Marshall Cavendish Education

SCIENCE Ahead International

Lower Secondary

STUDENT BOOK

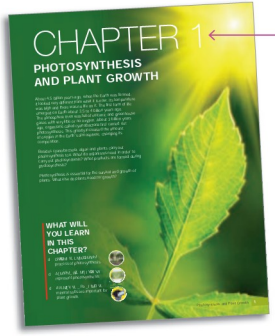
ALIGNED TO THE CAMBRIDGE CURRICULUM

Ho Peck Leng

PREFACE

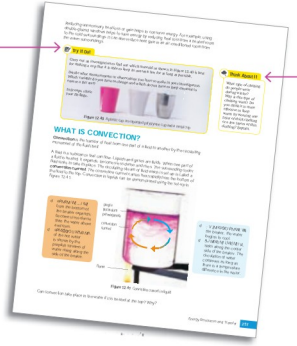
SCIENCE Ahead is a comprehensive, three-level science programme aligned to the Cambridge Assessment International Education lower secondary curriculum. The series uses the constructivist-inquiry approach to offer a learner-centred solution that helps students acquire scientific concepts, processes and skills. The use of spiral progression allows students to revisit concepts and skills at different stages with increasing depth in order to build a strong foundation.

The materials make use of exciting photographs, infographics, inquiry questions, activities and case studies to make science engaging and enjoyable. Interactive Augmented Reality (AR) models have been included at certain junctures to make science come alive for students.

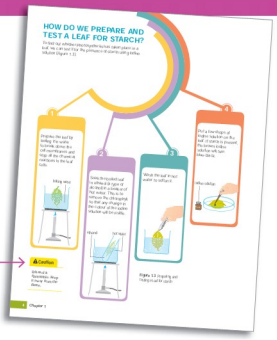


Chapter Opener
A short write-up, with trigger questions and a stunning photograph, to provide an engaging introduction to the chapter. Teachers and students can use the learning outcomes under 'What will you learn in this chapter?' as a checklist to check students' understanding.

Think About It
Questions to encourage critical thinking and support the constructivist-inquiry approach



Try It Out
Short activities or questions to provide opportunities for student-centred learning



Caution

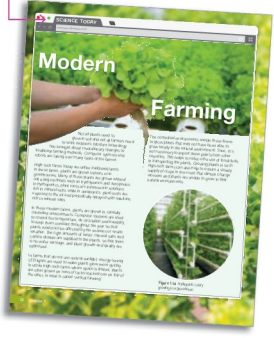
Precautions for handling chemical substances or other materials

Science Bytes

Interesting information related to the concepts taught to pique students' interest and engage them

SCIENCE TODAY

A recent article to showcase the current application of the concepts taught

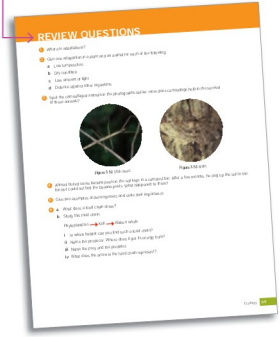


CASE STUDY

An article with real-life examples related to the concepts taught, along with questions for students to hone their critical thinking skills

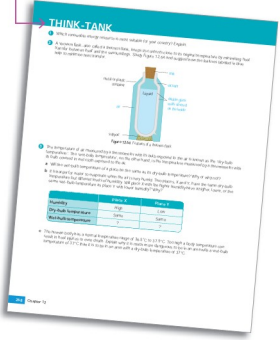
REVIEW QUESTIONS

End-of-chapter questions to test and evaluate students' understanding of the concepts learnt



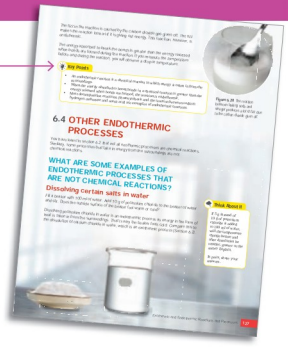
THINK-TANK

Challenging questions to encourage students to apply the concepts learnt and nurture higher-order thinking skills



Key Points

A summary of the key concepts learnt in each section



AR

Interactive 3D models that help to visualise concepts in a more engaging way

Follow these steps to view the AR models:

