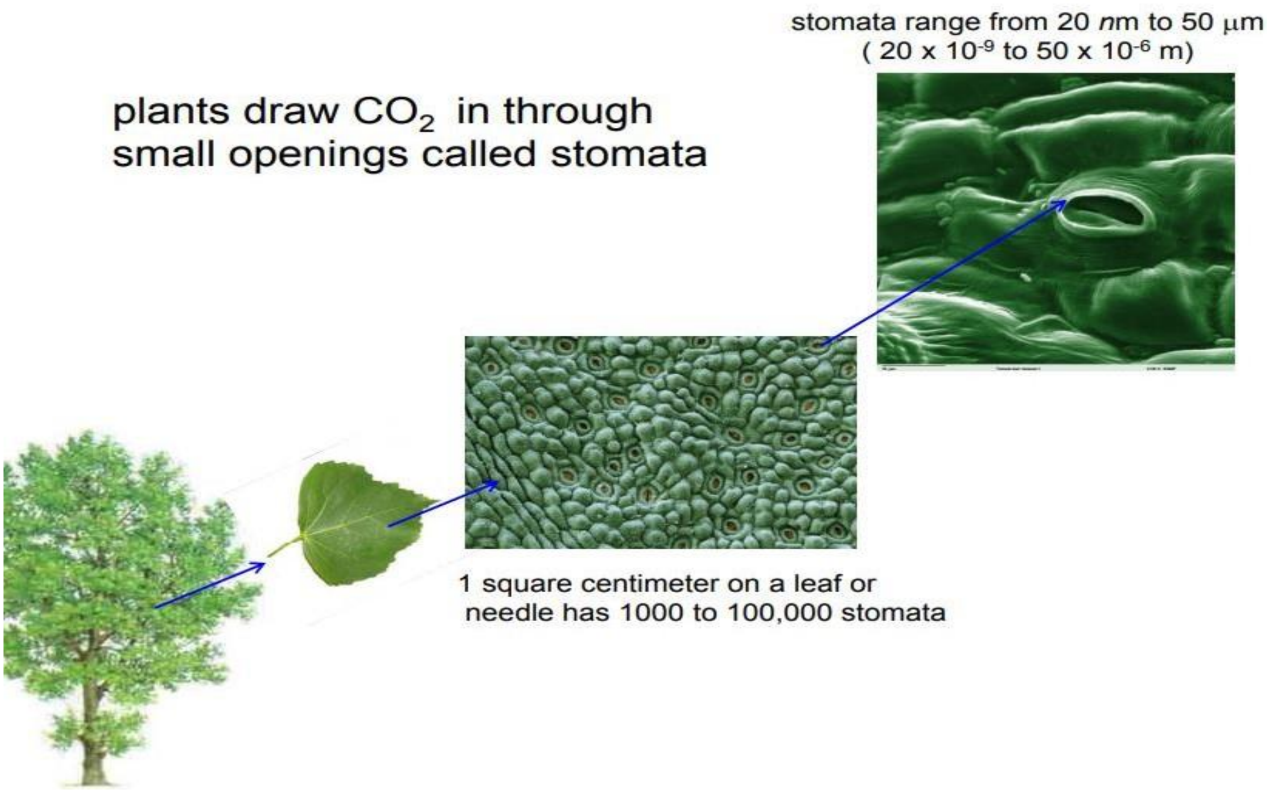
TRANSPIRATION

Guard cells are cells surrounding each stoma (which is a type of hole in the leaf surface). They help to ***regulate the rate of transpiration*** by opening and closing the stomata. When the guard cells are **turgid**, or **swollen**, and the stomatal **opening** is large, the water potential of the guard cells drops and water enters the guard cells. When the guard cells have **lost water**, the cells become **flaccid** and the stomatal opening **closes**. This may occur when the plant has **lost an excessive amount of water**.



Leaves also absorb visible and invisible radiations of the Sun and get **heated** up. The water vaporizers and is given out in the atmosphere. This results in cooling down of the temperature of the leaves. As water vapor evaporates from the stomata it is replaced by water being pulled from the xylem. The water in the xylem is coming from the tree's roots. In other words, water is being pulled up through the tree by transpiration, Transpiration uses about 90% of the water that enters the tree. The other 10% is an ingredient in photosynthesis and cell growth and it is called the tree's sap.

Types of Transpiration

Transpiration can be of different types depending upon the specialized organ from where it is occurring.

1. **Stomatal** transpiration: It is the loss of water through specialized pores in the leaves. It accounts for around **80 to 90%** of the total water loss from the plants.
2. **Cuticular** transpiration: Cuticle is an impermeable covering present on the leaves and stem. It causes only around **20%** transpiration in plants. It is further reduced due to a thicker cuticle in xerophytes.
3. **Lenticular** Transpiration: Lenticels are the tiny openings present on **the woody bark** through which transpiration occurs.

