



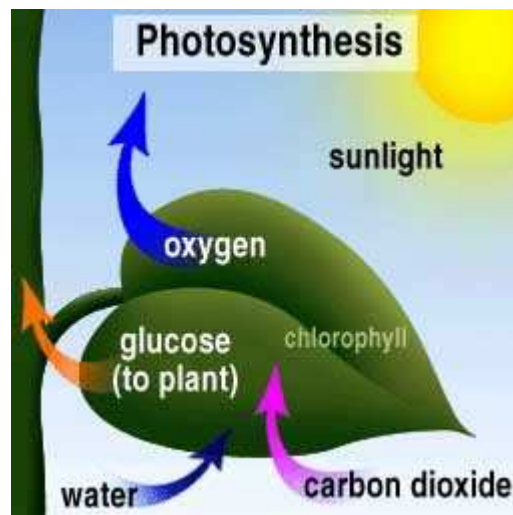
Williamwood High School
Biology Department

Biology

Intermediate 2

Unit 1

Living Cells



Cells and Photosynthesis

Unit 1 - Living Cells

Cells and Photosynthesis

Learning Objectives

SUNLIGHT AND STARCH PRODUCTION

1. State the source of energy used by plants to make food.
2. Define the term 'photosynthesis'.
3. Define the term 'carbohydrate'.
4. Describe how to test a leaf for the presence of starch.

THE ROLE OF CHLOROPHYLL

1. Name the green substance in plants that is needed for photosynthesis.
2. Explain what is meant by a variegated leaf.
3. Describe an experiment which shows that chlorophyll is required for photosynthesis.
4. Name the structures in a cell that contain chlorophyll and describe their appearance.
5. State the energy change that takes place in photosynthesis.

RAW MATERIALS AND PRODUCTS

1. Name the raw materials for photosynthesis.
2. State the source of these raw materials.
3. State that glucose is converted to starch for storage.
4. Describe an experiment which shows that carbon dioxide is required for photosynthesis.
5. Name the products of photosynthesis.
6. Describe how green plants affect the composition of gases in the atmosphere.
7. Write a summary equation for photosynthesis.

THE TWO STAGES OF PHOTOSYNTHESIS

1. Explain the term 'photolysis'.
2. Name the raw material and products of photolysis.
3. State the energy conversion that accompanies photolysis.
4. Name the molecule that transfers energy to the carbon fixation stage.
5. Explain the term 'carbon fixation' and state where the starting materials come from.
6. State how carbon fixation is controlled and how the energy needed is supplied.

STARCH AND CELLULOSE

1. Name the small molecules which link together to make starch and cellulose.
2. State the function of starch in plants.
3. State two properties of starch that make it suitable for this.
4. State the function of cellulose in plant cells
5. State two properties of cellulose that make it suitable for this function.
6. Describe how starch is stored in cells.
7. Describe the arrangement of cellulose fibres in cell walls.
8. Explain two properties of cell walls resulting from the arrangement of cellulose fibres.

LIMITING FACTORS IN PHOTOSYNTHESIS

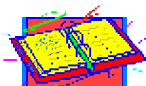
1. Define the term 'limiting factor' in the context of photosynthesis.
2. Give three possible limiting factors in photosynthesis.
3. Describe a method of measuring the rate of photosynthesis in a green plant.
4. Describe how increasing light intensity affects the rate of photosynthesis.
5. Describe how increasing concentration of carbon dioxide affects the rate of photosynthesis.
6. Describe how increasing temperature affects the rate of photosynthesis.
7. Explain why very high temperatures can cause the rate of photosynthesis to drop to zero.
8. Identify, on a graph for photosynthesis, when a substance or a condition is acting as a limiting factor and when it is not.

PHOTOSYNTHESIS AND HORTICULTURE

- | | |
|--|---|
| | 1. Explain the term 'supplementary lighting' in horticulture |
| | 2. Describe how carbon dioxide enrichment and heating can be provided in horticulture |
| | 3. State two effects of supplementary lighting, carbon dioxide enrichment and heating on the harvest of crops. |
| | 4. Describe a potential disadvantage in providing supplementary lighting, carbon dioxide and heating in horticulture. |

SUNLIGHT AND STARCH PRODUCTION

- Cells in green plants make their own food in a process known as **photosynthesis**.
 - Photosynthesis is an **enzyme-controlled process** where light energy from the sun is trapped by chlorophyll and converted into chemical energy.
 - **Sunlight** is extremely important as it provides the **energy** for plants to make their own food.
 - Light energy from the sun is "trapped" or fixed by the green pigment **chlorophyll**
 - Chlorophyll is found in disc-shaped structures called **chloroplasts** in green leaves
 - Plants make **glucose**. Some of this is used immediately as an energy source and the rest is converted to **starch for storage**.
 - Starch is a large molecule so it cannot leave the plant cell.
 - Glucose and starch are carbohydrates made up of the following elements:
 - Carbon (C)
 - Hydrogen (H)
 - Oxygen (O)
- } **Carbohydrate**
- Presence of starch shows that plants have first made glucose by photosynthesis.



READ Torrance pages 82-83



Task 1

Your teacher will demonstrate an experiment to illustrate how a green leaf can be tested for the presence of starch. You will then carry out this experiment yourself. The method for this experiment is given on the page overleaf. Make sure you refer to this while conducting your experiment.

OBSERVE THE SAFETY RULES!



