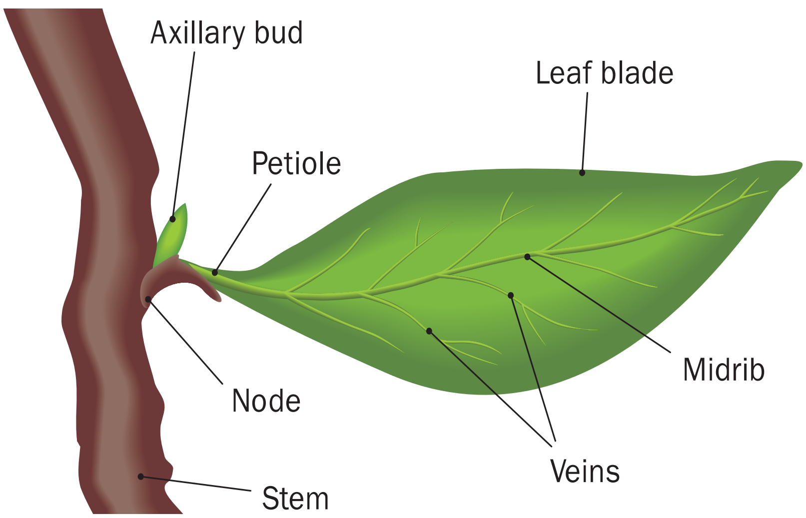
ME - Investigate the influence of light intensity or CO_2 on the rate of photosynthesis

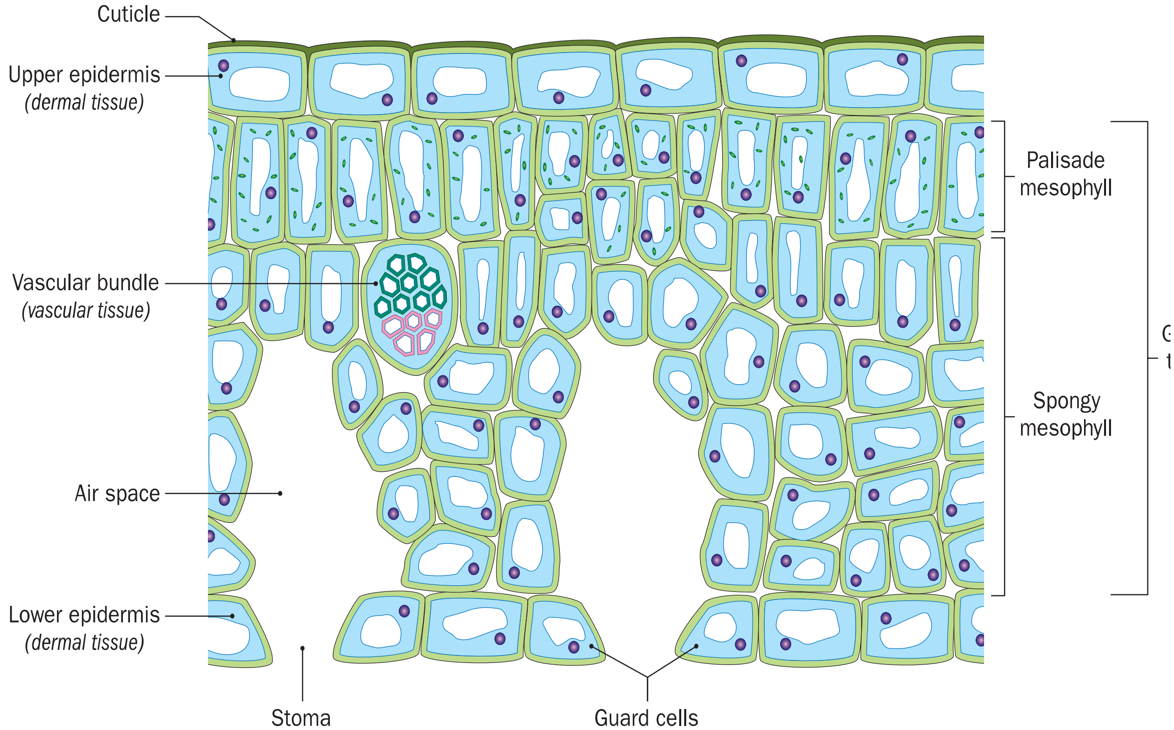
Photo<u>synthesis</u> is the process by which plants make food using carbon dioxide and water in the presence of sunlight and chlorophyll.

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

carbon dioxide   **water**   **glucose**   **oxygen**

Structure of leaf:





Leaf adaptations for photosynthesis:

1. **Stomata**
   for gaseous exchange. Mostly on lower epidermis. Open during day to allow carbon dioxide in for photosynthesis. Closed at night – reduces transpiration.
2. **Air spaces** -
   between spongy mesophyll cells allow for diffusion of CO_2 and H_2O within the leaf.
3. **Thin** - for rapid diffusion of CO_2 in and oxygen out. Also allows all cells to capture light.
4. **Cuticle** - prevents excessive water loss, transparent – allows light through for photosynthesis..
5. **Leaf flattened** to give a large surface area for maximum absorption of light and CO_2.
6. **Xylem vessels** to bring water for photosynthesis and **phloem sieve tubes** to translocate food -sucrose etc.
7. **Petiole** places lamina in best position for light absorption.
8. **Palisade mesophyll** has a high cell density and a large number of chloroplasts per cell for max.
9. photosynthesis.