1	2	3	4	5
Download the SnapLearn APP.	Click on 'Activate'.	Scan the barcode at the back of the book to download the AR content.	Tap on the Science Ahead book cover to launch the AR scanner.	Scan the pages featuring the AR icon to experience 3D models.
iOS 8.0 or Android 5.0 and above	Activate	SCAN		AR

Upgrade to the premium package in the SnapLearn APP for more AR models.
For AR-related queries, please contact: support@snaptolearn.com

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CONTENTS

Biology

Chemistry

Online resources available at: *www.MCEduHub.com*

CHAPTER 1

PHOTOSYNTHESIS AND PLANT GROWTH

About 4.5 billion years ago, when the Earth was formed, it looked very different from what it is now. Its temperature was high and there was no life on it. The first form of life emerged on Earth about 3.5 to 4 billion years ago. The atmosphere then was full of volcanic and greenhouse gases with very little or no oxygen. About 3 billion years ago, organisms called cyanobacteria first carried out photosynthesis. This greatly increased the amount of oxygen in the Earth's atmosphere, changing its composition.

Besides cyanobacteria, algae and plants carry out photosynthesis too. What do organisms need in order to carry out photosynthesis? What products are formed during photosynthesis?

Photosynthesis is essential for the survival and growth of plants. What else do plants need for growth?

WHAT WILL YOU LEARN IN THIS CHAPTER?

- O MAVMIVL LM[KZQMVPM process of photosynthesis.
- A[MVPM_WZL MY]IVQW\W represent photosynthesis.
- AVLMZ[NVL_Pa_IVWZIVL mineral salts are important for plant growth.

1.1 PHOTOSYNTHESIS

Can plants grow indoors? Can they grow in the dark?

Plants can grow indoors as long as they receive sufficient light. Plants need light for photosynthesis, without which they cannot survive.

Figure 1.1 Sunlight passes through the glass dome to allow these plants to carry out photosynthesis.

During **photosynthesis**, plants make their food in the presence of **light** using **carbon dioxide** and **water** as raw materials. The food they make is in the form of **glucose**, a kind of simple sugar. **Oxygen** is given out during the process.

The process of photosynthesis is not a single chemical reaction. It involves a series of chemical reactions. However, it can be summarised using this word equation:

$$\text{Carbon dioxide} + \text{Water} \xrightarrow[\text{Chlorophyll}]{\text{Light}} \text{Glucose} + \text{Oxygen}$$

Plants obtain carbon dioxide from the air. The carbon dioxide diffuses into the plant through tiny openings called **stomata** found in plant cells. Many stomata can be found on the underside of leaves. Any oxygen produced during photosynthesis that is not used up for aerobic respiration leaves the plant through the stomata.

Plant roots absorb water from the soil or surroundings. The water is transported to various parts of the plants through the **xylem** in vascular plants. A small proportion of this water is used for photosynthesis.

Photosynthesis takes place in structures called **chloroplasts** found in leaves and other plant parts. Chloroplasts contain **chlorophyll**, a green pigment found in plant cells. Chlorophyll captures sunlight. During photosynthesis, light energy is converted to chemical energy and stored in the plant.

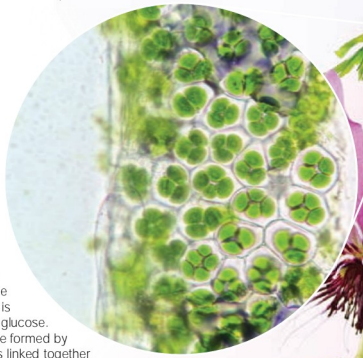


Figure 1.2 Chloroplasts of plant cells as seen under a light microscope

Plants do not use up all the glucose produced during photosynthesis immediately. They store the excess glucose in the form of starch as starch is insoluble in water unlike glucose. **Starch** is a carbohydrate formed by many glucose molecules linked together to form a long chain. The starch is stored in the leaves or other parts of the plant.

HOW DO WE PREPARE AND TEST A LEAF FOR STARCH?

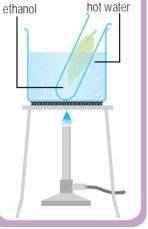
To find out whether photosynthesis has taken place in a leaf, we can test it for the presence of starch using iodine solution (Figure 1.3).

1

Prepare the leaf by boiling it in water to break down the cell membranes and stop all the chemical reactions in the leaf cells.