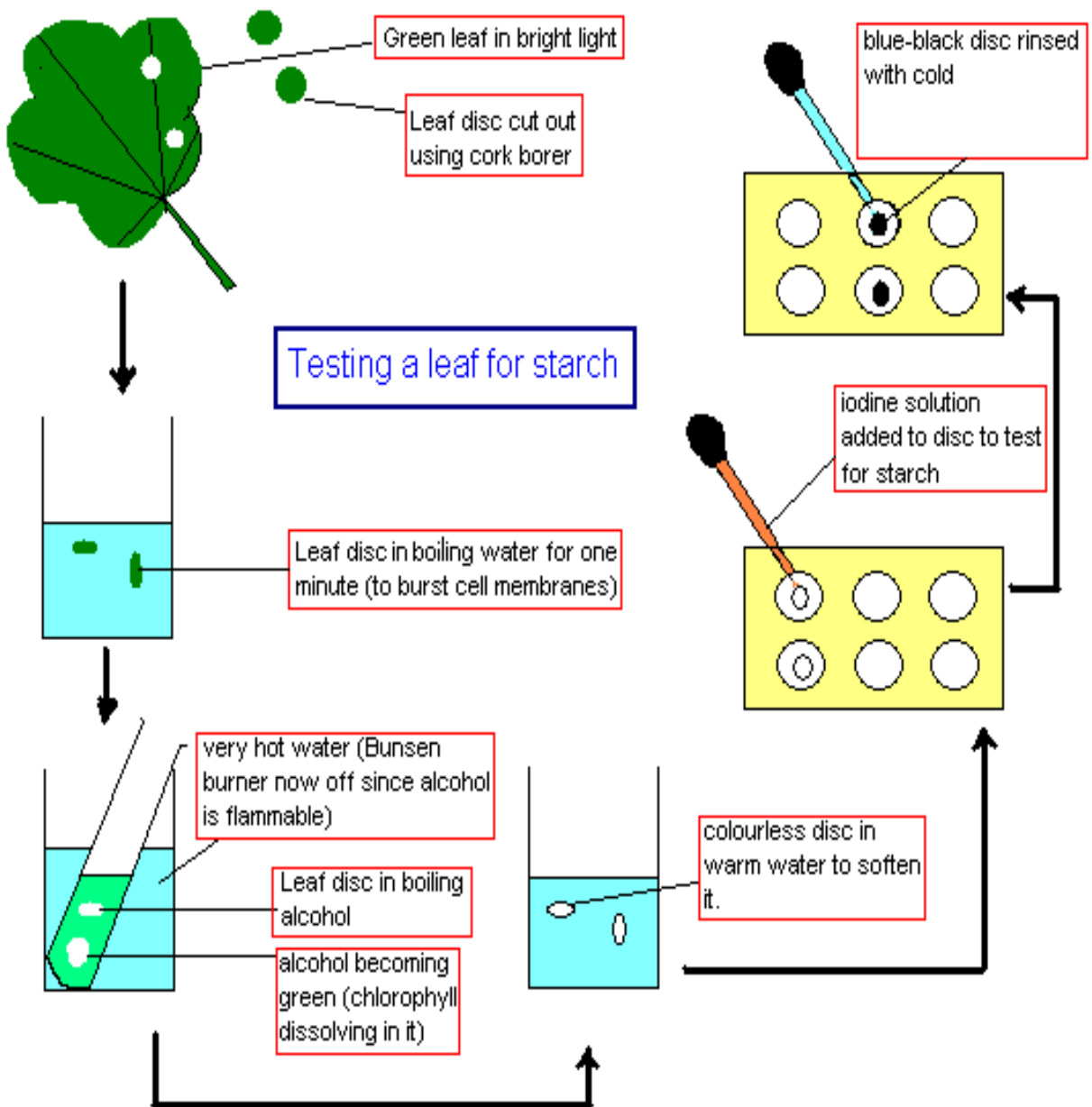
Wear goggles at all times during an experiment

Tie back long hair when using Bunsen burners

Switch off Bunsen burners when handling ethanol



TESTING A LEAF FOR STARCH





Task 2: Complete the questions below in your notebook. Make sure you write clearly and in sentences.

1. What is the name of the process by which plants manufacture their own food?
2. What is the energy conversion that takes place during this process?
3. What is the name of the structure and the chemical inside this structure that traps light energy?
4. Draw a diagram of a plant cell and label this structure.
5. Why is some glucose made by a plant converted to starch? Give two reasons.
6. What three elements make up a carbohydrate? Give two examples of carbohydrates.
7. What is the name of the testing solution that is used to test for the presence of starch in green plants?

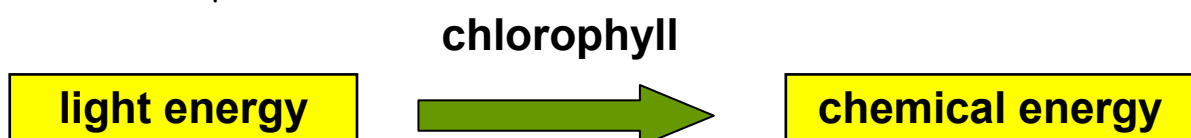
THE ROLE OF CHLOROPHYLL

- Light energy from the sun is "trapped" or fixed by the green pigment **chlorophyll**.
- **Chlorophyll** is found in disc-shaped structures called **chloroplasts** in green leaves.

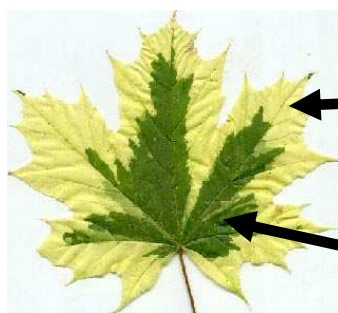


Cells containing chloroplasts

- Chlorophyll converts the trapped light energy into chemical energy which is **used to make carbohydrates**. This can be summarised as a word equation:



- Some plants have **variegated** leaves that have green areas containing chlorophyll.
- White or yellow areas **do not** contain any chlorophyll.
- **Variegation** is the appearance of differently coloured zones in the leaves of plants.



**White area:
No chlorophyll**

**Green area:
Contains chlorophyll**

Variegated leaf



Task 1 - Testing a variegated leaf for the presence of starch

Your teacher will demonstrate an experiment to illustrate how a variegated leaf can be tested for the presence of starch. You will then carry out this experiment yourself.