Transpiration serves three essential roles:

- **Movement of minerals** – water moves up from the root, by way of the xylem, and sugars which are products of photosynthesis throughout the tree by way of the phloem. Water serves as both the solvent and the avenue of transport.
- **Cooling** – 80% of the cooling effect of a shade tree comes from the evaporative cooling effects of transpiration. This benefits both plants and humans.
- **Turgor pressure** – Water maintains the turgor pressure in cells much like air inflates a balloon, giving the non-woody plant parts form. Turgidity is important so the plant can remain stiff and upright and gain a competitive advantage when it comes to sunlight. Turgidity is also important for the functioning of the guard cells, which surround the stomata and regulate water loss and carbon dioxide uptake. Turgidity also is the force that pushes roots through the soil.

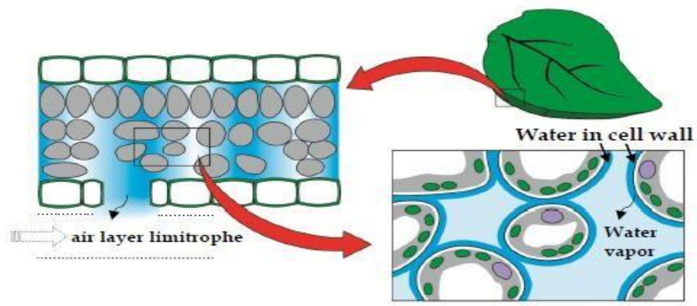
Leaf water and transpiration

In **leaf mesophyll** there is an extensive system of **intercellular spaces** - present in cell walls - which correspond to the internal surface of water contact with the air. By this ***interface between the cell walls and the intercellular spaces*** is established a water **potential gradient**. Due to the water evaporation in the surface of the cell walls which are in contact with the air in the intercellular spaces.

The tensile strength is transmitted to the xylem that drives the upward flow of the water column from the root and is produced in the internal evaporation process in the leaves. Throughout the water route between the leaf and the air there are **two components** that can exert **resistance** to the diffusion process:

1. **Stomatal resistance**, which is coordinated by the stomatal opening

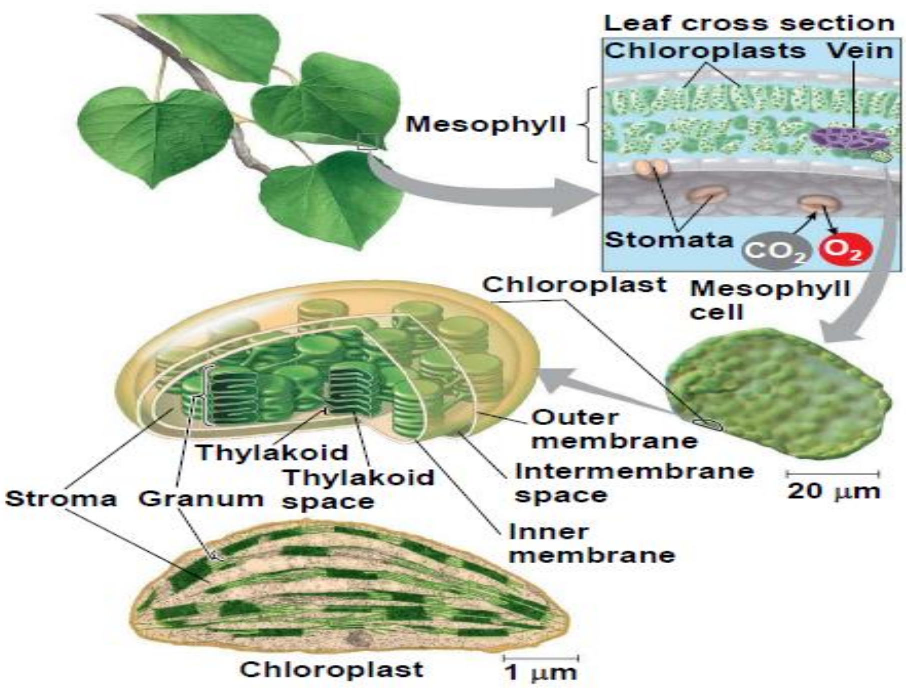
2. **Resistance of the air boundary layer**, which is located **closest to the leaf surface** and it, is directly influenced by wind speed. The **higher the speed** of the wind, the greater is the frequency of air **renewal** in this **layer surrounding** the leaf.



Plants have evolved over time to adapt to their local environment and reduce transpiration. Desert plant (xerophytes) and plants that grow on other plants (epiphytes) have limited access to water. Such plants usually have a much **thicker waxy cuticle** than those growing in more moderate, well-watered environments (mesophytes).

