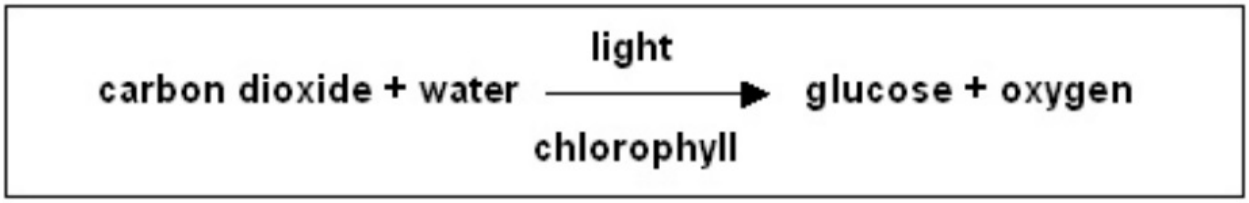
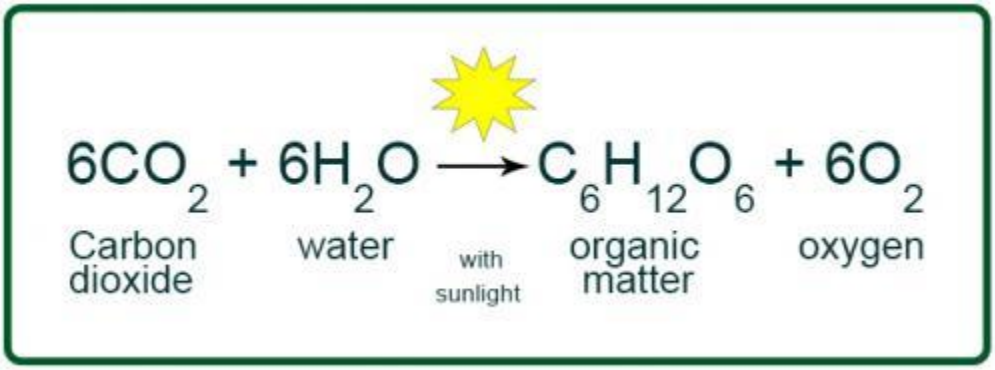
Unit 6: Plant Nutrition

The process of photosynthesis

- Green plants use light energy to convert carbon dioxide and water from their surroundings into simple sugars. This process is called photosynthesis. Photosynthesis is the process by which plants make carbohydrates from raw materials using sunlight energy.





- If too much sugar is dissolved in the cell sap of plant cell it would make a very concentrated solution. This would make water mice in from other cells by osmosis and cause the cells to swell up. To prevent this, glucose molecules are linked together to form larger starch molecules which are insoluble and have no effect on osmosis.

Testing a leaf for starch

- Submerge a leaf in boiling water for one minute in order to destroy the cell membranes and make it easier to extract the chlorophyll
- Put the leaf extract into a test tube of ethanol in a hot water bath for 10 minutes, the chlorophyll is extracted by dissolving into the ethanol.
- Wash the leaf with cold water and spread it out on a white surface
- Add a few drops of iodine solution
- For a positive result the iodine solution will turn from the yellow-brown color to a blue-black color on the surface of the leaf.

Requirements for photosynthesis

- Light
- Chlorophyll
- Carbon dioxide
- Water

De-starching a plant

- The plant is left in the dark for 48 hours in order to de-starch it. The plant is then given all the things that it needs except for the substance we are testing.

Showing that chlorophyll is needed for photosynthesis

- Take a de-starched variegated plant
- Place the plant in the sun for 6 hours
- Test the leaf for starch
- Only the green parts of the leaf go blue-black
- The green plants contain chlorophyll which is needed for photosynthesis to make starch
- The white parts contain no chlorophyll, so no photosynthesis occurs there
- Safety: wear eye protection.

Showing that carbon dioxide and light are needed for photosynthesis

- Take a de-starched leaf and enclose it in a plastic bag with a chemical that absorbs carbon dioxide (Soda Lime)
- Leave the plant in the light for a few hours
- Test the leaf for starch
- The leaf should show a negative result for the starch test. Deprived of carbon dioxide the leaf is unable to photosynthesize.
- A control experiment should be set up exactly in the same way without the soda lime. This means the plant in the control experiment does not have the carbon dioxide removed. Then we can be sure that it was the absence of carbon dioxide that caused the lack of starch and not keeping the plant inside a plastic bag.

Showing that light is needed for photosynthesis

- Take a de-starched plant. Cover part if the leaf with some aluminum foil to prevent light from getting through
- Leave the plant in the light for a few hours
- Test the leaf for starch
- Only the uncovered parts of the test will go blue black. The parts of the leaf that were covered did not receive light and could not carry out photosynthesis and so could not make starch.