Task 2: Complete the questions below in your notebook. Make sure you write clearly and in sentences.

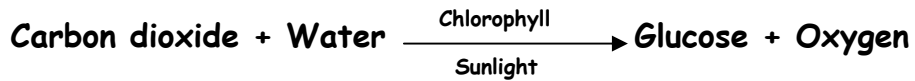
1. Copy and complete the table below into your notes jotter:

<i>Area of Leaf</i>	<i>Starch Present</i>
White	
Green	

2. Using the data from the table, state what the results of your experiment show.
3. Write a conclusion based on what your experimental results show. Give an explanation for these results.
4. What is the function of chlorophyll?
5. Write a word equation to summarise this.

RAW MATERIALS AND PRODUCTS

- The word equation for photosynthesis is:

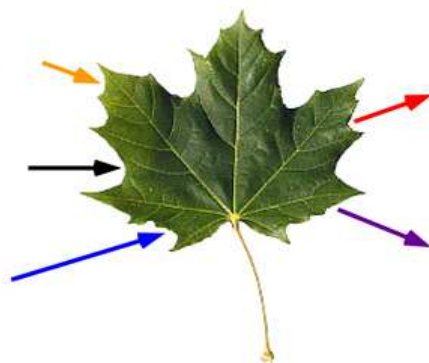


- The raw materials required for the photosynthesis reaction to occur are on the left side of the word equation. These are:
 - **Carbon dioxide**
 - **Water**
- Carbon dioxide for this reaction comes from air. It **enters the leaves by diffusion**.
- Water for this reaction comes from the soil and enters the plant via the roots.
- The end products of this reaction are on the right hand side of the word equation. These are:
 - **Glucose** - this is used by the plant as an energy source or stored as starch for later use.
 - **Oxygen** - a very small volume of this is in used aerobic respiration to make ATP for the plant. The rest is released as a by-product.
- **Oxygen** gas that is produced inside the leaf escapes by **diffusion**.
- Chlorophyll is essential as it traps sunlight. Without chlorophyll, light energy could not be captured by the plant.
- If any of the raw materials are missing, the reaction **will not** occur.



Task 1 Complete the questions below in your notebook. Make sure you write clearly and in sentences.

1. Write out the word equation for photosynthesis. In your word equation, label the raw materials and end products.
2. Where do the raw materials for photosynthesis come from?
3. What is the fate of the end products of this reaction?
4. What would happen if any of the raw materials were missing?
5. How does carbon dioxide enter and oxygen exit the leaves?
6. Copy and complete the diagram below into your notebook. Label the diagram using the words given below.



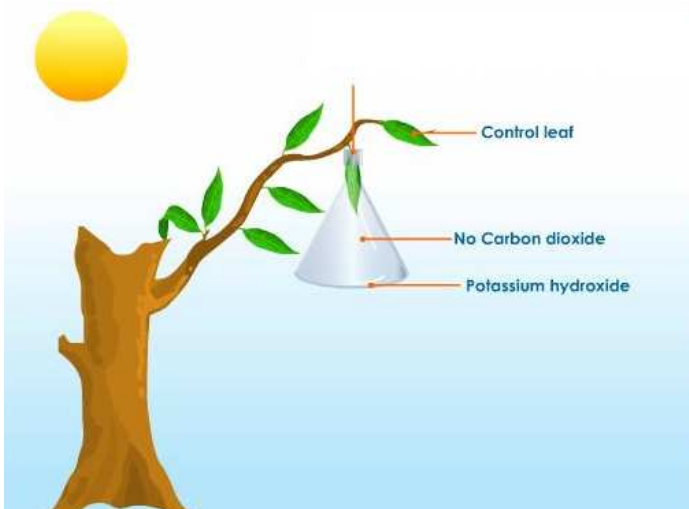
Sunlight Carbon Dioxide Water Glucose Oxygen

7. Complete TYK questions 1 - 4 on page 87 of your textbook.



Task 2

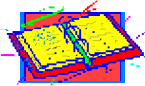
Your teacher will demonstrate an experiment that illustrates the need for carbon dioxide in photosynthesising plants.



In this experiment, the factor being investigated is the presence of carbon dioxide. Potassium hydroxide absorbs carbon dioxide and the plastic bag around the leaf ensures no carbon dioxide from the air can enter and diffuse into the leaf.

The control leaf is used to demonstrate that it is a lack of carbon dioxide which causes the result.

THE TWO STAGES OF PHOTOSYNTHESIS

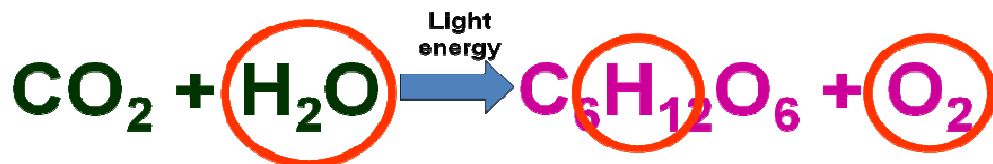
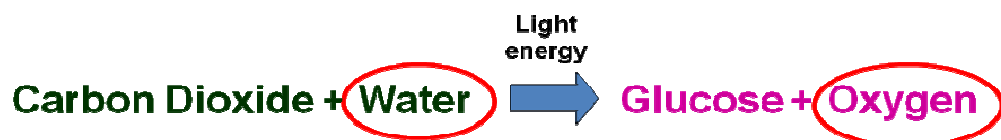


READ Torrance pages 87-89

- Photosynthesis occurs in **two stages**:
 - **Photolysis** (The splitting of water)
 - **Carbon Fixation**

PHOTOLYSIS (STAGE 1)