2

Soak the boiled leaf in ethanol (a type of alcohol) in a beaker of hot water. This is to remove the chlorophyll so that any change in the colour of the iodine solution will be visible.



3

Wash the leaf in hot water to soften it.

4

Put a few drops of iodine solution on the leaf. If starch is present, the brown iodine solution will turn blue-black.

Caution

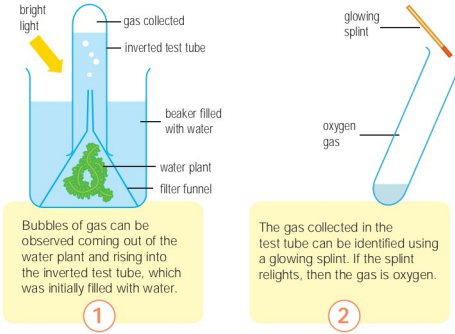
Ethanol is flammable. Keep it away from the flame.

Figure 1.3 Preparing and testing a leaf for starch

HOW DO WE COLLECT AND TEST THE GAS PRODUCED DURING PHOTOSYNTHESIS?

Another way to find out whether photosynthesis has taken place in a plant is to find out whether oxygen has been produced by the plant.

We can use a set-up as shown in Figure 1.4 to collect the gas produced during photosynthesis. A suitable water plant, such as elodea, cabomba or hydrilla, can be used. The set-up should be placed under bright light for a few hours.



▲Set-up to collect the gas produced by a plant during photosynthesis

▲Testing the gas produced during photosynthesis

Figure 1.4 Collecting and testing the gas produced during photosynthesis

Try It Out

If the rate of photosynthesis increases, the volume of oxygen gas collected over a fixed period of time will increase. In groups, carry out an investigation to find out whether the intensity of light increases the rate of photosynthesis in water plants. Discuss these questions before planning and carrying out the investigation:

1. What variable(s) should you change?
2. What variables should you keep constant?
3. How can the intensity of light be changed?
4. What variables should you measure or observe?

Key Points

- Photosynthesis is the process by which plants use light, carbon dioxide and water to make food in the form of glucose. Oxygen is produced in the process.
- Leaves and other plant parts have a green pigment called chlorophyll to capture sunlight. Chlorophyll is found in the chloroplasts of plant cells.
- Carbon dioxide gas needed for photosynthesis enters the plant through the stomata, usually found on the underside of leaves.
- The excess oxygen produced during photosynthesis leaves the plant through the stomata.
- The glucose produced and not used immediately is stored as starch in the leaves and other parts of the plant.
- We can use one of these ways to find out whether photosynthesis has taken place:
  - Test a leaf for the presence of starch using iodine solution.
    If starch is present, the iodine solution will turn blue-black.
  - Find out if oxygen was produced by the plant.

1.2 WATER AND PLANT GROWTH

Look at these corn plants during a drought. Why do you think they look dried up and dying?

WHY DO PLANTS NEED WATER?

Without water, plants cannot survive. Water is essential for the growth and survival of plants for several reasons.

Photosynthesis

Water is one of the reactants of photosynthesis. A small proportion of the water absorbed by the roots of the plant is used for photosynthesis. During photosynthesis, chlorophyll captures light energy. Some of this energy is used to split up water into oxygen and hydrogen. The hydrogen then combines with carbon dioxide to form carbohydrates in the form of glucose.

Figure 1.5 Dried corn plants during a drought

Support

You have a skeleton to support your body. Does a plant have a skeleton to support itself and stay upright?

Plants do not have bony skeletons, but water in the cells, especially in the vacuoles, keeps the cells firm and turgid (swollen). When water enters the vacuole of a cell, the vacuole swells and pushes against the cell wall. This pressure, called **turgor pressure**, supports the plant so that it does not wilt.

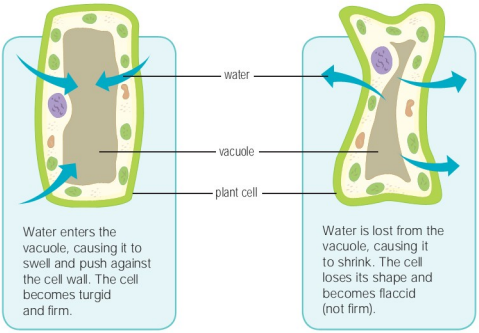


Figure 1.6 How water helps maintain the shape of a plant cell

We can observe how water helps support a plant by comparing a plant when it is regularly watered and when it has not been watered for some time.

