

LIFE SCIENCES

GRADE 11 CAPS

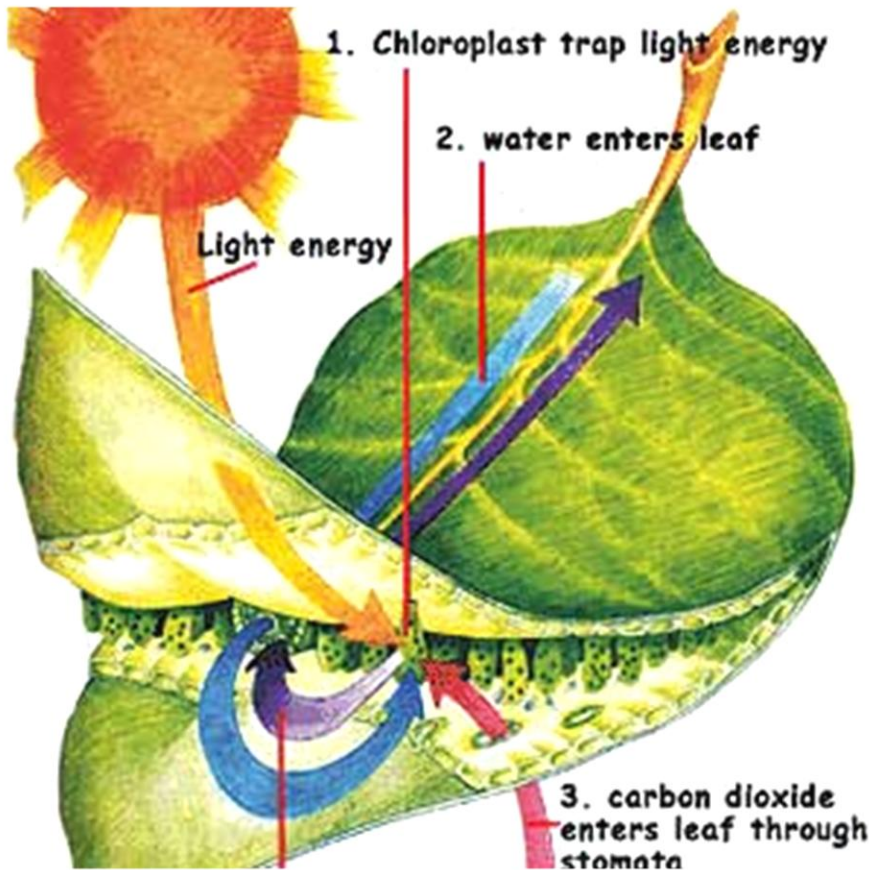
STRUCTURED, CLEAR,
PRACTICAL - HELPING
TEACHERS UNLOCK THE
POWER OF NCS

KNOWLEDGE AREA:

Life Process in Plants and
Animals.

TOPIC 2: Photosynthesis

**Photosynthesis:
The Process**



SUMMARY OF PRESENTATION:

Introduction

Structure of the Chloroplast

The Process of Photosynthesis

Factors affecting the Rate of Photosynthesis

Adaptations of the Leaves for
Photosynthesis

Biological Importance of Photosynthesis

Greenhouse

Role of Carbon Dioxide Enrichment, Optimal
Light, Temperature in Greenhouse Systems

INTRODUCTION:

- ⦿ **Photosynthesis** is the process whereby **green plants** use the **radiant energy** of the **sun** to **manufacture food** in the form of **glucose**.
- ⦿ The process is a **chemical reaction**.
- ⦿ In order for this chemical reaction to occur, there are some **requirements** and at the end of the process some **products** are formed.
- ⦿ The **requirements** of photosynthesis are a source of **energy (sunlight), carbon dioxide and water**.
- ⦿ The **products** of this reaction are **glucose**.