Products of Photosynthesis

Sugar	Use
Glucose	Used for respiration in the leaf (energy source)
Some of the glucose is changed to starch	Stored in the leaves for use in the nigh/during cloudy days
Glucose is converted to sucrose	Transported to other parts of the plant via the phloem
Glucose is converted to cellulose	Used to build cell walls
Glucose combines with nitrate	Forms amino acids which are built into proteins. Proteins are used for growth, cell repair and the making of hormones and enzymes
Glucose is converted to oils	Efficient way to store energy in seeds

- Oxygen is a by-product of photosynthesis. Some used for respiration in the plant but most diffuses out of the leaf through the stomata
- Plant products
    1. Food for humans and livestock
    2. Raw materials for industry
    3. Provides medicines
    4. Provides habitats for animals and microorganisms
    5. Keeps the concentration of gases in the air constant (lowers the amount of carbon dioxide and increases the amount of oxygen)

Glasshouse Production

Conditions inside a glasshouse allow plants to:

- Grow earlier in the year
- Grow in places they would not usually grow

The following conditions inside a glasshouse are controlled:

Temperature

- Sunlight heats up the inside of the glasshouse
- The glass stops a lot of this heat from escaping
- Electric heaters are used in cold weather
- Ventilator flaps are opened to cool the glasshouse on hot days

Light

- The glass lets in sunlight
- Artificial light can be used to grow plants when light intensity gets too low
- Blinds keep out very strong light and shading lowers the temperature in tropical countries

Carbon dioxide

- Growers can pump carbon dioxide into glasshouses to increase the carbon dioxide concentration
- They can also burn butane or natural gas which provides carbon dioxide and also heat to raise the temperature of glasshouses during cold water

Water

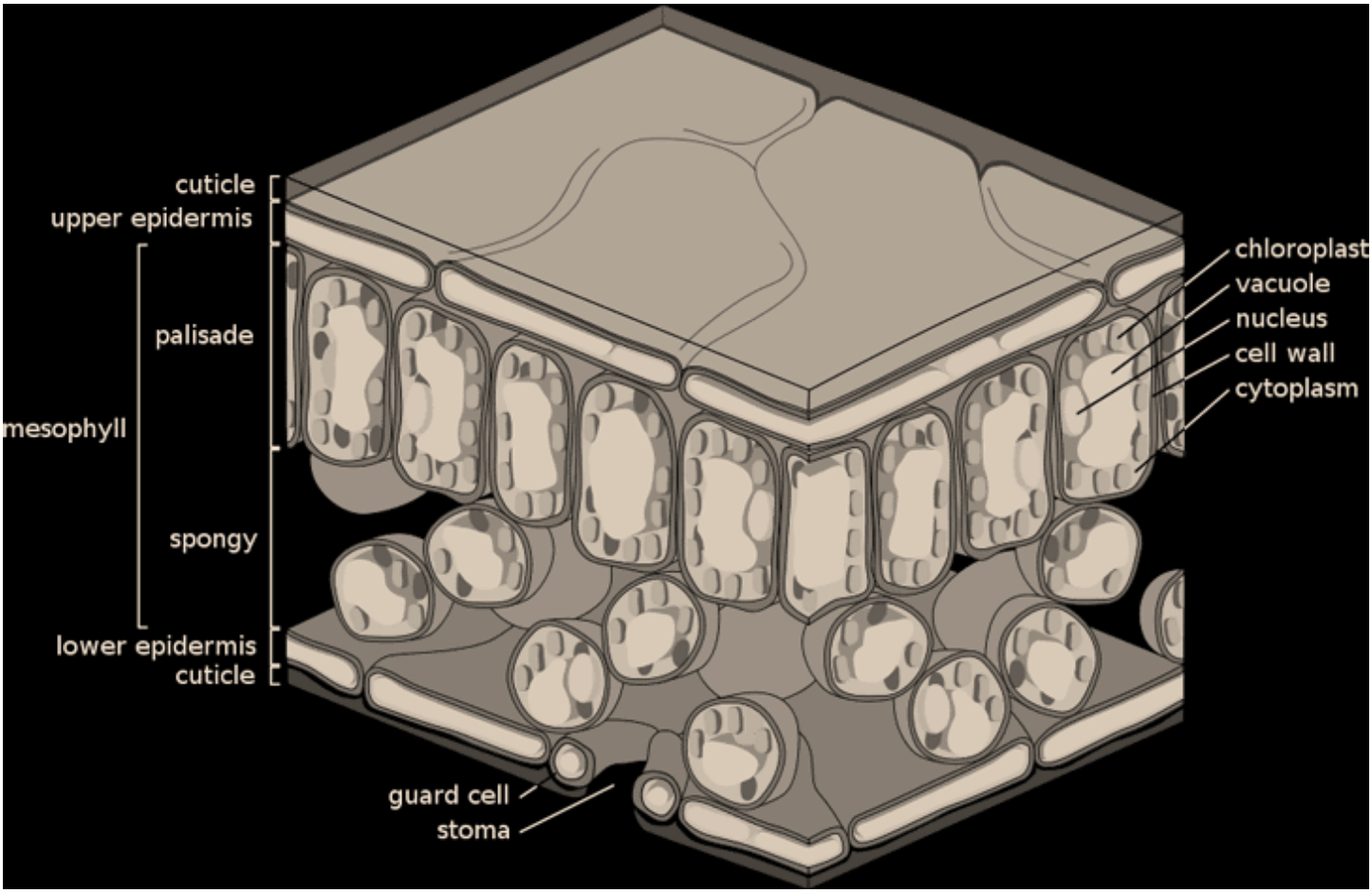
- Automatic sprinklers and humidifiers to ensure that plants always get enough water