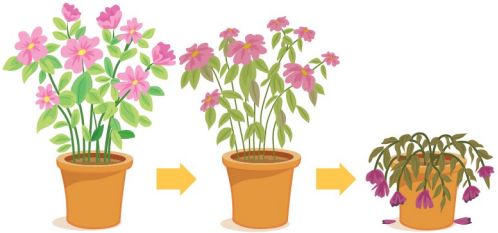


Figure 1.7 Wilting and collapse of a potted house plant that has not been watered for some time

Chemical reactions

Many chemical reactions take place in plant cells. Water is a reactant or a product in some of these reactions.

As a solvent

Water acts as a solvent in plants. Substances, such as the food made during photosynthesis and mineral salts, are dissolved in water before they are transported to the different parts of the plant. Some reactants need to be dissolved in water before chemical reactions can take place.

Cooling

Only a small proportion of the water taken in by plant roots is used for growth and chemical reactions in the plant. Most of the water is lost by a process called **transpiration**.

During transpiration, water moves from the roots, through the plant, before evaporating from the stem, leaves and flowers. The water is lost through the stomata. The process of evaporation draws energy from the surroundings. The water absorbs heat energy from the surroundings to change into water vapour. The surroundings, having lost heat, become cooler. This cooling effect is useful for plants that live in hot environments.

Figure 1.8 Transpiration in rainforests cools the local climate and also generates rainfall.

Transport

Some trees can be more than 100 metres tall. How do mineral salts needed for healthy plant growth travel against gravity from the roots to the top of the trees? How is the food made by the leaves transported to the other parts of the trees?

Water helps to transport the dissolved mineral salts absorbed by the roots to the various parts of the plant. This is done through the **xylem**, which are **vascular tissues** of plants. The water is drawn up the xylem during transpiration. Sugars and amino acids are dissolved in water and transported through vascular tissues called **phloem** to various parts of the plant.

Think About It

1. Why are there many dense forests in equatorial areas and very few plants in sandy deserts?
2. Why do polar regions have very little vegetation?

Figure 1.9 Water helps transport substances, such as sugars and mineral salts, from one part of the plant to the other parts.

Try It Out

Have you ever seen a terrarium? A sealed terrarium is a closed glass container containing soil and plants. The container can be opened for occasional watering and maintenance. In groups, discuss why a sealed terrarium is self-sustaining.

Find out the materials, suitable plants and steps required to make a sealed terrarium. You may use the Internet or other resources in your search. Use the information gathered to make your own sealed terrarium.

Figure 1.10 Terrarium

Key Points

- Water is essential for the growth and survival of plants.
- Water is needed by plants for photosynthesis, support, chemical reactions, as a solvent, for cooling and for transport.

1.3 MINERAL SALTS AND PLANT GROWTH

These photographs show a pitcher plant and a Venus flytrap. They are called 'insectivorous' or 'carnivorous' plants because they consume insects or small animals. Can these plants make food? If they can, why is there a need for them to consume animals?

Insectivorous plants have chlorophyll and can carry out photosynthesis. They trap insects or other small animals to get nutrients because they usually grow in soils that are poor in nutrients. Without nutrients, plants cannot grow healthily.

Figure 1.11 Insects and other small animals fall into the 'pitchers' (leaves shaped like jugs) of the pitcher plant and are digested by the digestive juice inside. The plant then absorbs the nutrients of the digested animals.

Figure 1.12 The leaf of the Venus flytrap is divided into two halves to form a trap that snaps shut when an insect lands on it. The leaf opens again when the insect has been digested.

Mineral salts are nutrients for plants. They are needed by plants for healthy growth. One way of providing plants with nutrients is to add **fertilisers** to the soil.

WHAT ARE THE DIFFERENT TYPES OF FERTILISERS?

There are two main types of fertilisers. **Organic fertilisers**, such as animal dung, fish and bone meals, decomposing plant matter, compost and seaweed extracts, come from living things. These fertilisers gradually release mineral salts to the soil as **decomposers** act on them.

Try It Out

Try making your own organic fertiliser by collecting dead leaves, grass clippings, tea leaves, vegetables and fruit peel and putting them in a heap. Turn and toss the heap regularly to aerate it. The compost heap should be moist but not too wet.

