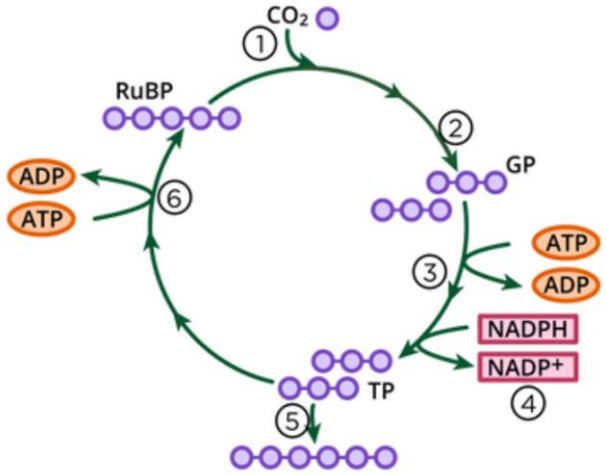
$$2H_2O \rightarrow 4H^+ + 4e^- + O_2$$

- Chlorophyll molecules absorb light energy via photosystem II, exciting a pair of electrons to a higher energy level, leaving the chlorophyll molecules ionized.
- The electron passes through an electron transfer chain to produce ATP, and reaches photosystem I.
- The electrons replace the electrons lost in photosystem I when it absorbs light to reduce NADP with the protons created from photolysis.
- The photoionized chlorophylls electrons in photosystem II are replaced by the electrons from photolysis of water
- Cyclic photophosphorylation only uses photosystem I, where the electrons are passed back to photosystem I rather than NADP via electron carriers, producing small amounts of ATP.



The light-independent reaction

- The light-independent reaction occurs in the stroma of Chloroplasts
- The **light independent reaction** of photosynthesis, consists of a cyclic set of reactions known as the **Calvin cycle.**
- The Calvin cycle depends on the products from the light dependant stage (ATP and reduced NADP)
- The fixation of carbon dioxide is catalysed by RuBisCo
- 5 out of every 6 TP molecules are used to regenerate RuBP instead of producing hexose sugars



1. **Carbon dioxide** reacts with **RuBP** to form two molecules of **glycerate-3-phosphate, (GP).** This reaction is catalysed by the enzyme **RuBisCo.**
2. **Reduced NADP** from the light dependent reaction is used to **reduce GP** into **triose phosphate (TP).**
3. TP is then either converted into useful organic substances such as **glucose, sucrose or cellulose** alternatively it is used to regenerate more RuBP.
4. The hydrolysis of **ATP**, also from the light dependent reaction, provides energy for the **reduction of GP to TP.**

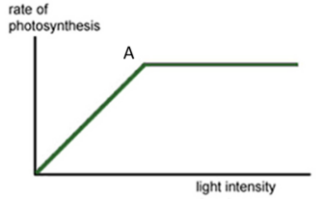
Limiting factors of photosynthesis

- When farming crop plants, the higher the yield the more money the farmer is likely to make.
- The greater the rate of photosynthesis the greater the **biomass.**

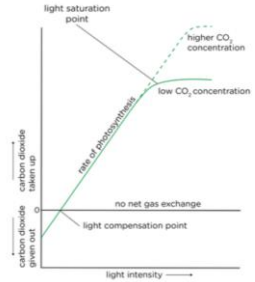
The rate of photosynthesis is limited by:

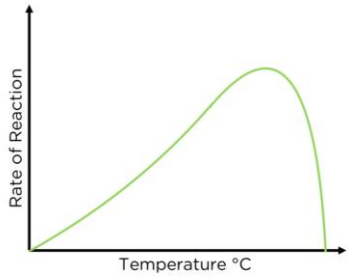
- temperature
- the availability of carbon dioxide
- availability of water within the soil
- light energy

- The law of limiting factors states that at any given moment, the rate of a physiological process is limited by the factor that is at its least favourable value.



The graph on the left shows that up to point A an increase in light intensity increases the rate of photosynthesis, **light is the limiting factor**. After this point any further increase in light intensity has **no effect** on the rate of photosynthesis, **another factor is limiting.**





Chromatography

•Chromatography can be used to separate out photosynthetic pigments, identifying them by their Rf value.

$$R_f \text{ value} = \frac{\text{distance travelled by spot}}{\text{distance travelled by the solvent}}$$

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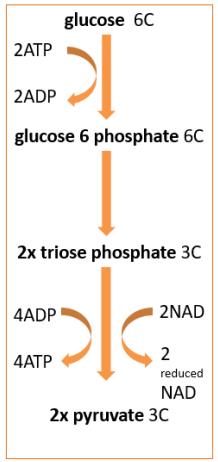
A-Level Energy Transfers in and between organisms

Respiration is the process, which occurs in living cells, that releases energy stored in organic molecules such as glucose.

- The energy released during respiration is used to synthesise molecules of ATP, which can be used as an immediate source of energy.