INTRODUCTION:

- ⊙ Oxygen is produced as a by product.
- ⊙ These requirements and products maybe represented in the form of an equation.
- ⊙ This equation is as follows:

Carbon dioxide + water + energy → glucose + oxygen



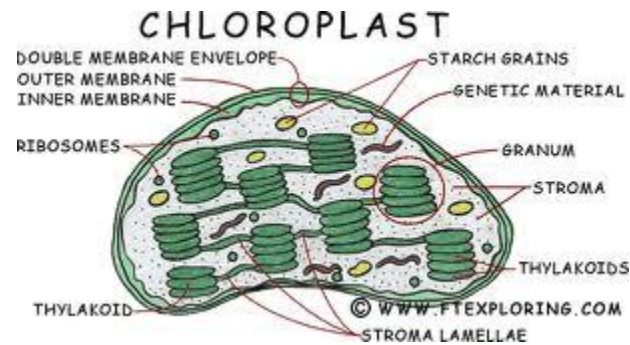
STRUCTURE OF CHLOROPLAST

- ⦿ Since photosynthesis occurs in chloroplast, we must understand the structure of the chloroplast.
- ⦿ The chloroplast is **surrounded** on the **outside** by a **double membrane**.
- ⦿ This **membrane allows carbon dioxide and water to enter the chloroplast**.
- ⦿ Within the double membrane lies the **ground substance** called the **stroma**.
- ⦿ Embedded within the stroma are **stacks of coin-like structures**. Each **coin-like structure** is called the **granum or many grana**.

STRUCTURE OF CHLOROPLAST

- ⦿ The **granum** is **made up of membranes** called the **lamella**.
- ⦿ Within the grana are structures called the **thylakoids**.
- ⦿ These **thylakoids contain the pigment called chlorophyll**.
- ⦿ The **chlorophyll** is used to **trap sunlight**.
- ⦿ Also found in the **stroma** are **starch granules, ribosome and enzymes**.
- ⦿ The **starch granules** are used to **store starch**.
- ⦿ **Ribosomes** are the **site of protein synthesis**, this means it is the **place where enzymes** are **manufactured**.
- ⦿ The **enzymes** are used for the **dark phase**.

STRUCTURE OF CHLOROPLAST



SOMETHING FOR YOU TO DO:

- ⦿ Look at the diagram on the previous slide and explain how the chloroplast is adapted for photosynthesis.

SOLUTION:

1. The double membrane allows for water and carbon dioxide to enter the chloroplast.
2. Chlorophyll is present to trap sunlight.
3. The grana are large flat discs that offers a large surface to trap sunlight.
4. Ribosomes are present for the production of enzymes.
5. Enzymes are present in the stroma for the reactions of the dark phase.
6. Starch granules are used to temporarily store starch.

THE PROCESS OF PHOTOSYNTHESIS:

- ⦿ The process can be divided into **2 phases**:
- ⦿ These are the:
 1. The light phase
 2. The dark phase

The Light Phase:

- ⦿ This phase is **dependent on light**.
- ⦿ This means that if **light is not present** this **phase will not occur**.
- ⦿ Therefore it **occurs** in the **presence of light**.
- ⦿ This phase **takes place** in the **grana** of the **chloroplast**.

THE PROCESS OF PHOTOSYNTHESIS:

- ⦿ Because the **grana** contain the **chlorophyll**.
- ⦿ The **chlorophyll** absorbs the radiant energy from the sun.
- ⦿ This radiant energy is used in 2 ways:
 1. It is used to form **ATP**. ATP is an **energy carrier**. It stands for **Adenosine Triphosphate**.
 2. The **energy** is also **used** to **split the water** molecule into **hydrogen and oxygen**.
- ⦿ These **hydrogen atoms** are **high energy atoms**. They combine with **coenzymes** that **carry them to the dark phase**.

THE PROCESS OF PHOTOSYNTHESIS:

- ⦿ The **oxygen** is released into the atmosphere as a **by-product**.
- ⦿ The **oxygen** leaves the leaves through the **stomata**.

THE PROCESS OF PHOTOSYNTHESIS:

The Dark Phase:

- ⦿ This phase is **independent of light**.
- ⦿ This means that it would **occur whether light is present or not**.
- ⦿ This phase occurs in the **stroma**.
- ⦿ The **carbon dioxide** provides the **carbon and oxygen**.
- ⦿ This **carbon and oxygen combine** with the **hydrogen atoms** of the **light phase** to form **high energy carbohydrates** such as **glucose**.

THE PROCESS OF PHOTOSYNTHESIS:

- ⦿ This reaction requires a **lot of energy**.
- ⦿ The **energy comes from the high energy hydrogen atoms and the ATP molecules**.
- ⦿ The reactions of the **dark phase are controlled by enzymes**.

