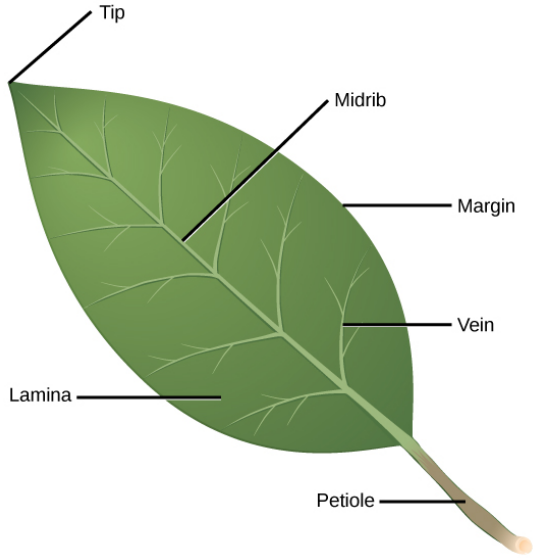
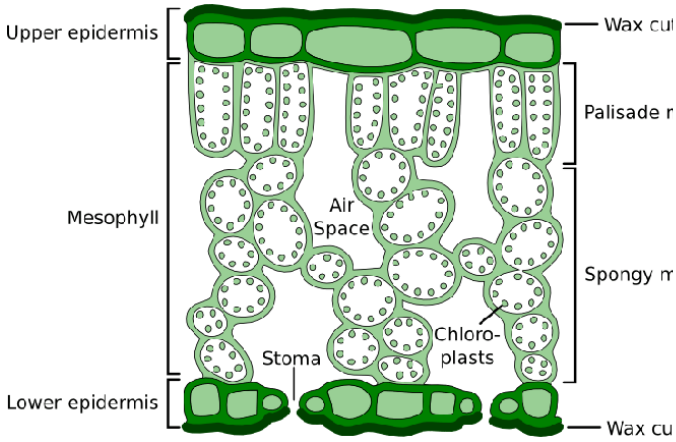
Plant Nutrition

Leaf Structure:



- Has a broad, flat lamina.
- Attached to stem by the leaf stalk which continues into the leaf as the midrib.
- Network of veins delivers water, salts and takes away food. It also forms the skeleton of the leaf.

Cross section of the leaf:



Waxy cuticle:

- Helps reduce water loss, acts as waterproofing.
- Waxy substance is produced by epidermal cells.

Epidermis:

- Single layer of cells on the upper and lower surfaces of the leaf.
- Upper epidermis - thin and transparent, lets sunlight pass.
- Lower epidermis - acts as a protective layer. Has stomata and guard cells.

Palisade Mesophyll:

- Function - photosynthesis.
- Cells are columnar, quite long.
- Packed with chloroplasts.

Spongy Mesophyll:

- Fewer chloroplasts.
- Cells have no definite shape.
- Cells are loosely packed, creating air spaces.

Air spaces:

- Allows for diffusion of gases.
- During daylight, CO_2 is rapidly used resulting in its less concentration in the air spaces. Therefore, more CO_2 diffuses in.
- Oxygen concentration in the air space increases causing oxygen to diffuse out.

Vascular bundle:

- Main vein - midrib. Other veins branch out from the midrib forming a network.
- Vascular bundle consists of xylem and phloem.
- Xylem takes water and salts to the cells. Water is taken into mesophyll cells by osmosis.
- Network of veins ensures no cell is far from a water supply.
- Phloem carries sugars away from the leaf.

Stomata:

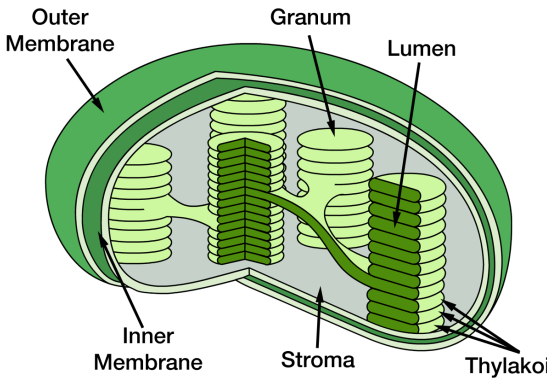
- Site of gaseous exchange in the leaf.
- Surrounded by a pair of guard cells which control its opening and closing.
- Generally open during the day, closed at night.
- Closing of stomata cuts off CO_2 supply, but prevents water loss.
- When there is light, potassium concentration in the guard cell vacuole increases causing water to enter from neighbouring epidermal cells by osmosis. Cell wall near the stomata is thicker causing the cell to curve in a manner that opens the stomatal pore.

