10 Transpiration, transport and support in plants

提升學習動機

試想想 Think about

★ 以貼身的**時事見聞**（例如超強颱風「山竹」）或**生活事例**作引子，引起學生的學習興趣

Trees knocked down by strong wind

A sad day for trees

On 16 September 2018, Super Typhoon Mangkhut* hit Hong Kong badly. Over 60 000 trees collapsed. Experts believed that this was related to the poor growing environment of the trees, e.g. roots of many trees in urban areas are enclosed in a small concrete shell.

Think about...

1 What are the functions of roots?

2 Why may enclosing the roots in a concrete shell lead to the collapse of trees?

(Answers on p. 42)

Watch more

Super Typhoon Mangkhut 超強颱風山竹

Flipped classroom
Watch this to prepare for your class and answer the questions.

Besides oxygen and carbon dioxide, plants need to get water and minerals from the environment to sustain life. In this chapter, we will learn how the uptake and transport of water and minerals occur in plants.

10.1 Transpiration

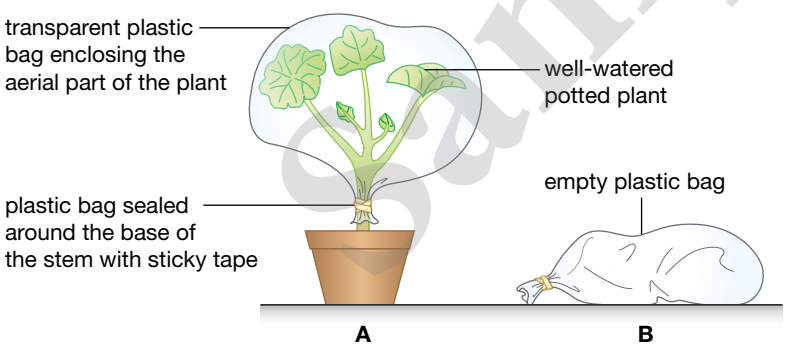
Plants absorb water from the soil. Only a small proportion of the water absorbed is used by plants for activities like photosynthesis. Most of the water is **lost** in the form of **water vapour** from plant surfaces due to **evaporation**. This process of water loss is called **transpiration***.

Practical 10.1 Demonstration of the occurrence of transpiration

Procedure

1 Prepare the set-ups as shown. Put them in bright light for two hours.

Practical 10.1



2 Observe any changes in the plastic bags. Test any liquid droplets formed in the bags with dry cobalt chloride paper*.

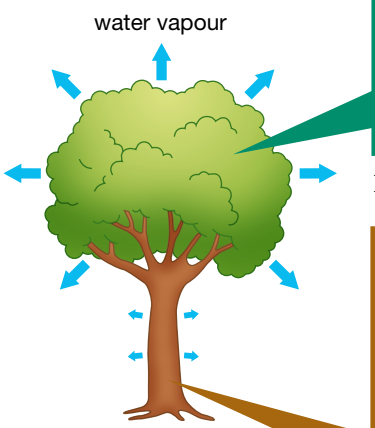
Results and discussion

- In set-up A, **drops of liquids are formed** on the inner side of the plastic bag. The liquid turns dry cobalt chloride paper from blue to pink. This indicates that the liquid contains water.
- Set-up B is a **control**. The plastic bag remains dry inside.
- The above results show that water vapour is released from the aerial part of the plant.

transpiration 蒸騰　　cobalt chloride paper 氯化鈷試紙

A Where does transpiration occur?