FACTORS AFFECTING THE RATE OF PHOTOSYNTHESIS:

- ⦿ The **rate of photosynthesis** is affected by both **external and internal factors**.

INTERNAL FACTORS:

- ⦿ There are many internal factors that affect photosynthesis.
- ⦿ However we shall only look at the leaves.
- ⦿ If the **leaves** allow **more light and carbon dioxide to enter** then **more photosynthesis will occur**.
- ⦿ Similarly the **rate of photosynthesis** will **decrease if less light and carbon dioxide enter the plant**.

FACTORS AFFECTING THE RATE OF PHOTOSYNTHESIS:

The following features will allow the leaf to absorb more sunlight and carbon dioxide and therefore increase the rate of photosynthesis.

1. Leaves that have **large stomata** therefore **more carbon dioxide will enter the leaf**.
2. Leaves that have **many stomata**, ensures **more carbon dioxide enters the leaf**.
3. **Large intercellular spaces** allows for the **quick and easy movement of gases and water to the chloroplast**.

FACTORS AFFECTING THE RATE OF PHOTOSYNTHESIS:

4. A **large amount of mesophyll tissue**, therefore **large number of chlorophyll**. This ensures a **maximum amount of sunlight will be absorbed**.
5. The **thin cuticle** allows for the **easy entry of light** and therefore **more light will enter the leaves**.
6. The **fewer or complete absence of epidermal hairs** prevents the reflection of light and therefore **more light will enter the leaf**.

ADAPTATIONS OF THE LEAVES FOR PHOTOSYNTHESIS:

- ⦿ The leaf is covered by a **thin, transparent cuticle** to **allow the light to pass through to the deeper lying tissues easily**.
- ⦿ The **cuticle** is **waxy** to **reduce water loss by transpiration**.
- ⦿ The **epidermis** is **transparent to allow a lot of light to pass through**.
- ⦿ The **epidermis** is only a **single layer thick** allowing **light to pass to the deeper lying tissues more easily**.

ADAPTATIONS OF THE LEAVES FOR PHOTOSYNTHESIS:

- ⦿ The **palisade mesophyll cells** are **elongated** so that they are **closely packed** therefore **more chlorophyll** and **more light would be absorbed**.
- ⦿ The **elongated cells** allows for the **deep penetration of light**.
- ⦿ The **palisade cells** have **thin cell walls** to **allow for the easy entry of carbon dioxide and water**.
- ⦿ The **spongy mesophyll cells** have an **irregular shape**, this creates **air spaces**. These air spaces **allow for gaseous exchange**.

ADAPTATIONS OF THE LEAVES FOR PHOTOSYNTHESIS:

- ⦿ The **spongy mesophyll** also has **chloroplast** to **trap sunlight**.
- ⦿ The **cell walls** are **thin** to allow for the **easy entry of carbon dioxide and water**.
- ⦿ Presence of **xylem to transport water to the chloroplast**.
- ⦿ The **presence of phloem to transport the manufactured food to all parts of the plant from the leaves**.
- ⦿ The **lower epidermis** has **guard cells that contain chloroplast to trap sunlight**.

ADAPTATIONS OF THE LEAVES FOR PHOTOSYNTHESIS:

- ⦿ The **guard cells** has **thick and thin cell walls** to **control the opening and closing of the stomata**.
- ⦿ The **stoma** found between the guard cells allow **carbon dioxide to enter and oxygen to leave the leaf**.

EXTERNAL FACTORS THAT AFFECT THE RATE OF PHOTOSYNTHESIS:

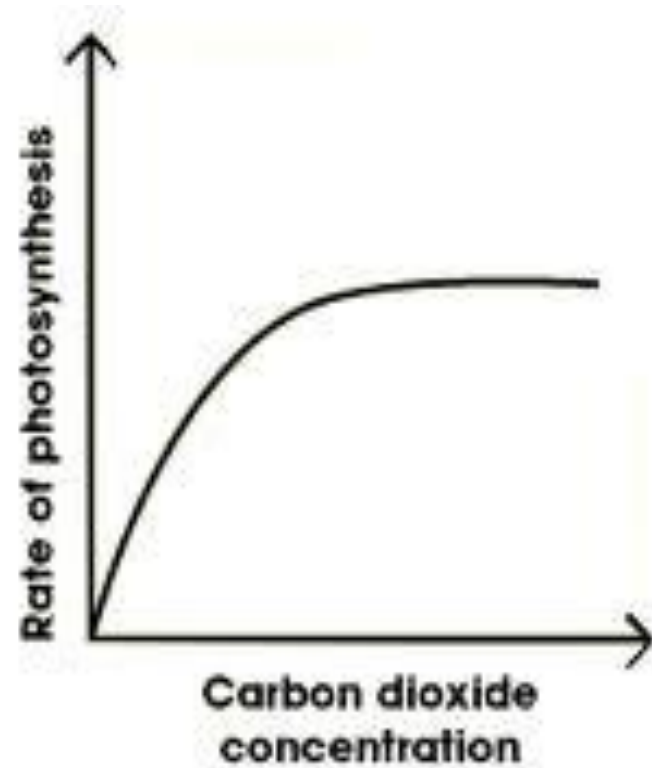
The external factors that affect the rate of photosynthesis are...

1. Carbon dioxide concentration
2. Light intensity
3. Temperature

EXTERNAL FACTORS THAT AFFECT THE RATE OF PHOTOSYNTHESIS:

THE CO₂ CONCENTRATION

- Normal CO₂ concentration in the atmosphere is 0,03%.
- If the CO₂ concentration increases then the rate of photosynthesis would increase too, because CO₂ is one of the requirements of photosynthesis.
- But if the CO₂ concentration remains high over a long period of time then the rate of photosynthesis remains constant.



EXTERNAL FACTORS THAT AFFECT THE RATE OF PHOTOSYNTHESIS:

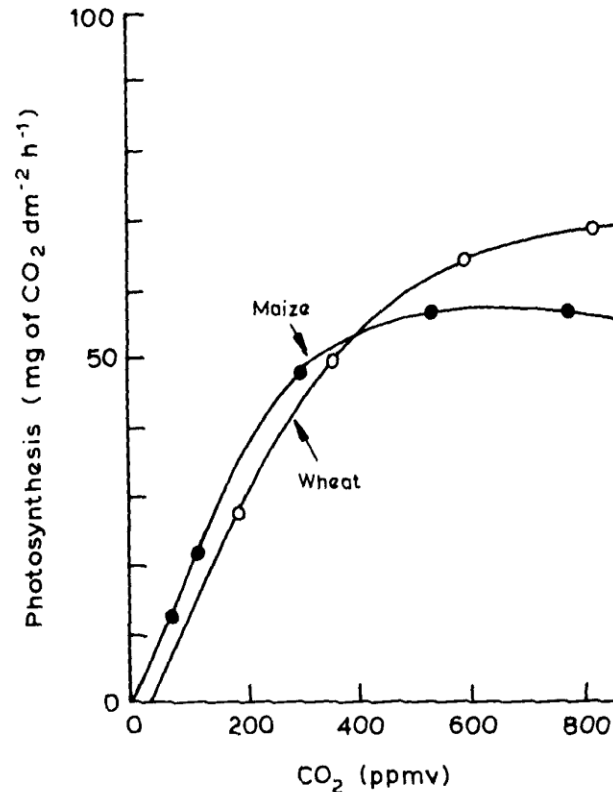
- ⦿ This happens because the **high level of CO₂ changes the pH in the cell** and the **enzymes can no longer work**.
- ⦿ Therefore the **rate of photosynthesis** would **remain the same (become constant)**.
- ⦿ The **rate may also remain constant** because there is **not enough water or light**.

SOMETHING FOR YOU TO DO:

Study the graph alongside and answer the questions that follow:

1. Provide a suitable heading for the graph.
2. Name the dependent and independent variables.
3. What is the optimum CO_2 concentration for the maize plant?
4. Use the graph to explain the relationship between concentration and rate of photosynthesis.