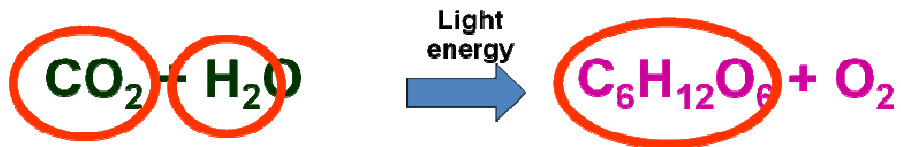
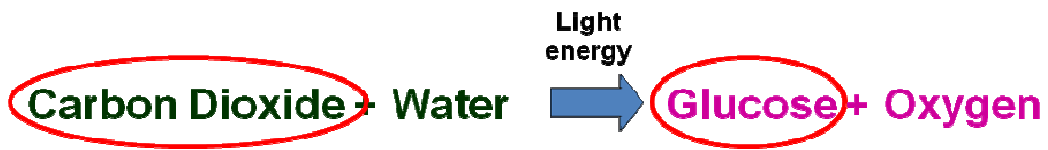
- **Water is split up** into the two elements that it is made from - **hydrogen and oxygen**.
- **Oxygen is a by-product** of plants and is given off as a gas.
- **Hydrogen is used in the second stage** to combine with carbon dioxide to make the carbohydrate glucose.
- **Light energy** from the sun is used to build up **ADP + Pi into ATP** in the second stage.
- Photolysis is controlled by a series of **enzymes**.



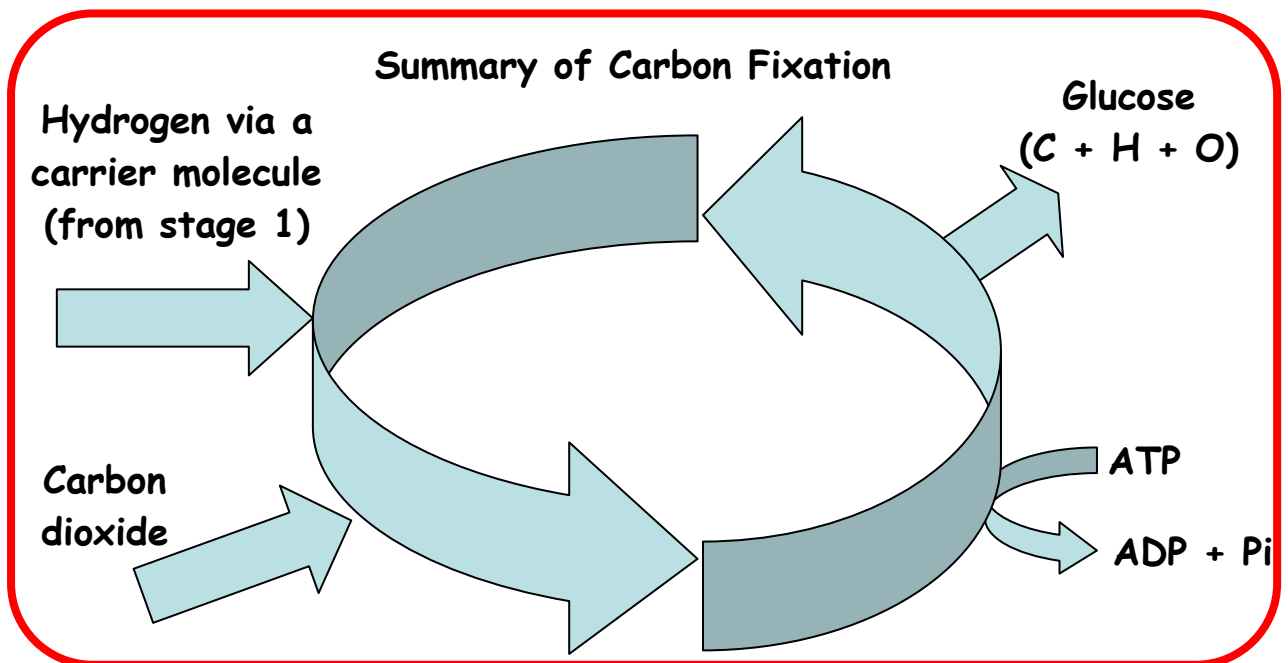
Summary of Photolysis:

1. Water is broken down into hydrogen and oxygen
2. Hydrogen is used in stage 2
3. ATP is formed in stage 1 for use in stage 2
4. Oxygen is a by-product that is given off

CARBON FIXATION (STAGE 2)