Plant Nutrition

Adaptations of the leaf for photosynthesis:

- Broad, flat lamina- large surface area for sunlight and CO_2 absorption.
- Thin leaves - shorter distance for CO_2 to diffuse
- Large air spaces - easy passage for CO_2diffusion.
- Many stomata- allows easy exchange of CO_2 and O_2
- Palisade cells just under epidermis - receive more sunlight.
- Branching network of veins - good water supply for all cells.

Chloroplasts:



- Photosynthesis takes place in the chloroplast.
- Chloroplasts contain chlorophyll which absorb energy from sunlight which are used in photosynthesis.

Photosynthesis:

- Process by which plants manufacture carbohydrates from raw materials using energy from light.
- Glucose is produced - $C_6H_{12}O_6$
- The carbon and oxygen in glucose is obtained from CO_2 while the hydrogen is obtained from H_2O

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{light energy}} C_6H_{12}O_6 + 6O_2$$

- Water - obtained from soil.
- Carbon dioxide - diffuses in through stomata.
- Enzyme required for photosynthesis - RUBISCO.

Light Dependant Reaction - Photolysis

- Takes place in the presence of sunlight.
- First reaction.
- Takes place in thylakoids which are called the site of photosynthesis.
- Energy from sunlight is used to split H2O into hydrogen and oxygen. Oxygen is released as the first product.

Light Independent Reaction -

- Hydrogen molecules move to stomata.
- It is combined with CO_2 to form sugar ($C_6H_{12}O_6$)

Utilization of glucose:

Storage:

- Glucose molecules are quickly built up into starch which is insoluble in order to maintain osmotic potential of the cells.
- Starch is steadily broken down into sucrose which is distributed to all parts of the plant.
- Some plants have tubers (storage organs) to store starch. E.g. potato, parsnip.
- Sugar is also stored in fruit.

Respiration:

- Sugar is oxidised by respiration to carbon dioxide and water.
- Energy is produced which drives other chemical reactions.

Synthesis of other substances:

- Cellulose (cell walls) - built up from glucose chains.
- Proteins (enzymes, cytoplasm) - amino acids are made by combining sugar and nitrogen from nitrates. Amino acids are joined to form proteins.
- Lipids, pigments, etc are also synthesized from glucose and other substances.

Gaseous exchange:

- Process of taking in and giving out oxygen, carbon dioxide, water vapour.
- When the rate of photosynthesis exceeds the rate of respiration CO_2 is taken in and O_2 is given out.

Plant Nutrition

Compensation point:

- All oxygen from photosynthesis is used for respiration and vice versa.
- No net intake or output of CO_2 or O_2
- Sugar produced by photosynthesis exactly compensates for sugar broken down by respiration.

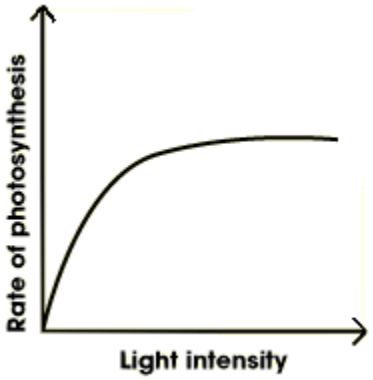
Role of the stomata:

- Opening and closing of stomata is regulated by rate of photosynthesis.

Factors affecting rate of photosynthesis:

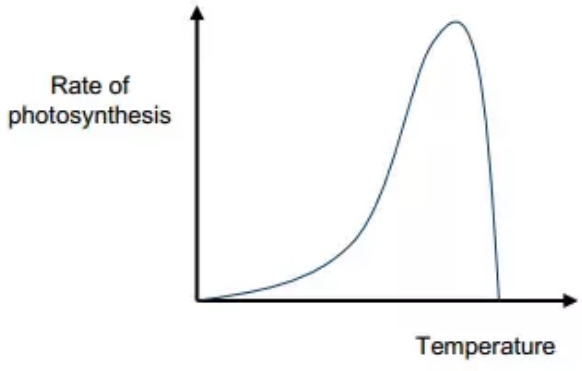
Light intensity:

- Brighter the light, faster the water molecules will be split.
- Increasing intensity past optimum value has no effect.



