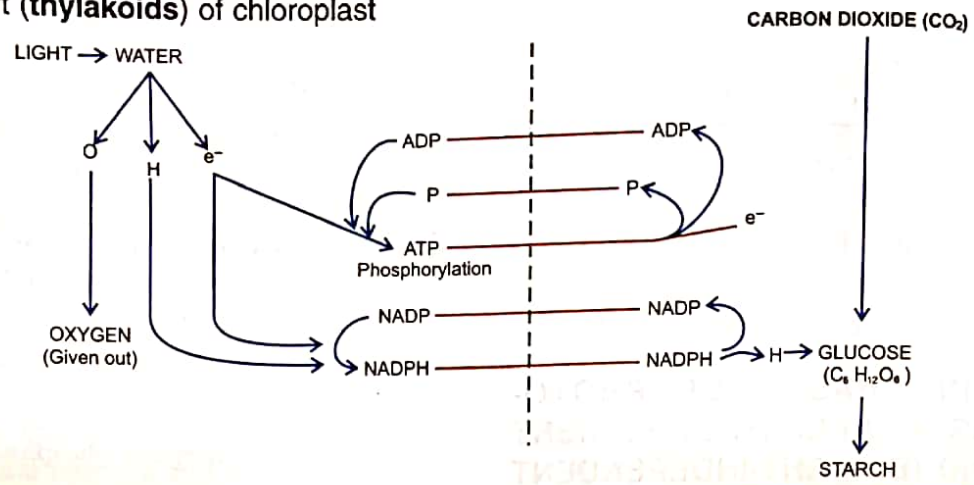
HIGHLY SIMPLIFIED SUMMARY OF THE EVENTS IN LIGHT REACTION AND LIGHT-INDEPENDENT REACTIONS OF PHOTOSYNTHESIS

LIGHT-DEPENDENT REACTIONS
Occur in chlorophyll-containing part (**thylakoids**) of chloroplast

LIGHT-INDEPENDENT REACTIONS
Occur in other part (**stroma**) of chloroplast



Progress Check

1. Write the overall summary chemical equation of photosynthesis.
2. Which single substance in the above equation is repeated in raw material as well as reproduced as an end product?
3. What is the source of oxygen released in photosynthesis — CO_2 or H_2O?
4. What happens in photolysis?
5. Dark reaction involves utilisation of CO_2 in producing $C_6H_{12}O_6$ (glucose). Why is this phase called dark reaction ?
6. Glucose produced during photosynthesis is soon polymerised into starch. What does polymerisation mean?
7. Why is it better to call the dark phase of photosynthesis as "light-independent phase"?

6.7 ADAPTATIONS IN LEAF TO PERFORM PHOTOSYNTHESIS

1. ***Large surface area*** for *maximum light absorption.* (Narrowing of leaves in certain plants is to minimise transpiration in order to conserve water, as in oleander and pine).
2. ***Leaf arrangement*** at the right angle to the light source to obtain maximum light.
3. ***Cuticle and upper epidermis*** are transparent and water proof *to allow light to enter freely.*
4. ***Numerous stomata*** *allow rapid exchange of gases* (oxygen and carbon dioxide).
5. ***The thinness of leaves*** reduces the distance between cells facilitating rapid transport.
6. ***The chloroplasts*** are concentrated in the upper layers of the leaf *to obtain light energy quickly.*
7. ***Extensive vein system*** *for rapid transport* to and from the mesophyll cells.

6.8 END RESULT OF THE PRODUCTS OF PHOTOSYNTHESIS

There are three end-products of photosynthesis:
1. Glucose ($C_6H_{12}O_6$)
2. Water
3. Oxygen.

1. ***Glucose :*** The **simple sugar glucose** is used in four different ways as required by the plant :
   (i) immediately consumed by the plant cells
   (ii) stored in the form of insoluble starch
   (iii) converted into sucrose
   (iv) used in synthesising fats, proteins, etc.

2. ***Water :*** The water produced in the process may be re-utilized in the continuance of photosynthesis.

3. *Oxygen* : Some of the oxygen may be used in respiration in the leaf cells (the phenomenon is called photorespiration), but the major portion of it is not required and it **diffuses out** into the atmosphere through the stomata. In a sense, even **this oxygen is not a waste,** because all organisms require it for their existence including the plants which require it at night.

4. **Utilisation of Synthesised Food and its Translocation** : Food manufactured in the leaf is required for use by all other parts of the plant. The glucose is formed in the leaf very rapidly during photosynthesis and it cannot be transported to other parts with the same rapidity. So, it is converted into **insoluble starch for temporary storage** in the leaf. At night, the starch is reconverted into soluble sugar which is transported in solution through the veins of the leaf and down through the phloem of the stem. In this way, it gets transported **(translocated)** to different parts of the plant where it may be reconverted into starch for storage (as in potato) to produce energy for various functions in the plant.

