**Topic 6. Plant Nutrition**

**Define photosynthesis** - the process by which plants manufacture carbohydrates from raw materials using energy from light.

**State the word equation for photosynthesis:**

carbon dioxide + water → glucose + oxygen, in the presence of light and chlorophyll

**State the balanced chemical equation for photosynthesis**

 Light

6CO2 + 6H2O C6H12O6 + 6O2

 Chlorophyll

**Explain that chlorophyll transfers light energy into chemical energy in molecules, for the synthesis of carbohydrates**

**Outline the subsequent use and storage of the carbohydrates made in photosynthesis**

* Chloroplasts containing chlorophyll are responsible for trapping light energy.
* This energy is converted to chemical energy for the formation of carbohydrates (glucose);
* Glucose is usually changed to sucrose for transport around the plant, or to starch for storage;
* Oxygen is released as a waste product, or used by the plant for respiration.

**Investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis, using appropriate controls**

* Experiments can be used to find out what factors are needed for photosynthesis.
* First the plant is destarched. This involves leaving the plant in the dark for 48 hours. The plant uses up all the stores of starch in its leaves (in respiration).
* One plant (or leaf) is exposed to all the conditions needed- this is the **control.**
* Another plant (or leaf) is deprived of one condition (this may be light or carbon dioxide).
* After a few hours the starch test is carried out on the control and the test plant/leaf.

TESTING A LEAF FOR STARCH

The starch test does not work by placing iodine solution on fresh leaves, it is not absorbed.

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| STAGE | REASON | SAFETY POINTS |
| Boil the leaf in water | To break the cell membranes, this makes it permeable | Danger of scalding |
| Boil the leaf in ethanol | To decolorize the leaf- chlorophyll dissolves in ethanol | No naked flames- ethanol is highly flammable |
| Rinse the leaf in water | Boiling the leaf in ethanol makes it brittle- water softens it |  |
| Leaf the leaf out on white tile | So that the results are easy to see |  |
| Add iodine solution to the leaf | To test for the presence of starch | Avoid skin contact with iodine solution |

***Experiment 1* - *To see if chlorophyll is needed for photosynthesis***



*Steps involved:*

1. Leave a plant with variegated leaves (green and white) in a warm, sunny spot for a few days.
2. Test the leaves for starch (the control is the green part of the variegated leaf; the experimental leaf is the white part of the variegated leaf)

Result: green part will give a positive test for starch due to the presence of chlorophyll

***Experiment 2 - To see if carbon dioxide is needed for photosynthesis***



Destarch a plant. Set up the experiment as shown in the figure. Test the leaves for starch.

Control is the flask with leaf & distilled water.

Experimental leaf shows the absence of starch as it is deprived of carbon dioxide due to the presence of potassium hydroxide or limewater

***Experiment 3 - To see if light is needed for photosynthesis***



Destarch a plant. Set up the experiment as shown in the figure. Test the leaves for starch.

Control is the uncovered part of the leaf which gives a positive test for starch. Experimental leaf is the covered part of the leaf, shows absence of starch in the absence of light.

**Investigate and describe the effects of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis, e.g. in submerged aquatic plants**

*Experiment to show the effect of light intensity on the rate of photosynthesis*



1. Set up the apparatus as shown in the diagram. Make sure that the test tube is completely full of water.
2. Vary the light intensity by changing the distance of light from the plant.
3. Count the number of bubbles produced per minute or the volume of gas (oxygen) collected after 10 minutes for each different intensity of light.

Control variables: Type of plant, size of plant, amount of water in the trough, amount of time to collect the volume of gas.



* As light intensity increases, so does the rate of photosynthesis.
* The light intensity (I) is related to the distance (d) between the lamp and the plant (I=1/d2).
* As the lamp is moved closer, the light intensity increases.
* The rate of photosynthesis is directly proportional to the light intensity.
* However the photosynthetic rate cannot be increased indefinitely, a point is reached where all the chloroplasts cannot trap anymore light.

*Experiment to show the effect of CO2 concentration on the rate of photosynthesis*

*Experiment to show the effect of temperature on the rate of photosynthesis*

**Define the term *limiting factor*** - something present in the environment in such short supply that it restricts life processes

**Identify and explain the limiting factors of photosynthesis in different environmental conditions**

**Describe the use of carbon dioxide enrichment, optimum light and optimum temperatures in glasshouses in temperate and tropical countries**

**Use hydrogencarbonate indicator solution to investigate the effect of gas exchange of an aquatic plant kept in the light and in the dark**

**6.2 Leaf structure**

**Identify chloroplasts, cuticle, guard cells and stomata, upper and lower epidermis, palisade mesophyll, spongy mesophyll, vascular bundles, xylem and phloem in leaves of a dicotyledonous plant**

**Explain how the internal structure of a leaf is adapted for photosynthesis**



 **Transverse section through a leaf Palisade cell**

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| --- | --- | --- |
| ***Parts of a leaf*** | ***Description*** | ***Functions*** |
| Cuticle | Made of wax, secreted by upper epidermis | Helps in water proofing the leaf to prevent water loss |
| Upper epidermis | Thin and transparent, absence of chloroplasts | Acts as protective layer & barrier to disease organisms; allows sunlight to penetrate |
| Palisade mesophyll | No gaps between cells. Cells are long, packed with chloroplasts  | Main region for absorption of light for photosynthesis |
| Spongy mesophyll | Spherical, loosely packed, contain chloroplasts but not as many as palisade | Air spaces between cells allow gaseous exchange - carbon dioxide to the cells, oxygen from the cells during photosynthesis |
| Vascular bundle | Thin vein made of xylem and phloem | Xylem vessels bring water and minerals to the leaf, phloem vessels transport sugars and amino acids away from the leaf |
| Lower epidermis | Stomata present  | Acts as protective layer,  |
| Stomata | Surrounded by guard cells | Guard cells regulate whether the stoma is open or closed to allow carbon dioxide in & regulate the loss of water vapour during transpiration |

**6.3 Mineral requirements**

 **Describe the importance of nitrate and magnesium ions.**

 **– nitrate ions for making amino acids**

 **– magnesium ions for making chlorophyll**

**Explain the effects of nitrate ion and magnesium ion deficiency on plant growth.**

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|  | NITROGEN | MAGNESIUM |
| Mineral salt | Nitrate or ammonium ions | Magnesium ions |
| Why needed | To make proteins | To make chlorophyll |
| Deficiency | Slow growth, weak stem, yellow leaves | Yellowing of leaves |