Aerobic Respiration (with oxygen)

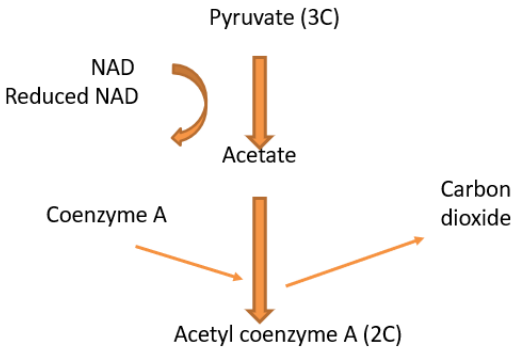
Stage 1 Glycolysis (occurs in cytoplasm of cells)



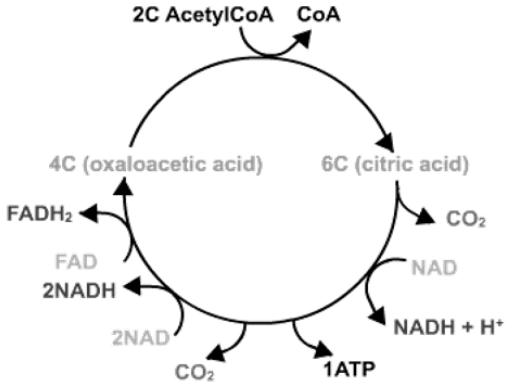
- **Glucose** is **phosphorylated** to form glucose 6 phosphate. This requires 2 molecules of **ATP**. Glucose 6 phosphate is converted to 2 molecules of **triose phosphate**, which are then oxidised to 2 molecules of **pyruvate.**

Stage 2 The Link Reaction

- The **pyruvate** produced in glycolysis is **oxidised** to **acetate.**
- **NAD is reduced** during this reaction.
- Acetate combines with coenzyme A to form **acetylcoenzyme A** which enters the Krebs cycle.
- Carbon dioxide is removed in a process known as **decarboxylation.**



Stage 3 The Krebs cycle

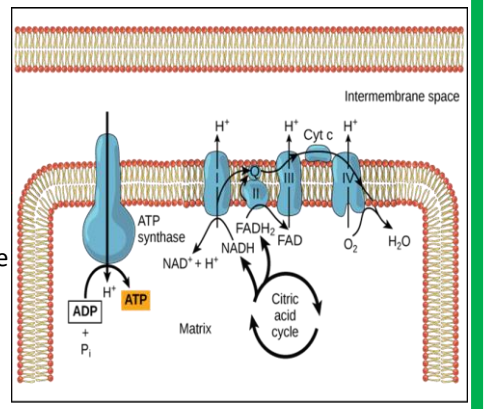


- **Acetylcoenzyme A** reacts with a 4 carbon compound to form a 6 carbon compound which enters the **Krebs cycle.**
- In a series of **oxidation** and **reduction** reactions, reduced coenzymes **NAD and FAD** are produced.
- **ATP** is produced by **substrate level phosphorylation**.
- **Coenzyme A** is released
- **CO_2** is released.
- Other respiratory substrates such as the breakdown of **lipids** and **amino acids** enter the Krebs cycle.

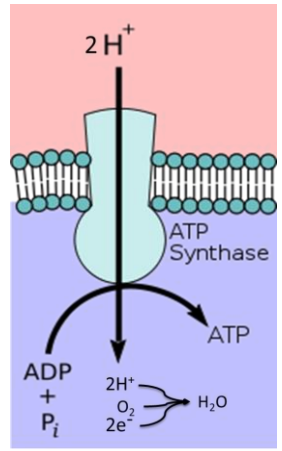
Stage 4 Oxidative phosphorylation

Electrons from the **reduced coenzymes NAD** and **FAD** are used to make **ATP:**

- Electrons travel along an **electron transport chain**, losing energy as they go.
- The energy is used to form a **proton gradient** across the inner mitochondrial membrane

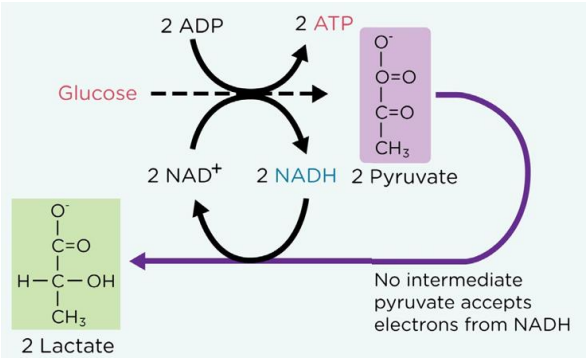


- **Protons** diffuse down their concentration gradient from the space between the membranes to the matrix.
- The protons diffuse through molecules of **ATP synthase** by the process of **chemiosmosis.**
- **ATP** is synthesised from **ADP** and **Pi**
- **O_2** is the final electron acceptor and combines with protons and electrons to produce **H_2O.**



Anaerobic respiration (without oxygen)

- Takes place in the **cytoplasm** of all cells.
- If oxygen is not available as the final electron acceptor, glycolysis can continue in anaerobic respiration.
- Glycolysis can continue if reduce NAD is reoxidised so that NAD is available to accept a hydrogen atom again.
- In mammals, the lactate fermentation pathway is used:



- Lactate can be converted to glycogen in the liver or oxidised further to release energy, when oxygen is available.
- In plants and fungi, the ethanol fermentation pathway is used:

pyruvate + reduced NAD → ethanol + carbon dioxide + oxidised NAD

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