Figure 4.1 Typical photosynthesis response of plants to CO_2 . Net photosynthesis of wheat is about $70 \text{ mg of CO}_2 \text{ dm}^{-2} \text{ h}^{-1}$ compared with maize (about $55 \text{ mg of CO}_2 \text{ dm}^{-2} \text{ h}^{-1}$) for equivalent light intensity ($0.4 \text{ cal cm}^{-2} \text{ min}^{-1}$). Maize is saturated at a lower CO_2 concentration (c.450 ppmv) than wheat (c.850 ppmv). (Adapted from Akita and Moss, 1973).⁴



SOMETHING FOR YOU TO DO:

5. Explain why the rate of photosynthesis does not continue to increase even though the CO_2 concentration does.

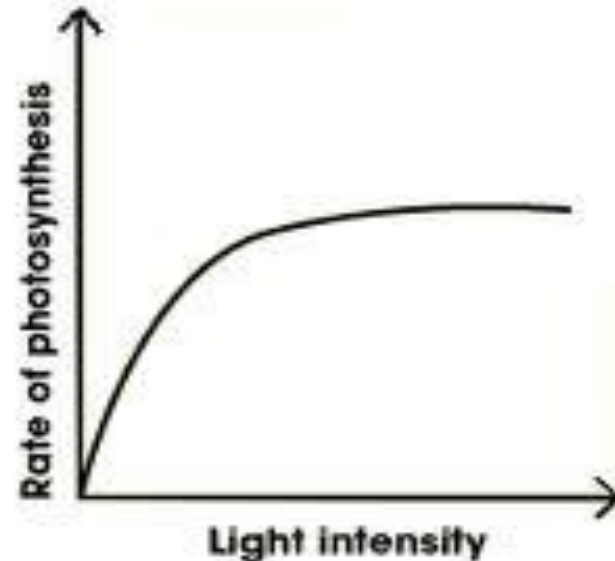
SOLUTION:

1. The effect of increasing concentration on the rate of photosynthesis.
2. dependent - rate of photosynthesis;
independent - CO₂ concentration
3. About 450ppmv
4. As the CO₂ concentration increase the rate of photosynthesis also increases, but it becomes constant and then appears to drop as the CO₂ concentration increases further.
5. The rate of photosynthesis does not increase any further because the levels of CO₂ in the cells becomes too high and this alters the pH and enzymes denature.

EXTERNAL FACTORS THAT AFFECT THE RATE OF PHOTOSYNTHESIS:

LIGHT INTENSITY:

- ⊙ According to the graph if the **light intensity increases**, so would the **rate of photosynthesis**.
- ⊙ If the **light intensity decreases**, so would the **rate of photosynthesis**.
- ⊙ Can anyone explain why?



SOLUTION:

- ⦿ Because light is one of the requirements of photosynthesis, therefore any change in light intensity would affect the rate of photosynthesis.

EXTERNAL FACTORS THAT AFFECT THE RATE OF PHOTOSYNTHESIS:

- ⦿ However **from the graph** we can see that the **rate of photosynthesis does not increase indefinitely**.
- ⦿ At a **certain light intensity** the **rate of photosynthesis becomes constant**.
- ⦿ This occurs because **there might not enough carbon dioxide and water**.

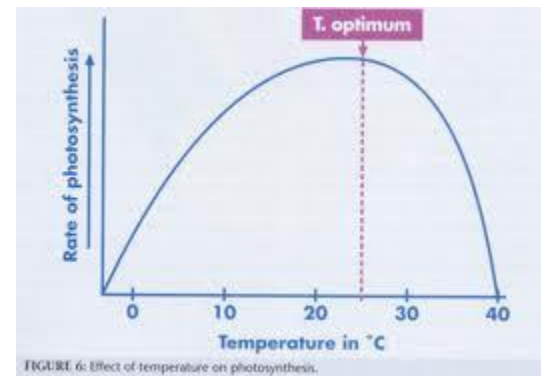
EXTERNAL FACTORS THAT AFFECT THE RATE OF PHOTOSYNTHESIS:

TEMPERATURE:

- ⦿ **Photosynthesis** in **mesophytic plants** have an **optimum temperature**.
- ⦿ This is the **temperature** at which the **rate of photosynthesis** is at its **maximum**.
- ⦿ The **optimum temperature** for photosynthesis in a mesophytic plant is **25°C**.

EXTERNAL FACTORS THAT AFFECT THE RATE OF PHOTOSYNTHESIS:

- ⦿ According to the graph, as the **temperature increase** so does the rate of **photosynthesis**.
- ⦿ It reaches its **maximum rate** at the **optimum temperature**.
- ⦿ If the **temperature continues to increase higher** than **optimum temperature** then the **rate of photosynthesis decreases** and **finally stops all together**.
- ⦿ **Why?**



SOLUTION:

- ⦿ This happens because once the temperature becomes higher than optimum, the temperature is too high and the enzymes start to denature. Therefore the rate of photosynthesis will decrease and eventually stop.

