Unit 3: A Level Biology

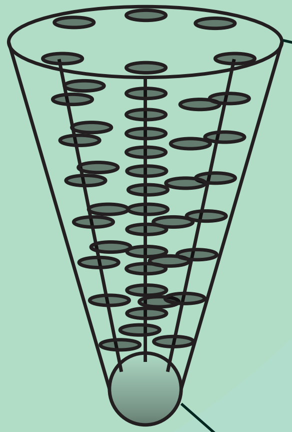
Photosynthesis 1

Chloroplasts are transducers - they convert light energy into chemical energy.

Use the 'Unit 2 – Adaptations for gaseous exchange in plants' to study the adaptations of a leaf for photosynthesis.

- Chloroplasts are mainly located in the palisade mesophyll.
- They are able to move and rotate in that layer in order to maximise light absorption.
- Chloroplasts have a large surface area for maximum light absorption.

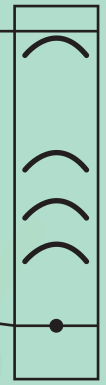
Photosystems - these light capturing complexes are located in the thylakoid membranes and contain different pigments which each absorb different wavelengths of light.



The antennae complex contains chlorophyll *a*, chlorophyll *b*, and the carotenoids xanthophyll and beta carotene. Light energy is absorbed and passed to the reaction centre.

The reaction centre contains 2 molecules of chlorophyll *a*. Electrons in these molecules are excited and raise to a higher energy level.

Chromatography - the different pigments involved in photosynthesis can be observed and identified using chromatography.



$$Rf = \frac{\text{distance travelled by pigment}}{\text{Distance travelled by solvent front}}$$

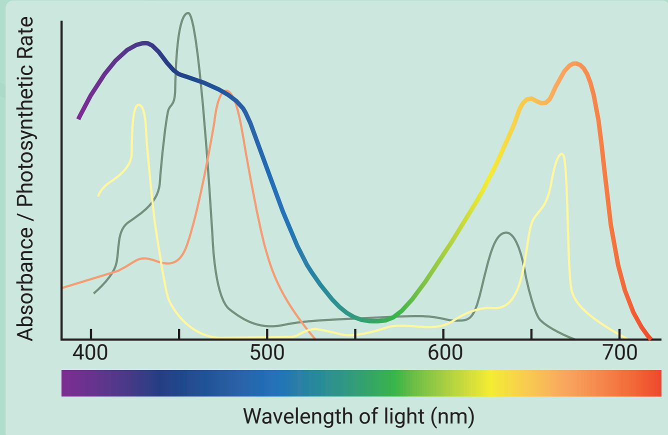
A mixture of pigments is extracted from leaves and applied to the origin of the chromatogram.

The chromatogram is placed into a solvent and left to run.

Pigments travel up the chromatography paper different distances according to their solubilities.

The distance moved by the solvent (the solvent front is marked) and the Rf values can be calculated and compared to known data to identify the different pigments.

Absorption and action spectra can give evidence that the light absorbing pigments are responsible for photosynthesis.



The absorbance spectra (faded lines) show the peak absorbances of the different wavelengths of light for each pigment.

The action spectra (overlaid bright line) shows the rate of photosynthesis at different wavelengths of light.

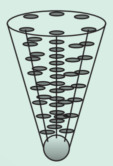
Both lines show peaks in the red and blue regions and a dip in the green region. This supports the theory that red and blue light is absorbed and is used in photosynthesis whereas light in the green region is reflected by the plant and does not contribute to photosynthesis.

Light-dependent reaction
Non-cyclic photophosphorylation (the Z scheme)

Electron acceptor

2e⁻

1. A photon of light is absorbed by a pigment in the antenna complex of photosystem II (PSII). The energy is passed to the reaction centre where an electron from each of the chlorophyll *a* molecule is excited from its ground state to an excited state. These excited electrons reduce an electron acceptor leaving the oxidised chlorophyll *a*.



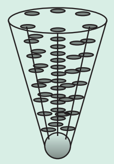
PSII

2. Electrons are passed along an electron transport chain powering proton pumps to pump protons from the stroma into the thylakoid space, decreasing the pH. The increased concentration of protons causes them to flow down the gradient back out of the thylakoid through ATP synthetase driving the creation of ATP from ADP and Pi.

ATP

3. A photon of light hits PSI and the same process occurs as in section 1. However, this time the electron acceptor passes the electron to NADP, forming reduced NADP.

Electron acceptor



PSI

2e⁻

Reduced NADP

H^+

4. Photolysis of water.
Light splits molecules of water within thylakoid spaces into hydrogen ions, electrons and oxygen.
The electrons replace those lost by the chlorophyll *a* of photosystem II.
The protons pass into the stroma and are picked up by reduced NADP.
The oxygen is a by-product and is removed.

Cyclic photophosphorylation

In this case, the electron acceptor that received electrons from PSI passes them back down the electron transport chain to PSI.

Using light (photo) to create the high energy electrons needed to power the electron transport chain to drive ATP synthetase (phosphorylation) gives plants a good source of ATP.

ATP and Reduced NADP will now be used in the stroma for the light independent stage of photosynthesis to create hexose sugars.