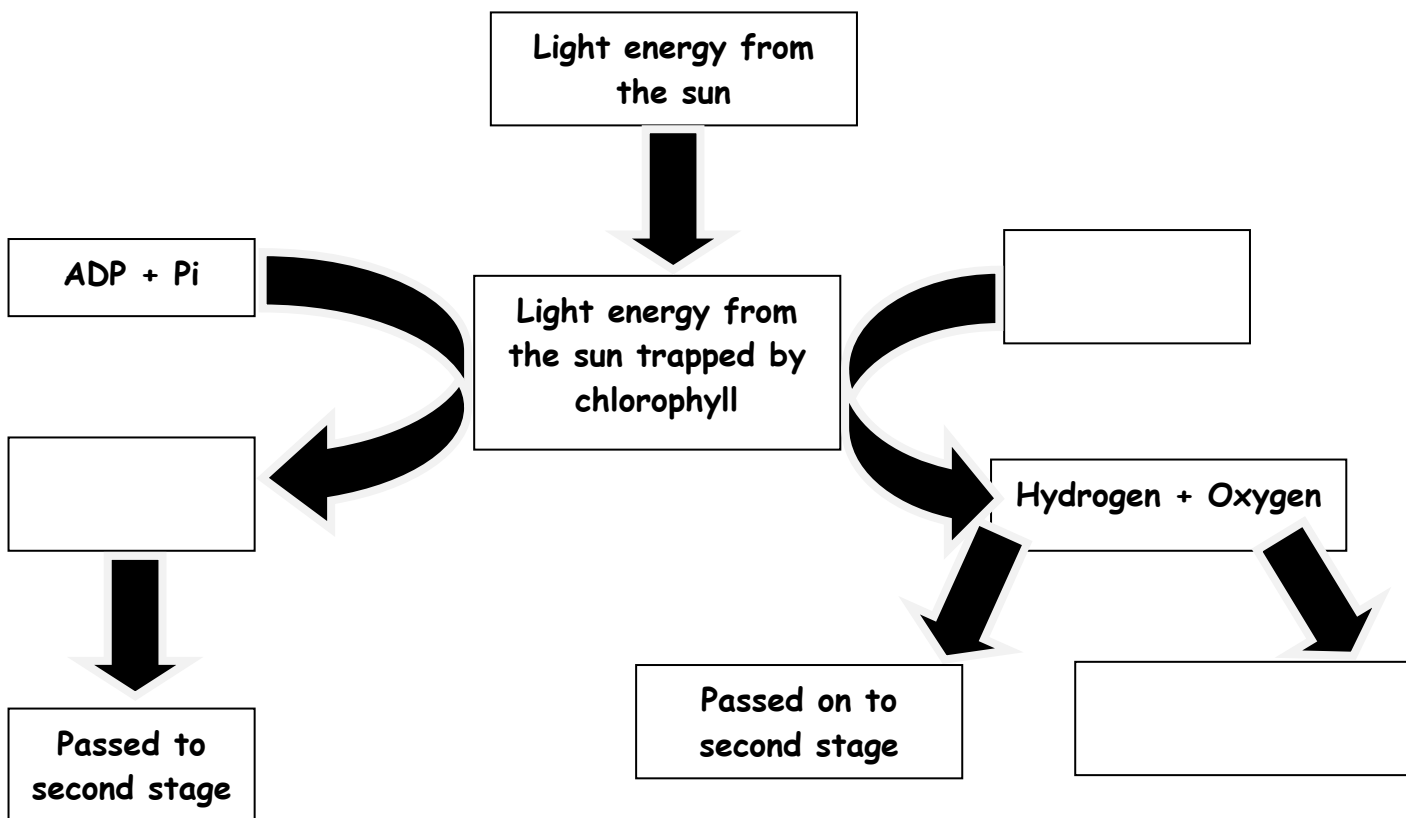
- Hydrogen that is produced in photolysis **combines with carbon dioxide** to form the **carbohydrate, glucose**.
- Hydrogen is carried to the second stage by a **hydrogen carrier molecule**.
- Carbon dioxide and hydrogen are able to combine using the energy from the **ATP** made in the first stage, photolysis.



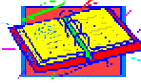


Task 1: Complete the questions below in your notebook. Make sure you write clearly and in sentences.

1. What is the name of the first stage of photosynthesis?
2. Describe what two events occur in the first stage of photosynthesis.
3. How is ATP regenerated from ADP + Pi in stage one?
4. What is the name of the second stage of photosynthesis?
5. What two products from stage one are needed to form glucose in stage two?
6. What controls the process of photosynthesis?
7. Copy and complete the flow diagram below summarising stage one of photosynthesis:



STARCH AND CELLULOSE

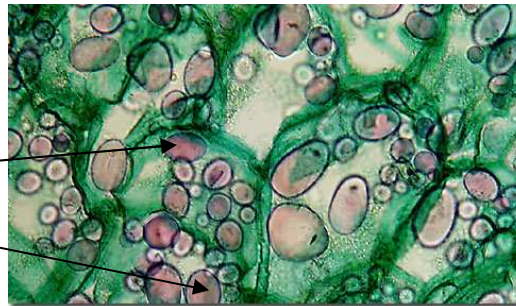


READ Torrance pages 90-91

STARCH

- Glucose molecules can link to each other in different ways.
- This results in different types of carbohydrates being formed e.g. **starch and cellulose**.
- Plants store excess carbohydrates as **starch** because it is **large and insoluble**.
- Chains of glucose units that form are coiled up and become tangled to form a dense starch grain.

Starch grains in
plant cells



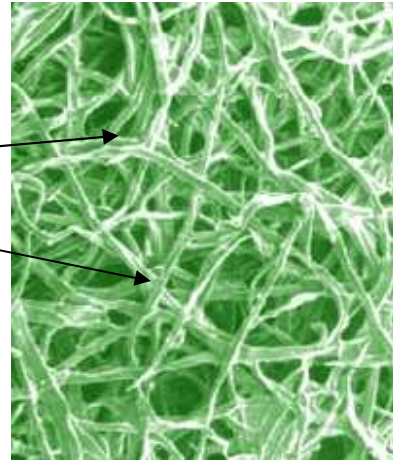
- Starch is a good storage molecule because it is easily broken down to be used as a source of energy.

CELLULOSE

- Cellulose is a complex carbohydrate used for building materials such as **cell walls** in plants.
- Cellulose is **not soluble** in water and is **not broken down easily**.
- Cellulose is arranged in **parallel chains that form fibres**. These fibres are arranged in sheets that run at right angles to each other.
- This criss-cross arrangement adds **strength** to cell wall.

- **Small molecules are soluble**, e.g. glucose, water and carbon dioxide and therefore can pass into cell through the small holes in the cell wall.

Cellulose fibres of a cell wall with spaces for small molecules to diffuse.



Task 1: Complete the questions below in your notebook. Make sure you write clearly and in sentences.

1. What is the name of the storage carbohydrate found in plant cells?
2. What is the name of the structural carbohydrate that makes up plant cell walls?
3. What are the properties of the structural carbohydrate that make it suited to its function? A labelled diagram of its structure may help you.
4. Why can only small molecules pass through the cell wall?