Transpiration occurs in the aerial parts of a plant:



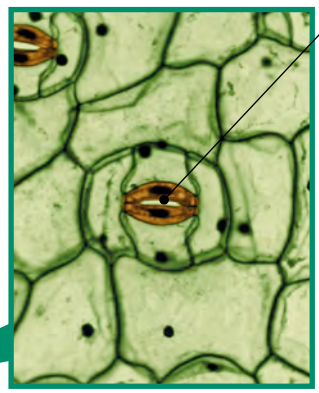


Fig 10.1 Stoma (×200)

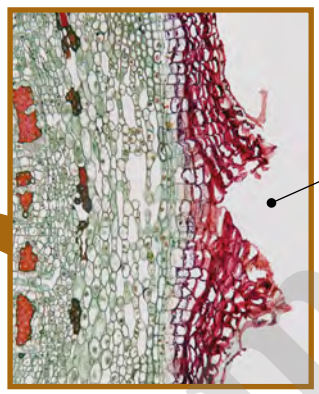


Fig 10.2 Lenticel (×20)

1 Through the stomata

About 90–95% of the total water loss takes place through the **stomata** in the leaves and herbaceous stems.

2 Through the cuticle

About 5–10% of the total water loss takes place through the **cuticle** on the surface of the leaves and herbaceous stems.

The cuticle serves to reduce water loss by transpiration but it is not 100% efficient. Some water is still lost through it.

3 Through the lenticels

In woody plants, a very small proportion (about 0.1%) of water is lost through the **lenticels** on the woody stems. However, in trees that have lost their leaves, water is mainly lost through the lenticels.

Did you know?

Stomata in other parts of plants

Besides leaves and herbaceous stems, stomata may also be found in some other parts of the plants, e.g. floral parts like sepals and petals (Fig 10.3), fruits and seeds.

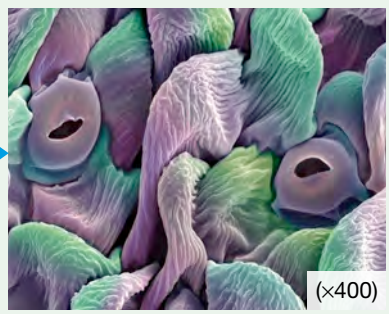


Fig 10.3 Stomata on orchid petals

DSE
17(IA)Q13

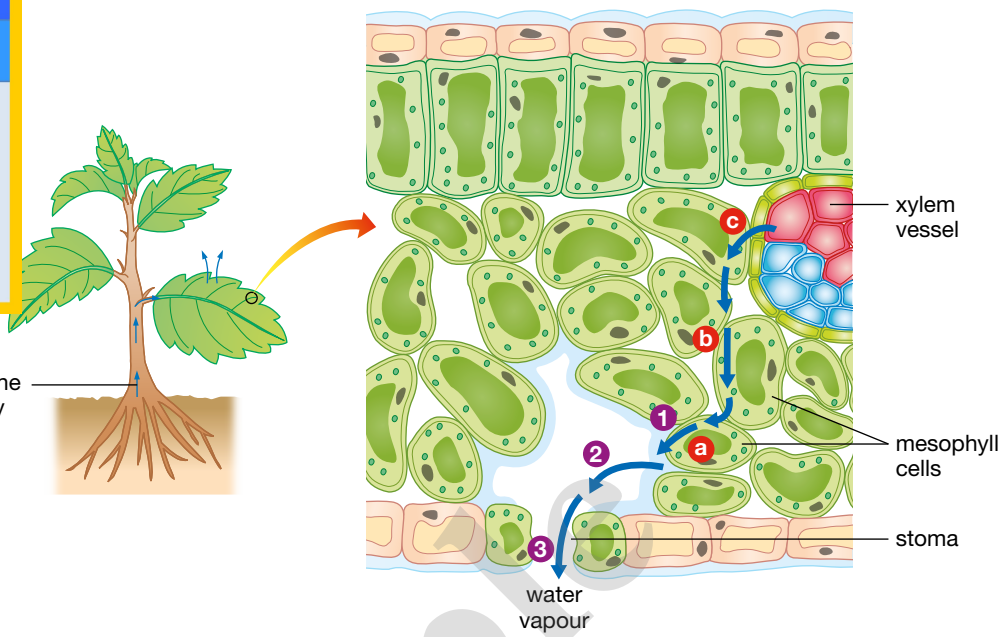
緊貼DSE趨勢

DSE (2012–2019) 題號 新增

★ 列出歷屆 DSE 相關的題號，方便學生溫習

B Process of transpiration

The process of transpiration through stomata is described below:



Animation 10.1

1. Water diffuses out of the mesophyll cells to form a **water film** on the cell surface.
2. Water of the water film **evaporates** to form **water vapour**. The water vapour moves into the **air space** among the mesophyll cells.
3. Water vapour in the air space **diffuses** through the stomata **to the atmosphere**.

Creation of transpiration pull

During the above process of transpiration, the following happens:

a. When mesophyll cells near the air space lose water to the air space, their **water potential lowers**.

b. As a result, water moves from neighbouring cells into these cells by **osmosis**. This is repeated across the layer of mesophyll cells.

c. Eventually, water moves out of the xylem vessels by osmosis to replace the water loss in mesophyll cells.

Overall, a **water potential gradient is created** along a chain of cells across the leaf. This causes water to flow from the xylem vessels to the mesophyll cells near the air space. A force is created to pull water up the xylem vessels from roots. This force is called **transpiration pull***.

transpiration pull 蒸騰拉力

C Significance of transpiration

Transpiration is important to plants in several ways:

The mechanisms of the transport and absorption of water will be discussed in ***Section 10.2*** and ***10.3*** respectively.

- Transpiration **creates transpiration pull**. This force enables **water and minerals** to be **transported** from roots to other parts of the plant.
- Transpiration pull **facilitates the absorption of water** by roots.
- During transpiration, the evaporation of water from the mesophyll cells removes heat from the leaves. This produces a **cooling effect** to prevent plants from being overheated under hot conditions.

Besides the cooling effect, green roofs can also improve air quality and provide habitats for wildlife. Watch the video below to learn about it.

https://www.youtube.com/watch?v=hbPe_SD2q8E

STSE connections

Roof greening

In the daytime, roofs of buildings are directly illuminated by the sun and they are quite hot. Growing plants on them can reduce their temperature through shading and transpiration. This in turn helps reduce the use of electricity for air conditioning of the buildings.

Fig 10.4 Green roof

提升學習動機

新增內容 New content

★ 加入更多STSE內容（例如屋頂綠化與蒸騰的關係），讓學生體會生物學與日常生活息息相關

Key learning

1 *What is transpiration? Where does transpiration mainly occur?*

- Transpiration is the loss of water in the form of water vapour from plants due to evaporation. It occurs mainly through stomata.

2 *How does transpiration take place through stomata?*

- Water on the surfaces of mesophyll cells evaporates into the air space. Then the water vapour in the air space diffuses through the stomata into the atmosphere.

3 *What is the significance of transpiration to plants?*

- It creates transpiration pull for the transport of water and minerals from roots to other parts of the plant.
- Transpiration pull facilitates the absorption of water by roots.
- Transpiration has a cooling effect on plants.

DSE
14(IA)Q22, 15(IA)Q18

D Adaptations of leaves to prevent excessive water loss

Transpiration is important to plants but excessive transpiration may result in dehydration* and death of the plants. Hence transpiration is said to be a necessary evil. To prevent excessive water loss by transpiration, leaves of terrestrial plants have the following features:

- The epidermis is **covered with a waxy cuticle**. The cuticle is almost impermeable to water. This reduces water loss through leaf surfaces.
- In the leaves of most dicotyledonous plants, there are only **a few or no stomata on the upper epidermis**. Stomata are mainly found on the lower epidermis (see ***Practical 10.2*** on p. 7). As the leaves of dicotyledonous plants are usually **oriented horizontally** (Fig 10.5), their upper epidermis faces the sun and is hotter than the lower epidermis. The small number of stomata on the upper epidermis helps reduce water loss by evaporation.
- **Guard cells** are present to **control the opening and closing of the stomata**. In the daytime, the stomata usually open to allow efficient gas exchange. At night, when the need for gas exchange decreases in the absence of photosynthesis, the stomata close to reduce water loss from the leaves.