BIOLOGICAL IMPORTANCE OF PHOTOSYNTHESIS:

- ⦿ Photosynthesis has 2 areas of biological importance.
- ⦿ These are:

Provision of food/energy:

- ⦿ **Green plants** absorb **radiant energy** and uses it to **make food** through the **process of photosynthesis**.
- ⦿ In this way **food is provided to all other organisms**.
- ⦿ Also the **radiant energy is transferred to all organisms** that **feed on the plant or on animals that feed on those animals that feed on the plant**.
- ⦿ In this way **all living organisms on Earth posses energy from the sun**.

BIOLOGICAL IMPORTANCE OF PHOTOSYNTHESIS

Control of Carbon dioxide/oxygen levels:

- ⊙ All plants and animals take in oxygen for the process of cellular respiration.
- ⊙ Therefore the levels of O_2 in the atmosphere drops.
- ⊙ All plants and animals give off CO_2 during cellular respiration.
- ⊙ Remember that CO_2 is also given off during decomposition and the burning of fuels.
- ⊙ Therefore the levels of CO_2 in the atmosphere increase and become harmful.

BIOLOGICAL IMPORTANCE OF PHOTOSYNTHESIS

- ⊙ During **photosynthesis** CO_2 is required.
- ⊙ Therefore the **plant absorbs the excess CO_2** .
- ⊙ This causes the **level of CO_2 in the atmosphere to drop to normal**.
- ⊙ During **photosynthesis** O_2 is given off.
- ⊙ This **increases the levels of O_2 in the atmosphere back to normal**.
- ⊙ Therefore **photosynthesis ensures** that the **level of CO_2 and O_2 in the atmosphere is always constant**.

GREENHOUSE:

- ⦿ A **greenhouse** is a **building** in which **plants are grown**.
- ⦿ These **plants will not usually grow in that area or season**.
- ⦿ The **green house** is **made up of glass or layers of polyethylene**.
- ⦿ **Polyethylene** is a **special type of plastic**.



Greenhouses

GREENHOUSE:

The greenhouse works in the following way:

- The **glass walls and ceiling** allows light to enter.
- At the same time **cold air and pests** to the plant (such as **birds, bugs etc**) are kept out.
- By **providing the plant** with **water, fertilizer, good air flow and heat** the plant can grow in any season and climate.
- In **large commercial greenhouses** special equipment and trained staff are available to **ensure the correct amount of water, fertilizer, good air flow and heat** are available to the plant at all times.
- Remember the **mentioned factors** will **affect the rate of photosynthesis and cellular respiration** and therefore the **growth of the plant**.

ROLE OF CO₂ ENRICHMENT, OPTIMAL LIGHT & TEMPERATURE IN GREENHOUSE SYSTEMS

- ◉ We already know that **light, temperature and (CO₂) concentration affect the rate of photosynthesis.**
- ◉ Therefore if these **factors increase or decrease the rate of photosynthesis will change accordingly.**
- ◉ In a greenhouse these factors can be controlled according to needs these of the plant.
- ◉ **For example:**
 - If it is **too bright** then **shade cloths may used to reduce light entering.**

ROLE OF CO₂ ENRICHMENT, OPTIMAL LIGHT & TEMPERATURE IN GREENHOUSE SYSTEMS

- If there is **not enough light** then **artificial light maybe added**.
- **Temperature** can be **altered** by using **heaters to increase temperature or fans to decrease temperature**.
- The **carbon dioxide concentration** can be **increased by pumping in compressed CO₂**.

TERMINOLOGY:

- ⦿ **Photosynthesis**: is the process whereby a green plant uses the radiant energy of the sun to manufacture food in the form of glucose.
- ⦿ **Granum**: coin-like structure that contains chlorophyll.
- ⦿ **Chloroplast**: organelle that contains chlorophyll.
- ⦿ **Chlorophyll**: green pigment that traps sunlight and gives the plant its green colour.
- ⦿ **Stroma**: ground substance of chloroplast
- ⦿ **Light phase**: the reactions of photosynthesis that can only occur in the presence of light.