PHOTOSYNTHESIS

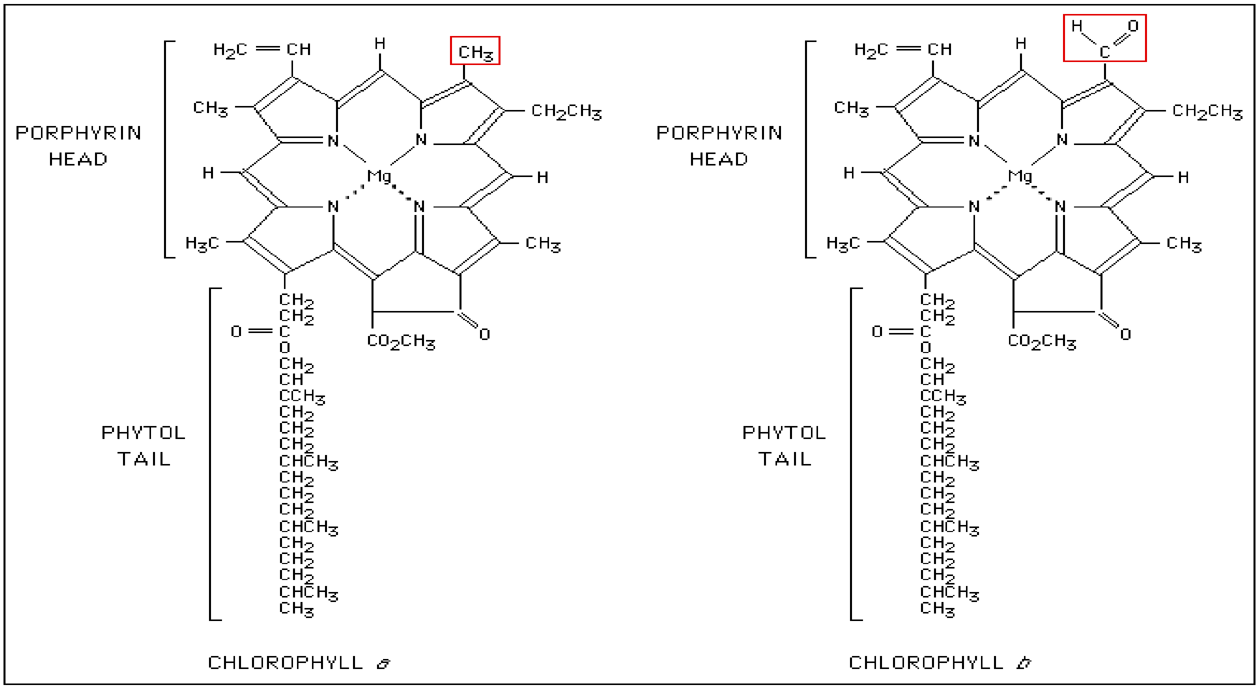
Leaves are the major locations of **photosynthesis**. Their **green color** is from **chlorophyll**, the green pigment within **chloroplasts**. Chloroplasts are found mainly in cells of the **mesophyll**, the interior tissue of the leaf. Each mesophyll cell contains 30–40 chloroplasts. **CO2** enters and **O2** exits the leaf through microscopic pores called stomata. The chlorophyll is in the membranes of thylakoids (connected sacs in the chloroplast); thylakoids may be stacked in columns called grana. Chloroplasts also contain stroma, a dense interior fluid.



CHLOROPHYLL

Chlorophyll is the chemical compound where solar energy (**light**) is **captured** and photosynthesis happens. Chlorophyll is ***continuously produced and broken down during the growing season.*** The heart of the chlorophyll compound is a **magnesium** molecule. The magnesium molecule is bonded to many molecules of hydrogen, carbon, oxygen, and nitrogen. There are **two main types** of chlorophyll in higher plants; **a** and **b**.

1. **Chlorophyll a** is the **primary** photosynthetic pigment. It absorbs energy from wavelengths of **blue-violet and orange-red** light
2. chlorophyll **b** is the **accessory** pigment that collects energy and passes it on to chlorophyll a. It absorbs energy from wavelengths of **green light**.



CAROTENOIDS

Help capture light, but they also have an important role in ***getting rid of excess light energy.*** When a leaf is exposed to **full sun**, it receives a **huge amount of energy**; if that energy is not handled properly, it can damage the photosynthetic machinery. Carotenoids in chloroplasts help **absorb the excess energy and dissipate it as heat**.