LIMITING FACTORS IN PHOTOSYNTHESIS

The rate of photosynthesis can be measured in the following ways:

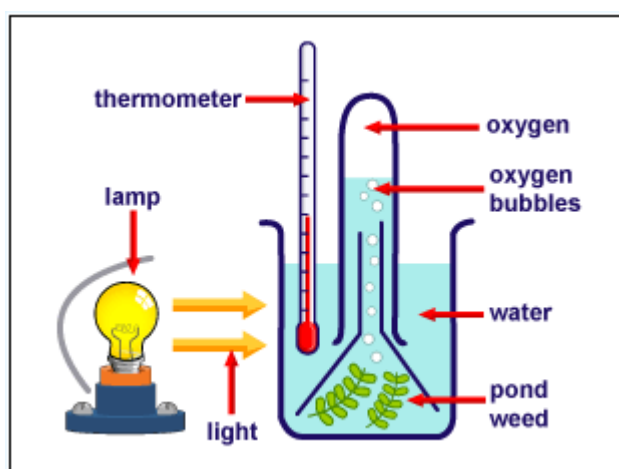
1. Measuring the increase in dry mass of a plant over a period of time (the mass of starch produced minus the water content of the plant).
2. Measuring the volume of oxygen given off over a period of time.
3. Measuring the volume of carbon dioxide taken in over a period of time .



Task 1

The rate of photosynthesis is often demonstrated using the pond weed *Elodea*. The oxygen gas that is given off can be measured over a period of time to indicate how fast photosynthesis is taking place.

Your teacher will show you an animation demonstrating how this experiment is set up and how the rate of photosynthesis can be altered.

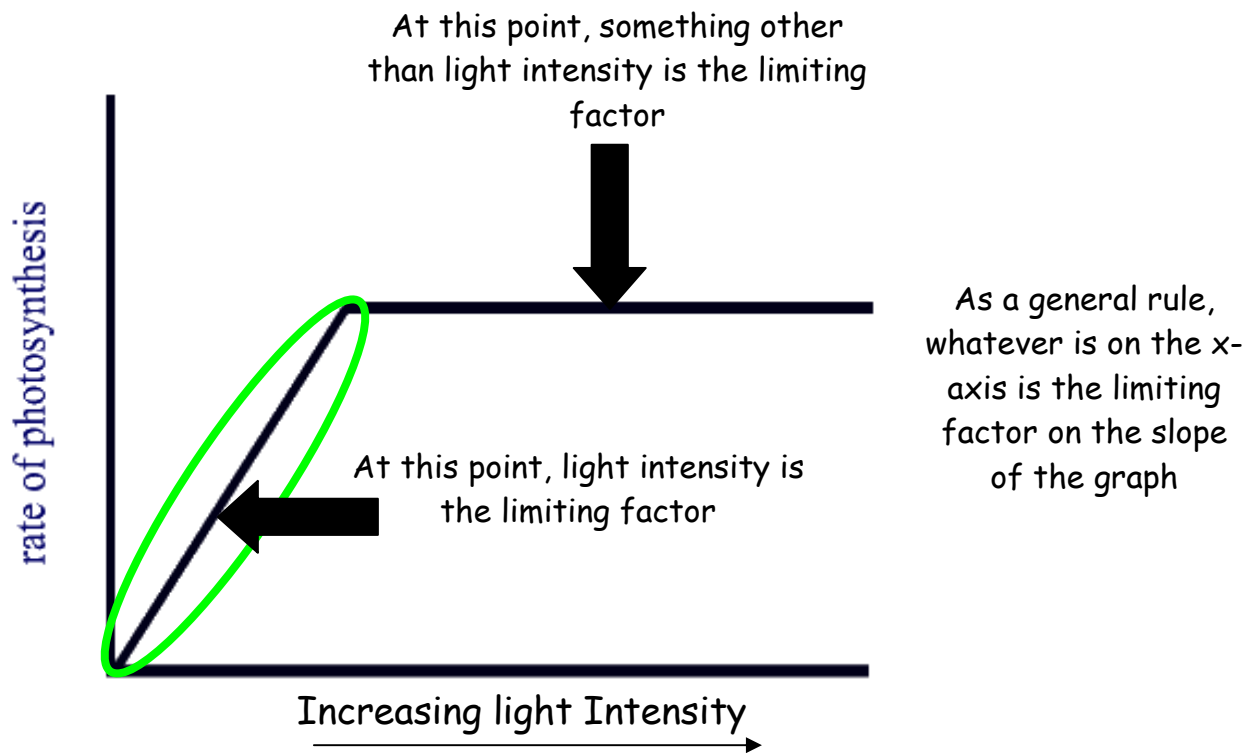


There are **three limiting factors** that affect the rate of photosynthesis:

1. **Light intensity**
2. **Carbon dioxide concentration**

Note that the words underlined give a better description of what is being measured.

3. **Temperature** (remember that photosynthesis is an enzyme-controlled reaction and enzymes can be denatured at high temperatures).



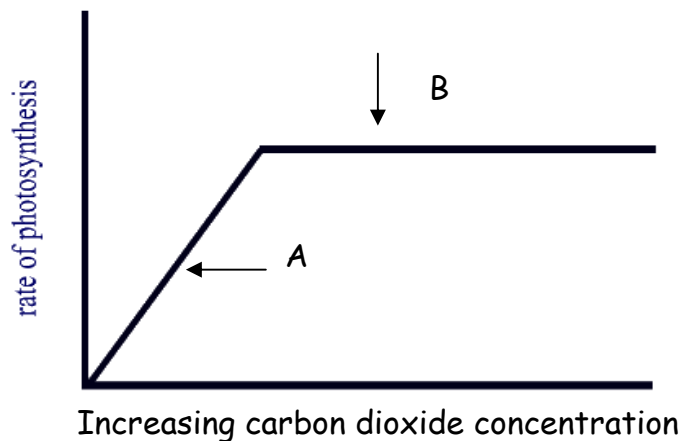
PHOTOSYNTHESIS AND HORTICULTURE

- By covering plants with **polythene tunnels**, or growing them in **greenhouses**, the **temperature is raised** and the plants are protected from damaging wind and pests.
- Polythene tunnels are useful because they still **allow light** to get to the plant, while keeping the plant warm.
- If a **paraffin stove** is burned, this warms the plants and has the added benefit of providing them with **extra carbon dioxide**.
- **Artificial lights** provide **extra light and warmth** for plants



Task 2: Complete the questions below in your notebook. Make sure you write clearly and in sentences.