Figure 1.13 Garden compost bin for recycling kitchen food and garden waste

Inorganic fertilisers are man-made fertilisers produced from chemicals and are hence called chemical fertilisers. Chemical fertilisers contain various types of mineral salts essential for plant growth. Some mineral salts are needed for leaf growth, while others are useful for healthy root growth and flower formation.

Figure 1.14
Inorganic fetiliser

Figure 1.15 NPK fertiliser

Look at the labels of some containers of fertilisers. Are they organic or chemical fertilisers? Which mineral salts do they contain? Do you see the letters 'NPK' on some of the labels? What does 'NPK' stand for?

This table shows some important mineral salts that fertilisers contain and their functions.

Table 1.1 Mineral salts in fertilisers and their functions

Mineral salt	Function(s)
Nitrate	d : QZAVOVW KWU XVW/MV\VMKM[I Za NVZXT V\[\WU I SM proteins, DNA and chlorophyll d 2WZTMI NL MVMVKU MV\ d 2WZQZV_ \P I VL ZVKI QZ d @WXZVMVV\LMKQVW/Ka \PI \KI V TMI L \WTMI ^M[\] ZVQVO yellow, and stunted growth
Phosphorus	d 2WZLMVMVKU MV\ VWZVWX[/NV_ N[/[MML[I VL N[QI
Potassium	d 2WZLMVMVKU MV\ VWZVWX[d 2WZZVQI VKMI QI QV[\LQVMI [M d 2WZXZVU WQVO NV_ MQVO I VL N[QVO
Magnesium	d 2WZU I SQVO KPTWVKPaTT d @WXZVMVV\LMKQVW/Ka \PI \KI V TMI L \WTMI ^M[\] ZVQVO yellow

Try It Out

Study Table 1.1.

1. Which two mineral salts could a plant be lacking if its leaves are yellowish?
2. Which mineral salt could a plant be lacking if its growth is stunted?
3. If you want a plant to flower and fruit, which mineral salts should the fertiliser for the plant have more of?
4. If you have a stem cutting and want the roots to develop quickly, which two mineral salts are essential?

Modern Farming

Not all plants need to grow in soil and not all farmers need to work outdoors. Modern technology has brought about revolutionary changes to traditional farming methods. Computer systems and robots are taking over many tasks of the farmer.

High-tech farms today are unlike traditional farms. In these farms, plants are grown indoors or in greenhouses. Many of these plants are grown without soil using methods such as hydroponics and aeroponics. In hydroponics, plant roots are immersed in solutions rich in mineral salts, while in aeroponics, plant roots are exposed to the air and periodically sprayed with solutions rich in mineral salts

In these modern farms, plants are grown in carefully controlled environments. Computer systems are used to control the temperature, air circulation and humidity, to keep them constant throughout the year so that plants would not be affected by the seasons or erratic weather. The right amounts of water, mineral salts and carbon dioxide are supplied to the plants, so that there is no water wastage, and plant growth and quality are optimised.

In farms that do not use natural sunlight, energy-saving LED lights are used to make plants grow more quickly. In urban high-tech farms where space is limited, plants are often grown on rows of racks stacked one on top of the other, in what is called 'vertical farming'.

The controlled environments enable these farms to grow plants that may not have been able to grow locally in the natural environment. Thus, it is not necessary to import these plants from other countries. This helps to reduce the use of fossil fuels in transporting the plants. Growing plants in such high-tech farms can also help to ensure a steady supply of crops in the event that climate change worsens and plants are unable to grow in their natural environments.

Figure 1.16 Hydroponic celery growing in a greenhouse

Try It Out

In groups, investigate how different brands or types of fertilisers affect plant growth. Use these guidelines to help you:

1. Decide on the aim of your investigation, e.g. 'Is organic or chemical fertiliser better for plant growth?' or 'Is Brand A or Brand B of NPK fertiliser better for plant growth?'
2. How are you going to measure or observe plant growth? One way is to measure the increase in the height or the mass of the plant.
3. What variable would you change?
4. What variables would you keep the same?
5. How would you record and present your observations or measurements?

Science Bytes

Have you ever eaten organic food? Organic food comes from organic farms that do not use chemical fertilisers or pesticides.