PHOTOSYNTHESIS REACTIONS

All trees **photosynthesize** and **respire**. Photosynthesis is a process unique to green plants and produces **sugars**, which are "**tree food**". Trees produce their own food called sugar. These sugars are **not like the refined sugar** that people eat, and these sugars don't usually taste sweet, but the basic organic components are similar. The chemical formula for producing sugars is:

(6) CO_2 + (6) H_2O + sunlight energy = $C_6H_{12}O_6$ + (6) O_2

1. Light dependent reaction:

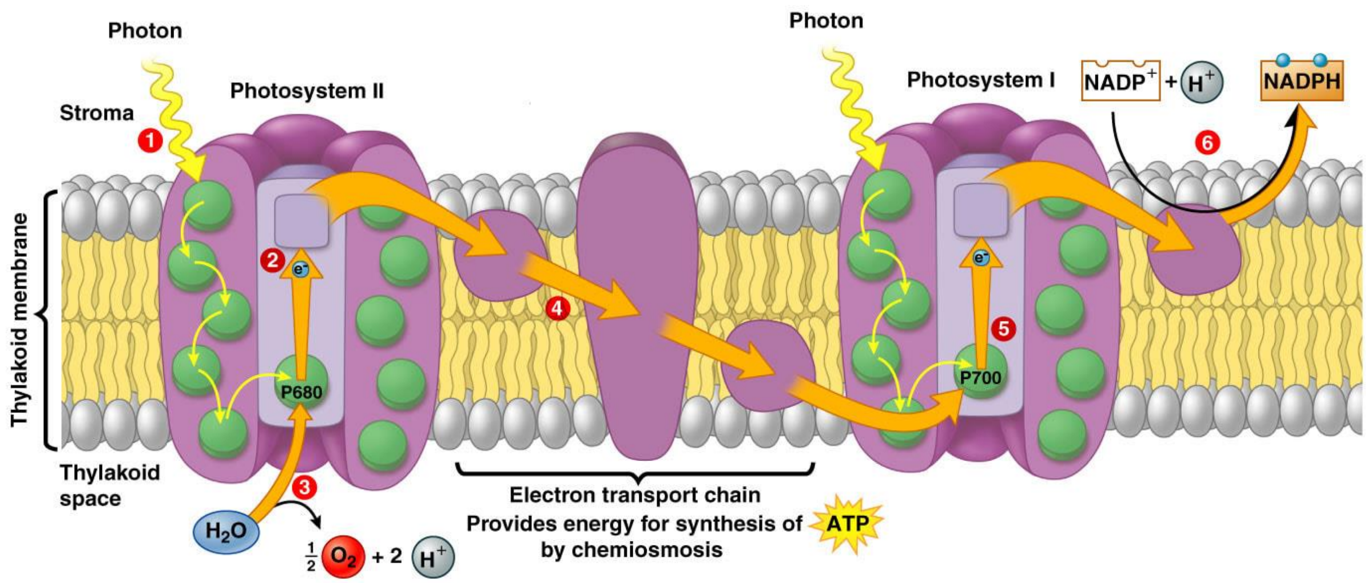
The light energy used to make two molecules needed for the next stage of photosynthesis: the energy storage molecule **ATP** and the reduced electron carrier **NADPH**. In plants, the light reactions take place in the **thylakoid** membranes of chloroplasts. In light dependent reaction; chloroplasts "**capture**" **sunlight energy** in two ways;

A. Light "**excites" electrons in pigmen**t molecules
B. light provides the energy to **split water molecules**, providing **more electrons** as well as **hydrogen ions**.

Photosystems:

large complexes of proteins and pigments (**light-absorbing molecules**) that are optimized to harvest light, play a key role in the light reactions. There are two types of photosystems: photosystem I (**PSI**) and photosystem II (**PSII**).

Both photosystems contain **many pigments** that help collect light energy, as well as a **special pair of chlorophyll molecules** found at the core (**reaction center**) of the photosystem. The special pair of **photosystem I** is called **P700**, while the special pair of **photosystem II** is called **P680**.



When **light strikes chlorophyll a** or an **accessory pigment** within the chloroplast, it **energizes electrons** within that molecule. These electrons **jump up to higher energy levels;** they have absorbed or captured, and now carry, that energy. The excited electrons leave chlorophyll to participate in further reactions, leaving the chlorophyll "at a loss"; eventually they must be **replaced**. That replacement process also **requires light**, working with an enzyme complex to **split water** molecules. In this process of **photolysis** ("splitting by light"), H_2O molecules are broken into hydrogen ions H^+, **electrons**, and oxygen atoms **O_2**. The electrons **replace those originally lost from chlorophyll**. The oxygen atoms, however, form **oxygen gas**, which is a **waste product** of photosynthesis. The oxygen given off supplies most of the oxygen in our atmosphere. In a process called **non-cyclic photophosphorylation** (the "standard" form of the light-dependent reactions), **electrons are removed from water** and passed through **PSII and PSI** before ending up in NADPH. This process **requires light** to be **absorbed twice**, once in each photosystem, and it makes **ATP**. In fact, it's called photophosphorylation because it involves using light energy (***photo***) to make **ATP** from **ADP** (***phosphorylation***).