Fig 10.5 Dicot leaves are usually oriented horizontally

Extended learning

Opening and closing of stomata

Guard cells are bean-shaped. Their cell wall has uneven thickness. When the guard cells take up water from the surrounding cells, they become turgid. The thinner outer side expands more than the thicker inner side. Thus, the guard cells bend and the stoma opens (Fig 10.6). The stoma closes when the guard cells lose water and become flaccid.

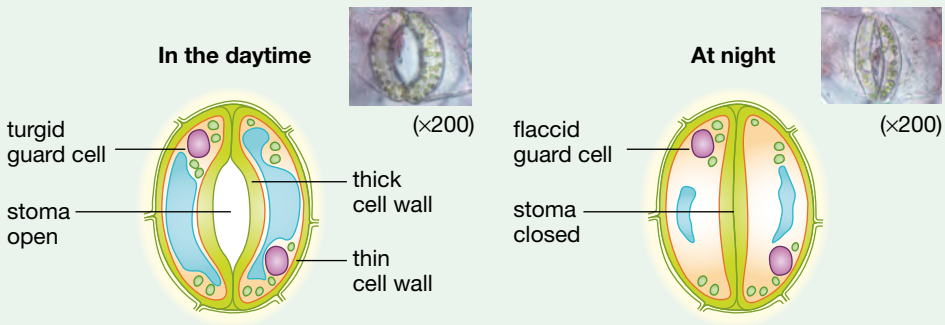


Fig 10.6 Guard cells control the opening and closing of stomata

dehydration 脱水

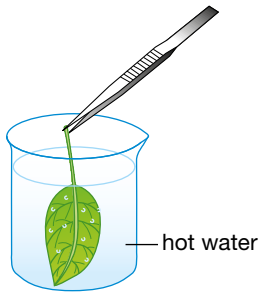
Practical 10.2

Comparing the abundance of stomata on the upper and lower surfaces of a terrestrial dicotyledonous leaf

Procedure

1 Pick a leaf from a terrestrial dicotyledonous plant. Immerse it in a beaker of hot water (about 80 °C).

2 Observe the upper and lower leaf surfaces carefully.



Practical 10.2

Caution

Handle the hot water with care.

Results and discussion

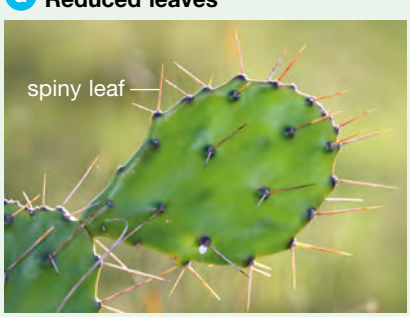
- Air bubbles appear on the leaf surfaces. There are **more air bubbles** on the **lower surface** than on the upper surface.
- When the leaf is put in hot water, the air inside the leaf expands and comes out from the leaf surface through the stomata. More air bubbles coming out from the lower surface indicates that there are **more stomata** on the **lower surface of the leaf**.

Extended learning

Xerophytes

Some plants live in particularly hot, dry places such as deserts. They are called xerophytes*. Their leaves have special features to reduce water loss through transpiration. Below are some examples.