6.9 FACTORS AFFECTING PHOTOSYNTHESIS

There are four external and three internal factors which affect photosynthesis :

A. EXTERNAL FACTORS

(i) Light intensity

(ii) Carbon dioxide concentration

(iii) Temperature **(iv) Water content**

(i) *Light intensity and* (ii) *Carbon dioxide concentration*

One would easily think that the rate of photosynthesis will increase with light intensity. To some extent, it is true (Fig. 6.3A). Photosynthesis increases with the light intensity up to a certain limit only, and then it gets stabilised at the point S′ (0.02% CO_2). But if, at this point, the carbon dioxide concentration is increased, the photosynthesis also increases further (Fig. 6.3 B) and again gets stabilised at a point S″ = (0.05% CO_2) for the two factors together.

(iii) *Temperature*

With the rise in temperature, the rate of photosynthesis rises. This rise occurs up to the optimum temperature of 35°C (maximum suitable temperature when the photosynthesis occurs best) after which the rate falls and stops above 40°C. At this uppermost limit, the enzymes are destroyed. A rise of 10°C up to the optimum temperature (35°C) doubles the rate of photosynthesis. *For example*, a rise from 20°C to 30°C, or 22°C to 32°C, or 25°C to 35°C, doubles the rate of photosynthesis.

(iv) *Water Content*

The scarcity of water due to reduced absorption from the soil or due to an excessive loss through transpiration reduces the rate of photosynthesis by decreasing diffusive capacity (CO_2 intake) due to the closure of stomata. Only 1% of water absorbed by the root is utilised in photosynthesis.

B. INTERNAL FACTORS

(i) *Chlorophyll* – Nutritional deficiencies of minerals cause loss of chlorophyll, and hence the drop in trapping solar energy.

(ii) *Protoplasm* – Dehydration of protoplasm for some reason reduces the rate of photosynthesis. Similarly, the accumulation of carbohydrates (sugar and starch) also reduces the rate of photosynthesis.

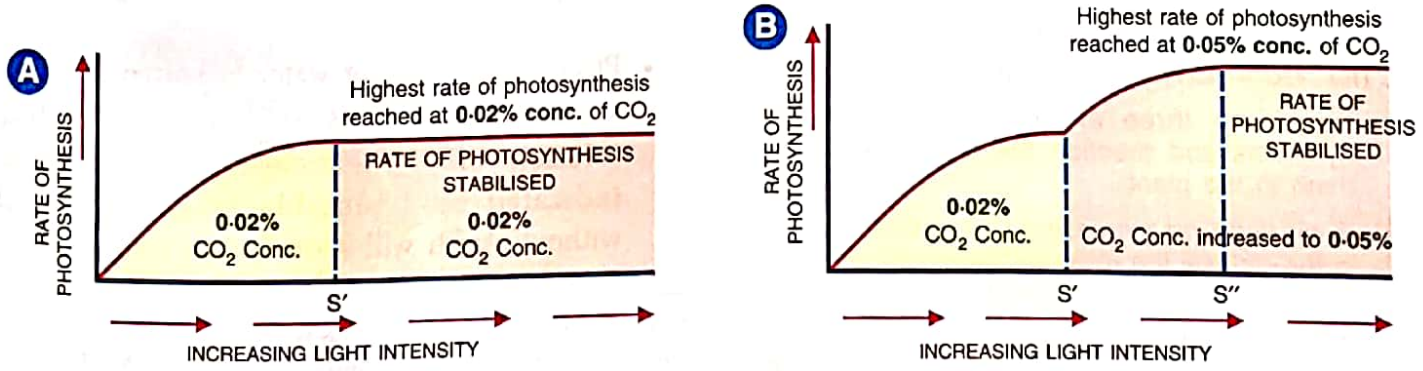


Fig. 6.3 : Photosynthesis at increasing light intensities and CO_2 concentrations

(iii) *Structure of leaf* – The thickness of cuticle, the distribution of stomata and the size of the leaf influence the amount of light and the amount of CO_2 entering the leaf.

Read

Dawn-to-Dusk natural changes in environmental conditions and photosynthesis

In every period of twenty-four hours, plants are subjected to a regular cycle of changes in light intensity, and the rate of photosynthesis increases from dawn to midday and declines as dusk approaches. Plants, like other organisms, respire, taking in oxygen and giving out carbon dioxide. **In light**, the effects of this respiratory activity are masked by those of photosynthesis and there is a net output of oxygen. In **darkness**, respiration alone is responsible for changes in the gaseous composition of a plant's surrounding atmosphere.

"Photosynthesis at night"???

Some desert plants and epiphytes are able to release oxygen even during the night as they perform photosynthesis using a different pathway called the CAM pathway. Examples of such plants include Aloe vera, Tulsi, Neem, Peepal, etc.

Progress Check

1. How do the following favour increased photosynthesis?
   (i) Large surface area of the leaf.
   (ii) Thinness of the leaf.
   (iii) More numerous stomata.
2. Name the three end-products of photosynthesis and mention the fate of each of them in the plant.
3. If we keep on increasing CO_2 concentration in the air, will the rate of photosynthesis also keep on increasing in direct proportion ?
   Yes/No. Explain.