1. What is meant by the term "limiting factor"?
2. Give three examples of a limiting factor.
3. Why does the rate of photosynthesis decrease at high temperatures?
4. Look carefully at the diagram below:

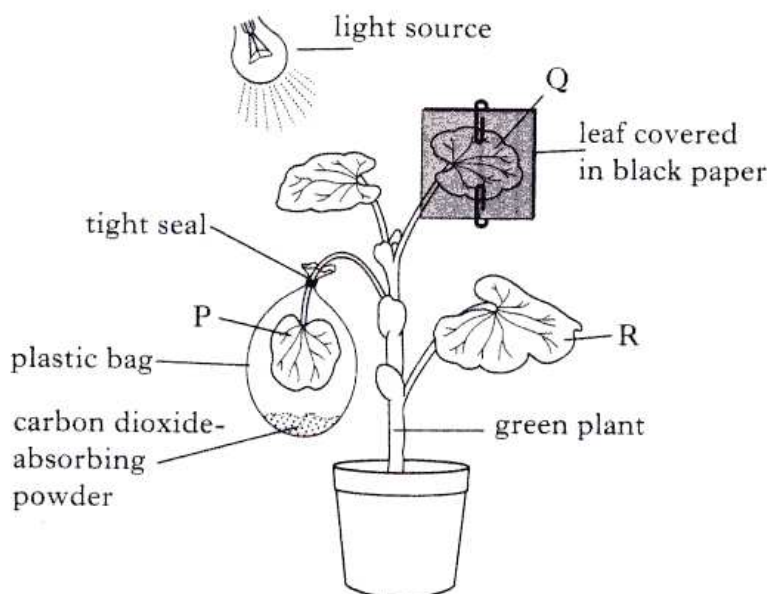


- (a) What is the limiting factor at point A on the graph?
 - (b) What could be limiting the rate of photosynthesis at point B on the graph?
5. Give two reasons why polythene tunnels are used in horticulture.
 6. Why are paraffin stoves used in greenhouses instead of electric heaters?

PAST PAPER QUESTIONS RESPIRATION

Section A: Multiple Choice

1. The diagram below shows an investigation into photosynthesis.



Which of the following statements is correct?

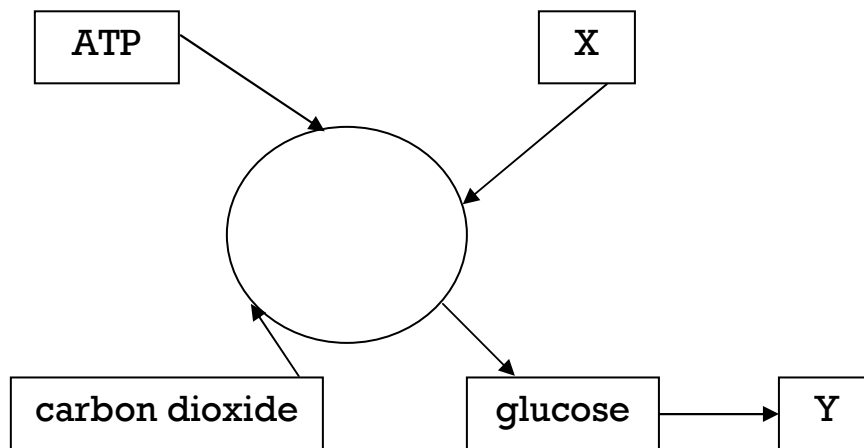
- A P, Q and R make food
 - B only P and Q make food
 - C only P makes food
 - D only R makes food
2. The following stages occur during photosynthesis.

- W glucose is formed
- X water is broken down to produce hydrogen
- Y glucose is converted to starch
- Z hydrogen is combined with carbon dioxide

The correct order for these stages is

- A W Z X Y
- B Z Y X W
- C X Z W Y
- D Y X Z W

3. The diagram below shows the carbon fixation stage of photosynthesis.



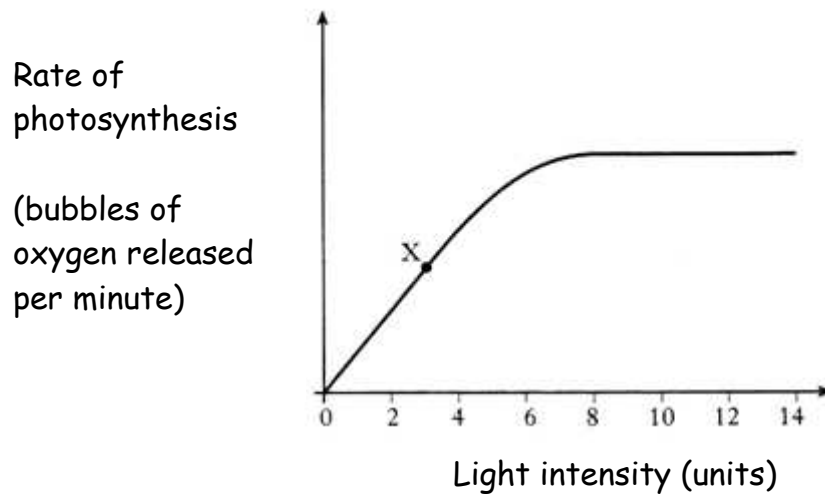
Which line in the table correctly identifies X and Y?