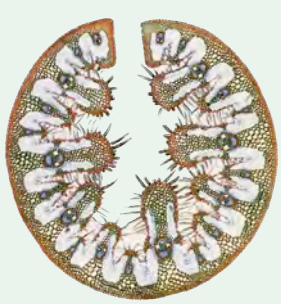
a Reduced leaves



A cactus plant

Leaves of some plants are spiny (e.g. cactus) or needle-shaped (e.g. pine). This reduces water loss by decreasing the surface area of leaves.

b Rolled leaves



Cross section of a rolled leaf (×30)

Leaves of some plants roll up to enclose the stomata in a still, humid environment. This slows down the diffusion of water vapour from the stomata.

c Sunken stomata

Cross section of a leaf (×100)

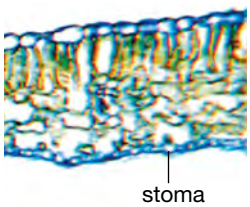
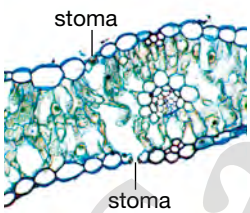
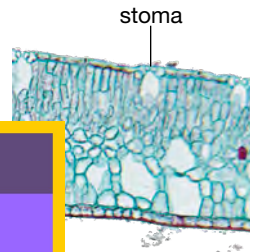
Some plants have their stomata located in pits. Like rolled leaves, this can reduce water loss by keeping stomata in a still, humid environment.

xerophyte 旱生植物

DSE
12(IA)Q12, 18(IA)Q30, 31

E Distribution of stomata on leaves of different types of plants

The distribution of stomata in the leaves of some types of plants is different from that of dicotyledonous plants. It is an adaptation to the environment of the plants. The table below gives a summary.

Type of plant	Stomatal density (number per cm^2)		Adaptation
	Upper epidermis	Lower epidermis	
Terrestrial dicot plants, e.g. tomato   (×50)	1200	13 100	The **lower epidermis has more stomata** than the upper epidermis. As the upper epidermis is directly illuminated by the sun, having fewer stomata on it helps reduce water loss (discussed on p. 6).
Terrestrial monocot plants, e.g. wheat   (×100)	5000	4000	The stomata are almost **equally distributed on both sides** of the leaves. As the leaves are **oriented vertically**, both sides of the leaves receive similar sunlight. They lose water at a similar rate.
Submerged plants, e.g. seagrass   (×50)	0	0	Stomata are **absent** in the epidermis. **Cross-link** Gas exchange occurs throughout the whole leaf surface due to the absence of cuticle. Refer to p. 11 of ***Ch 9***.
Floating plants, e.g. pond weed  	11 000	0	Stomata are **present in the upper epidermis only**. The lower epidermis is in contact with water. It has no stomata. **Cross-link** Gas exchange takes place through the stomata in the upper epidermis. Refer to p. 11 of ***Ch 9***.

促進概念理解

顯微照片 Photomicrograph

★ 新增大量顯微照片，幫助學生理解生物構造和過程

Practical 10.3

Design an investigation to study the relative abundance of stomata on both sides of a leaf of different types of plants

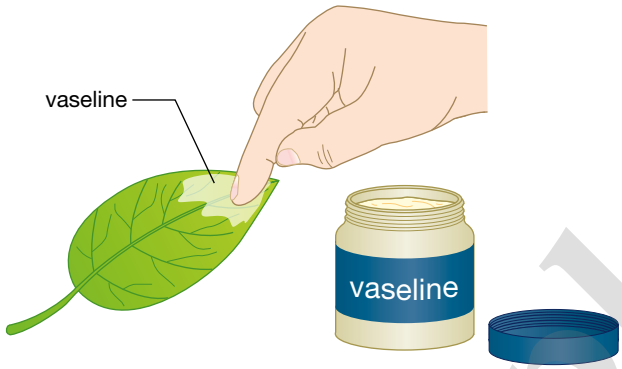
Task

Design and carry out an investigation to study the relative abundance of stomata on both sides of a leaf of different types of plants. Write a full report of your investigation. The following may give you some hints.