Overuse of chemical fertilisers can deplete essential nutrients and minerals found naturally in fertile soils. They may also cause 'fertiliser burn' as they can dehydrate the plants.

Pesticides are harmful not only to pests, but also to human beings who eat the plants treated with pesticides.

Figure 1.17
Organic vegetables

Key Points

- Plants need nutrients to grow well. Mineral salts are nutrients for plants.
- Mineral salts needed by plants can be provided by fertilisers.
- Organic fertilisers come from living things. Chemical fertilisers or inorganic fertilisers are man-made.
- Different types of mineral salts are needed by plants for different functions and to prevent deficiency diseases. For example, nitrates and magnesium are needed for healthy leaf growth, and phosphorus and potassium are needed for development of roots.

REVIEW QUESTIONS

1. Complete this table to show what plants need in order to grow well.

What do plants need to grow well?	Why?
Light	
	d As a raw material for photosynthesis d To support plants and keep them firm d To transport materials d To dissolve mineral salts and food d For chemical reactions in plant cells d To keep plants cool
Carbon dioxide	
	For aerobic respiration
	As nutrients for plants to have healthy growth

2. Correct these misconceptions.
   - **a** Soil is necessary for plant growth.
   - **b** Plants cannot be grown indoors.
   - **c** Fertilisers are food for plants.
   - **d** Most of the water taken in by the roots is used for photosynthesis.
   - **e** Plants carry out photosynthesis during the day and aerobic respiration at night.

3. Plants carry out photosynthesis in order to make food.
   - **a** Write a word equation to summarise the process of photosynthesis.
   - **b** What are the reactants of this process? Where and how do plants obtain these reactants?
   - **c** What are the products of this process? What happens to the products after photosynthesis?

4. A leaf is plucked off a plant and prepared for a starch test by boiling it in water and soaking it in hot ethanol.
   - **a** What is the purpose of boiling the leaf?
   - **b** What is the purpose of soaking it in hot ethanol?
   - **c** What precaution must be taken when soaking the leaf in ethanol?
   - **d** How is the prepared leaf tested for starch?

5 Study this experimental set-up.

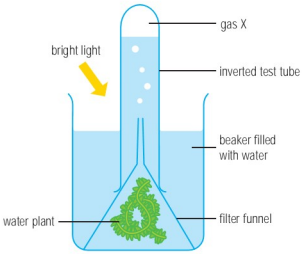


Figure 1.18 Experimental set-up

a Identify gas X.

b Will more, less, or no gas X be collected during the same time period if the set-up is placed
i in the dark:
ii under dim light?

Explain your answers.

6 Water is essential for plant growth and survival.

a Explain how water provides support for a plant.

b Explain why plants will not be able to get mineral salts without water.

7 What do fertilisers provide plants with?

8 What will happen to a plant if it lacks these mineral salts?

a Nitrates

b Potassium

9 This leaf shows symptoms of magnesium deficiency. Why does magnesium deficiency cause the leaf to turn yellow?

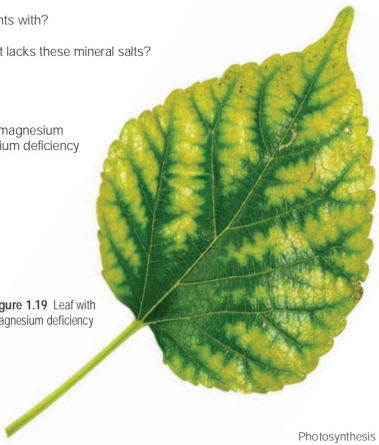


Figure 1.19 Leaf with magnesium deficiency

THINK-TANK

1. Study the two graphs.

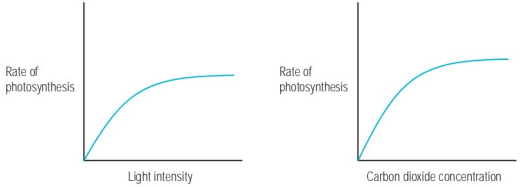


Figure 1.20 Graphs showing how the rate of photosynthesis changes

   a From the graphs, infer two factors that affect the rate of photosynthesis.

   b Suggest why both graphs become almost horizontal after the rate of photosynthesis increases to a certain level.

2. Suggest two advantages of growing plants using hydroponics and aeroponics.

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