- All these factors are controlled by computers so few staff are needed. Sensors are used to detect changes in the limiting factors. Computers process the data transmitted from the sensors and control the heating, ventilation, lighting and shading in the glasshouse.

Leaves

Leaves have:

- A large surface area to absorb light rays
- A thin shape to allow efficient diffusion
- Many chloroplasts to absorb light for the reactions that take place in photosynthesis
- Veins to support the plant, carry water and ions to the leaf cells, take sucrose and amino acids away from the leaf and to other parts of the plant

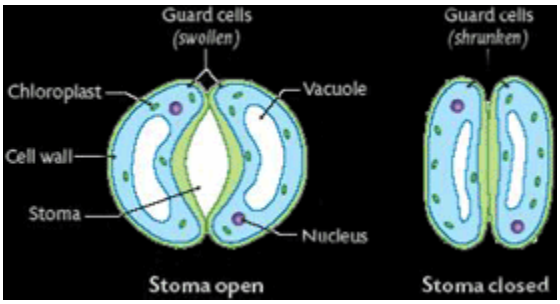


Adaptations of leaves for photosynthesis

- Palisade mesophyll cells are packed tightly together and near the surface of the leaf to maximize the absorption of light where the intensity is the highest
- There are many chloroplasts in the palisade mesophyll cells to absorb as much light as possible
- Stomata open to allow carbon dioxide to diffuse into the leaf. Carbon dioxide is a raw material for photosynthesis
- Leaves are thin so that the carbon dioxide does not have to diffuse far from the atmosphere to the cells of the palisade and spongy mesophyll
- There are large intercellular air spaces within the spongy mesophyll layer. This makes it easy for carbon dioxide to diffuse to all the mesophyll cells. Diffusion through air is much faster than diffusion from cell to cell.

- Xylem veins bring water and ions to the mesophyll cells. Water is a raw material of photosynthesis and magnesium ions are needed by the cells to make chlorophyll
- The sugar produced in photosynthesis is converted to sucrose and transported away from the leaves in the phloem and veins

Stomata



- Stomata are opened and closed by guard cells
- Stomata are usually open during the day water passes into the guard cells via osmosis
- Carbon dioxide diffuses inti the leaf, and oxygen and photosynthesis diffuses out
- At night the stomata close, water passes out of the guard cells by osmosis and they straighten and move closer together to close the pores
- The stomata also close in hot, dry weather to prevent the plant from wilting
- Stomata are usually in the lower epidermis, but some plants like water lilies have them on their upper epidermis.

Plant Nutrients

- Needed for healthy growth
- Deficiency symptoms as a result of nutrient shortage
- Nitrate (nitrogen) - needed for the making of amino acids, to make proteins for growth. A deficiency in nitrates result in poor growth
- Magnesium is needed to make chlorophyll. A deficiency in magnesium results in the plant turning yellow (chlorosis)
- Phosphates are needed to make DNA and for respiration
- Fertilizers may be used as supplements to growth

Gas exchange

- Respiration is a property of all living things
- Night: plants exchange gases with surroundings and respire
- Day: carry out photosynthesis and respiration
- Bright light allows a higher rate of photosynthesis, and more oxygen is produced
- Oxygen is used for respiration in mitochondria and the rest diffuses out of the plant
- Carbon dioxide made by respiration is used for photosynthesis and more diffuses into the plant to make up for the shortage

Aquatic Plants

- Investigate gas exchange using sodium hydrogen carbonate indicator solution
    1. Provides carbon dioxide to the solution
    2. Acts as a pH indicator and provides carbon dioxide
    3. Carbon dioxide dissolves in water to form carbonic acid
- Sodium hydrogen carbonate indicator solution is red
    1. Turns yellow in acidic conditions
    2. Turns purple in the absence of carbon dioxide