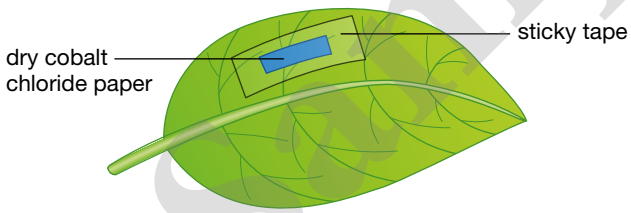
Practical 10.2 (p. 7) shows an easy way to compare the abundance of stomata on both sides of a leaf. However, it gives a rough comparison only and it does not involve any measurement.

Practical 10.3

1 Water loss through the stomata will lead to weight loss in a leaf. If the stomata are covered with vaseline, the weight loss will be smaller.



2 Water is lost from a leaf mainly through stomata. This water can be tested by attaching a piece of dry cobalt chloride paper on the leaf surface.



Materials and apparatus

The materials and apparatus you need will depend on the design of your investigation. You may choose from the following:

electronic balance	1	dry cobalt chloride paper
stop-watch	1	vaseline
forceps	1 pair	sticky tape
leaves of different plants		

To find the distribution of stomata on leaves more accurately, we can observe the epidermis under a microscope and count the number of stomata on it directly. Let us carry out ***Practical 10.4*** on the next page to learn about it.

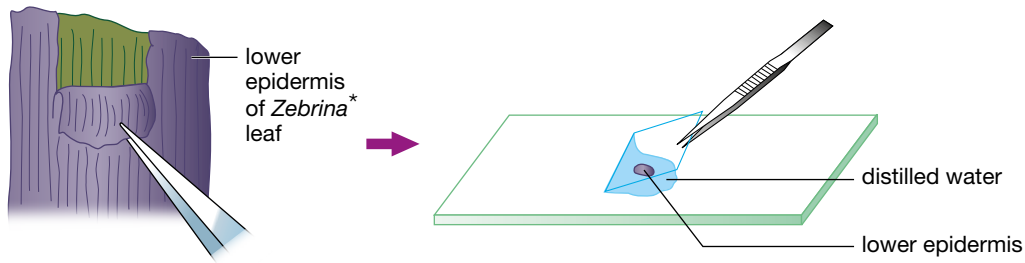
Practical 10.4 Investigation of the stomatal density on the epidermis of a leaf

Procedure

Practical 10.4

1 Tear a leaf (e.g. *Zebrina* leaf) diagonally. Use a pair of forceps to peel off a small piece of the lower epidermis from the leaf.

2 Mount the epidermis with a drop of water. Observe it with a microscope.

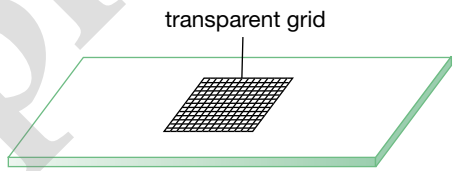


3 Under a suitable field of view, count and record the number of stomata.

4 Count the number of stomata in two more areas on the epidermis. Calculate the average of the three counts.

5 Repeat the above steps with the upper epidermis.

6 Examine a transparent grid with a microscope under the same magnification. Count the number of grid squares and estimate the area of the field of view.



7 Calculate the stomatal densities of the epidermis using the equation below:

$$\text{Stomatal density} = \frac{\text{Average number of stomata}}{\text{Area of the microscopic field of view (mm}^2\text{)}}$$

Key learning

What are the adaptive features of leaves of terrestrial plants for preventing excessive water loss through transpiration?

- The epidermis of the leaves is covered with cuticle.
- Leaves of dicotyledonous plants usually have few or no stomata on the upper epidermis.
- Guard cells are present to control the opening and closing of the stomata.

Zebrina 水竹草

DSE
12(IA)Q10, 13(IB)Q6, 14(IA)Q21, 15(IA)Q17

F Measurement of the rate of transpiration

Measuring the **rate of transpiration** directly is almost impossible as it is difficult to condense and collect all the water vapour lost from a plant. However, we can estimate it using a **potometer***. There are different types of potometers. Let us learn two of them in the following practicals.