TERMINOLOGY:

- ⦿ **Dark phase:** the reactions of photosynthesis that is independent of light.
- ⦿ **Greenhouse:** a building made up entirely of glass or polyethylene that is used to grow plants all year round.
- ⦿ **Polyethylene:** is a special type of plastic used to make greenhouses.

QUESTION 1

The requirements for photosynthesis are...

- A. CO_2 , light, water
- B. O_2 and glucose
- C. Light, water and glucose
- D. CO_2 and glucose



QUESTION 2

The products of photosynthesis are...

- A. CO_2 , light, water
- B. O_2 and glucose
- C. Light, water and glucose
- D. CO_2 and glucose



QUESTION 3

The by product of photosynthesis is...

- A. CO_2
- B. O_2
- C. glucose
- D. water



QUESTION 4

The leaf is adapted to absorb sunlight because it contains...

- A. Chromoplasts
- B. Leucoplasts
- C. Chloroplasts
- D. Amyoplasts



QUESTION 5

The pigment that is responsible to absorb sunlight is...

- A. Haemoglobin
- B. Melanin
- C. Both A and D
- D. Chlorophyll



QUESTION 6

The glucose that is made during photosynthesis is stored as...

- A. Starch granules
- B. Ribosomes
- C. Enzymes
- D. chlorophyll



QUESTION 7

The small round body found in the chloroplast that is involved in the production of enzymes is...

- A. Starch granules
- B. Ribosomes
- C. Enzymes
- D. Chlorophyll



QUESTION 8

The protein molecule that is used to speed up chemical reactions without being used in the reaction is...

- A. Starch granules
- B. Ribosomes
- C. Enzymes
- D. Chlorophyll



QUESTION 9

The ground substance of the chloroplast is called...

- A. Stroma
- B. Stoma
- C. Granum
- D. Lamella



QUESTION 10

The stacks of coin-like structures found in the chloroplast are called...

- A. Stroma
- B. Stoma
- C. Granum
- D. Lamella



QUESTION 11

Each coin-like structure is made up of membranes called...

- A. Stroma
- B. Stoma
- C. Granum
- D. Lamella



QUESTION 12

The 2 phases of photosynthesis are...

- A. Light phase and dark phase
- B. Light phase and Krebs cycle
- C. Dark phase and Krebs cycle
- D. None of the above



QUESTION 13

The difference between the light and dark phase is...

- A. The light occurs only in the day and the dark phase occurs in the night.
- B. The light phase is independent of light while the dark phase is dependent on light.
- C. The light phase is dependent on light and the dark phase is independent of light.
- D. The light phase is dependent on light and the dark phase can only occur in the day.



QUESTION 14

During photosynthesis the light energy is used ...

- A. To form ATP
- B. To split the water molecule
- C. To make oxygen
- D. Both A and B



QUESTION 15

The energy required for the dark phase comes from...

- A. High energy H atoms and ATP
- B. Sunlight and ATP
- C. Enzymes and ATP
- D. Enzymes and coenzymes



QUESTION 16

The substance that transfers the high energy H atoms of the light phase to the dark phase is...

- A. Enzyme
- B. Coenzyme
- C. ATP
- D. None of the above



QUESTION 17

The part of the chloroplast where the ATP is produced during photosynthesis is...

- A. Grana
- B. Stroma
- C. Ribosome
- D. Starch granule



QUESTION 18

Name the part of the chloroplast that will only be active in light...

- A. Grana
- B. Stroma
- C. Ribosome
- D. Starch granule



QUESTION 19

The rate of photosynthesis will increase if...

- A. CO₂ concentration increase and light intensity decreases.
- B. CO₂ concentration increases and the stomata are closed.
- C. CO₂ concentration decreases and stomata are opened.
- D. CO₂ concentration increases and stomata are opened.



QUESTION 20

The following internal factors will decrease the rate of photosynthesis...

- A. Low CO₂ concentration and low light intensity.
- B. Thick cuticle and closed stomata.
- C. High CO₂ concentration and closed stomata.
- D. High light intensity and closed stomata.



SOLUTION:

1. A
2. B
3. B
4. C
5. D
6. A
7. B
8. C
9. A
10. C

11. D
12. A
13. C
14. D
15. A
16. B
17. A
18. A
19. D
20. B