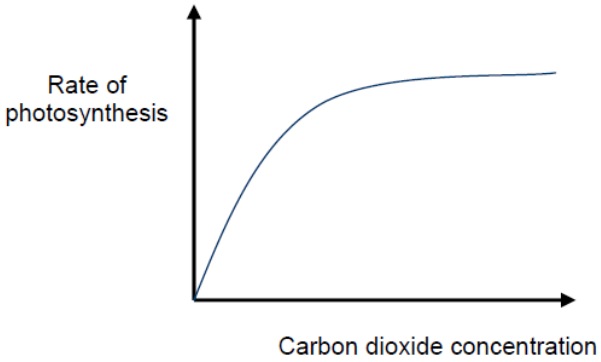
Temperature:

- Affects the light independent reaction.
- Increase in temperature increases the rate at which carbon dioxide and hydrogen combine.
- Increasing the temperature after the optimum causes a decrease in rate of photosynthesis.



CO_2 concentration:

- Increasing concentration past optimum has no effect.
- More CO_2 - faster reaction.



Limiting Factors:

- Something present in the environment in such short supply that it restricts life processes.
- Increase in light intensity past optimum would have no effect as it is limited by carbon dioxide concentration or too few chloroplasts.
- Light independent reactions can be limited by low temperatures.
- An external factor that resists the effect of others is the limiting factor.
- Main effect of extra carbon dioxide is to decrease the rate of oxidation of sugar (photorespiration) which increases the rate of photosynthesis.
- Uptake of mineral ions is limited by absorbing area of roots, rate of respiration, aeration of the soil, availability of carbohydrates from photosynthesis.
- Stomata -
    - Stomata are open when there is low concentration of CO_2 and high light intensity.
    - However, they sometimes close during daytime to prevent excess water loss. This limits photosynthesis.

Green houses:

- Have artificially high CO_2 concentration which increases crop yield.
- Maintain high temperature so that temperature is not a limiting factor.
- Optimise light reaching the plants.

Plant Nutrition

- Allows growers to control the amount of water and nutrients plants receive.
- Reduces damage caused by pests and disease.

Mineral requirements:

- Nitrate ions (NO_3^{--}) - making amino acids for proteins, absorbed from soil.
- Magnesium ions (Mg^{+2}) - needed to form chlorophyll. Obtained from salts in the soil.
- Lack of mineral elements causes deficiency diseases.
    - NO_3^{--}- weak stem, stunted growth, lower leaves become yellow, upper leaves turn pale green.
    - Mg^{+2}- leaves turn yellow from the bottom of the stem upwards - chlorosis.
- Mineral elements are absorbed in the form of salts.
- Salts come from rocks broken down to form soil.
- Salts from dead organisms are returned to the soil.
- In arable farming plants are not allowed to decay so salts must be provided through fertilizers.

Fertilizers:

Ammonium Nitrate (NH_4NO_3)

- Provides only nitrogen
- Sometimes mixed with calcium carbonate to form 'nitro-chalk'.

Superphosphates:

- Mixture of minerals.
- Calcium, phosphate, sometimes sulphate.

Compound NPK fertilizers:

- N - nitrogen
  P - phosphorus
  K - potassium
- Ammonium sulphate, ammonium phosphate, potassium chloride.
- These ions are most likely to be below optimum level in agricultural soil.

Water Cultures:

- Water cultures - solution containing salts that provide all necessary mineral elements.
- Salts can be:
    - Potassium nitrate
    - Magnesium sulphate
    - Potassium phosphate
    - Calcium nitrate
- Some branches of horticulture employ large scale water cultures.
- Increases yield, no pests.
- This technique is called hydroponics.

Image source:

- http://cnx.org/content/m44706/latest/Figure_30_04_01.jpg
- https://www.researchgate.net/profile/Antonio-Rodriguez-9/publication/327734269/figure/fig2/AS:775923011944449@1562005870866/Color-online-Typical-cross-section-of-dicotyledonous-leaf-that-show-their-general.png
- https://www.researchgate.net/profile/Callixte-Yadufashije/publication/324543378/figure/fig8/AS:616049691086852@1523889100577/Chloroplast-structure.png
- https://www.evolvingsciences.com/wpimages/wpc405ac32_06.png
- https://lh3.googleusercontent.com/proxy/vCnGNwH2-NocinUNbIlQQXH3xFu-tbvBrPsORM3aQr3z1a3VGIBMW0see4ArzUH66KyR-iXTNIzyL_FdalrYdSxp25NZu2zKHTj64QpvjoI1TkyeZc2bKJorv9c1S2U
- https://qph.fs.quoracdn.net/main-qimg-1400d93acb1c40b6303b8a84615a300a.webp

---