	X	Y
A	hydrogen	starch
B	starch	ADP
C	starch	oxygen
D	water	starch

4. The word equation for photosynthesis is

- A carbon dioxide + water → glucose + oxygen
- B oxygen + water → glucose + carbon dioxide
- C glucose + oxygen → carbon dioxide + water
- D carbon dioxide + oxygen → glucose + water

5. The graph below shows the effect of increasing light intensity on the rate of photosynthesis.



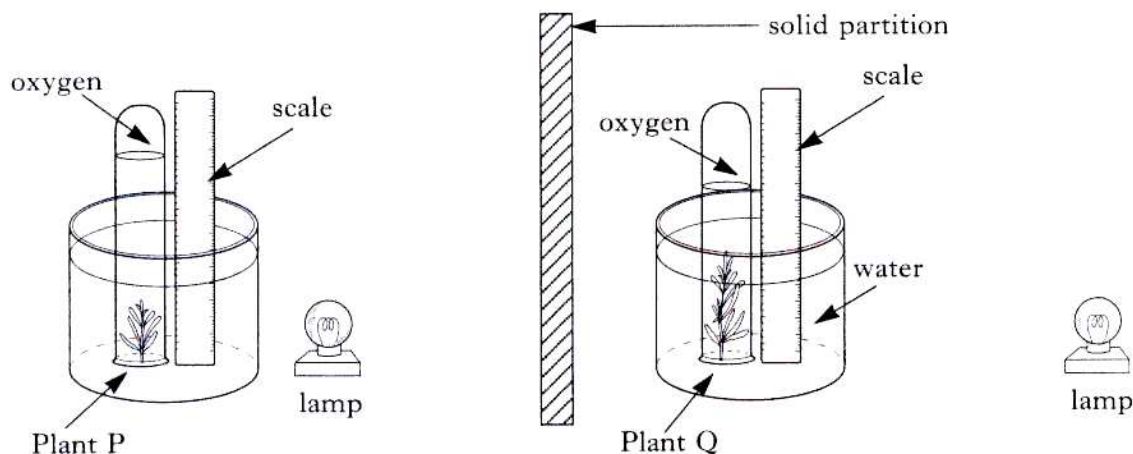
Which factor is limiting the rate of photosynthesis at point X on the graph?

- A carbon dioxide concentration
- B temperature
- C light intensity
- D oxygen concentration

Section B: Structured Questions

- 1 Some students were asked to design an investigation to compare the rate of production of oxygen gas by two different species of water plant.

The diagrams below show the proposed procedure.



(a) Identify **two** changes to the procedure that should be made to ensure that a valid conclusion can be made.

(b) When changes were made to ensure validity, the following results were obtained.

<i>Plant</i>	<i>Total volume of oxygen produced in 8 minutes (cm³)</i>	<i>Rate of oxygen production (cm³/minute)</i>
P	64	8
Q	96	

(i) Calculate the rate of oxygen production for Plant Q.

_____ (1)

(ii) Calculate the ratio of oxygen produced by Plant P to that produced by Plant Q.

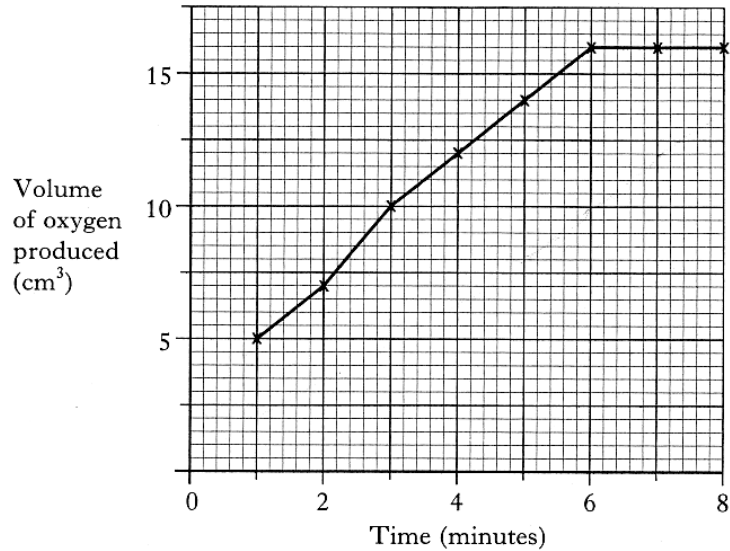
_____ : _____ (1)

Plant P Plant Q

1. Contd.

(c) The volume of oxygen produced was measured at time intervals of one minute.

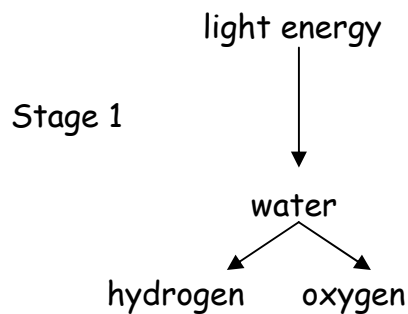
The results for Plant Q are shown in the line graph below.



Describe what happens to the volume of oxygen produced per minute as the investigation proceeds.

(1)

(d) The diagram below shows the first stage of photosynthesis.



(i) Name the substance, which captures the light energy, needed at Stage 1.

(1)

(ii) The energy is used to split water molecules. What name is given to this process?

_____ (1)

(iii) The hydrogen then combines with carbon dioxide to form glucose. Name this second stage in photosynthesis.

_____ (1)

Section C: Essay Question

1. The rate of photosynthesis is limited by certain environmental factors.

Name **two** limiting factors and describe how the growth of greenhouse plants in winter can be increased. (5)