Factors affecting rate of photosynthesis:

1. Carbon dioxide
2. Light
3. Temperature
4. Water - always available
5. Chlorophyll - variegated leaves.

Rate of photosynthesis is determined by the factor which is in short supply. This factor is called the limiting factor.
Rate can be measured roughly (respiration occurring 24 hours a day) by the amount of CO_2 absorbed or O_2 released by a plant.

1. **Carbon dioxide** - enters through stomata on the lower epidermis and diffuses through the air spaces of the mesophyll.

As CO_2 increases so does the rate of photosynthesis until it reaches a plateau (optimum = 0.1%).
Increase crop production in a greenhouse by pumping in CO_2.
CO_2 may be a limiting factor when plants are overcrowded on a sunny day.
Expt.: To investigate the effect of carbon dioxide concentration on the rate of photosynthesis.
<u>Graph</u>

2. Light:
Light is necessary because it provides the energy needed to convert carbon dioxide and water into glucose.
With an increase in light intensity photosynthsis increases up to light saturation when a plateau is formed. Light may be limiting at dawn, dusk, in a wood or on a warm but dull day.
Compensation point is the **light intensity** at which the rate of photosynthesis equals the rate of respiration i.e. no change in the amount of food in the plant or in the oxygen or carbon dioxide conc. of the air around the plant.
Expt.: To investigate the effect of light intensity on the rate of photosynthesis
<u>Graph</u>

3. Temperature:
The optimum temp. for most plant enzymes is 25ºC (minimum = 0ºC). This is why plants grow better in warm climates, indoors, heated glasshouses or in summer. Growth of plants is slower in colder months due to lower light intensity (hence lower photosynthesis).
Temp. may be a limiting factor in early morning when it is bright but cool.

4. Water
Water is freely available - absorbed by plant root hairs and is conducted through the xylem by the transpiration stream.

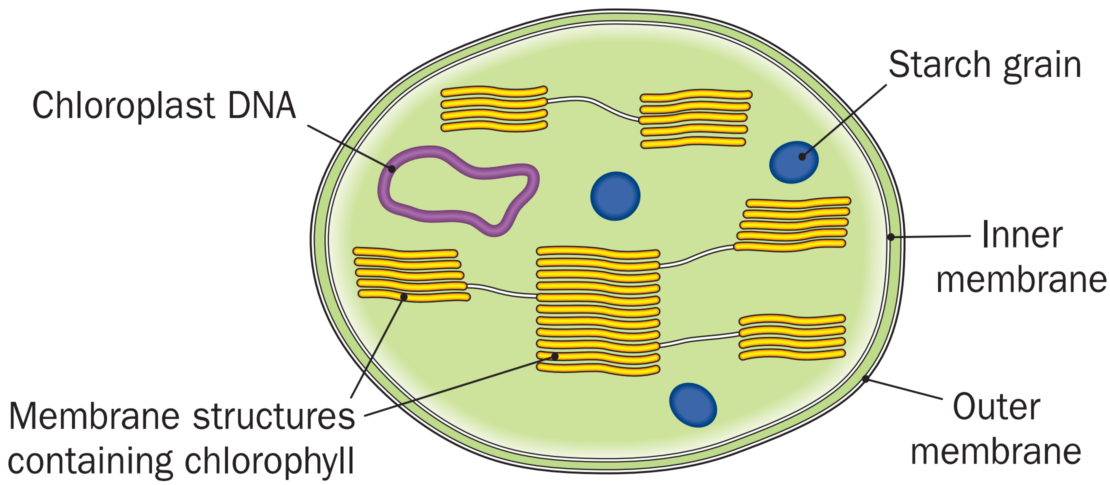
Biochemistry of photosynthesis

2 phases:

1**. Light phase**: a photochemical reaction in which light energy is converted into chemical energy in the **grana** of the chloroplast

2. **Dark phase** - light independent. Sugar is assembled ('synthesised'). It occurs in the **stroma**. Reactions are catalysed by enzymes ∴ the rate is affected by temperature.
(Reactions in light stage are so fast that enzymes are needed.)

Diagram of chloroplast



Light phase
Plants use light to produce ATP – photophosphorylation.
Occurs in two parts:

- **Cyclic photophosphorylation**

Light is absorbed by chlorophyll* and electrons in the chlorophyll molecule are excited. They are picked up by a series of carriers in the electron transport system where ATP is made. The electrons return to the chlorophyll.
*A variety of pigments, chlorophyll included, absorb light energy of different wavelengths and pass the energy onto the chlorophyll molecule next to the electron acceptor. The energised electrons are passed onto the electron acceptor.

- **Non-cyclic photophosphorylation**

Light splits water into hydrogen ions (H^+), oxygen and electrons. These electrons are passed to the chlorophyll molecule. The sun's energy excites electrons from the chlorophyll which are used to combine H^+ with NADP to form NADPH
En route the electrons go through a series of carriers and give up their energy to phosphorylate ADP to ATP. The electrons do not recycle – they start with water and end up in NADPH.

Dark phase
In a series of reactions CO_2 combines with hydrogen (from NADPH) using energy from ATP to form glucose.

Utilisation of the products of photosynthesis:
1. Glucose produced is carried away as **sucrose** in the phloem i.e. translocated.
2. Glucose can be converted to **starch** and lipids as storage.
3. Glucose can act as a respiratory substrate.
4. Glucose is used to form **cellulose** for cell walls and **proteins** for growth (given a supply of N, S etc.).

Diagram of biochemistry of photosynthesis