Practical 10.5 Measurement of the rate of transpiration using a bubble potometer

Introduction

A **bubble potometer*** can be used to measure the **rate of water uptake** by a plant. As about 99% of water taken up by a plant is lost in transpiration, we can **assume that the rate of water uptake is the same as the rate of transpiration**.

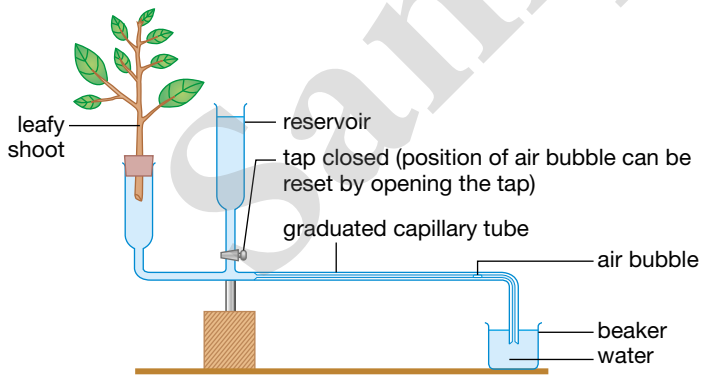
Practical 10.5

Procedure

1 Cut a leafy shoot from a plant and fit it into a bubble potometer *under water*. Doing this under water can prevent air bubbles from entering the xylem vessels and blocking water uptake.

Caution
Be careful when cutting the leafy shoot.

2 Set up the apparatus as shown below. Seal off all connections with vaseline to ensure no leakage of water.



3 Introduce an air bubble into the capillary tube by lifting the end of the tube from the water for a while and then putting it back into the water.

4 Wait for the air bubble to move into the graduated part of the tube.

5 Record the initial position of the air bubble. Then record the distance travelled by the air bubble in a certain period of time (e.g. 5 minutes).

Results and discussion

The rate of water uptake by the leafy shoot can be found out by calculating the rate of movement of the air bubble (the unit is cm s^{-1}). This is an indirect measurement of the rate of transpiration.

bubble potometer 氣泡蒸騰計　potometer 蒸騰計

Practical 10.6 Measurement of the amount of water absorbed and lost by a plant using a weight potometer

Introduction

A **weight potometer*** has two main parts:

(1) a **measuring cylinder** which is used to **measure the amount of water absorbed** by a plant, and

(2) a **balance** which is used to **measure the amount of water lost** by the plant due to transpiration.

Practical 10.6

Procedure

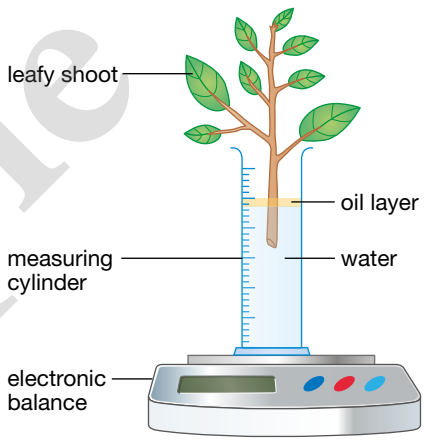
Caution
Be careful when cutting the leafy shoot.

1 Cut a leafy shoot from a plant and put it into a measuring cylinder *under water*.

2 Set up the apparatus as shown. Add a thin layer of oil to the water surface to prevent evaporation of water, which will otherwise affect the results.

3 Record the initial water level (V_i) in the measuring cylinder and the initial weight (W_i) of the whole set-up.

4 After a period of time (e.g. 3 hours), record the final water level (V_f) in the measuring cylinder and the final weight (W_f) of the whole set-up.



Results and discussion

- Amount of water **absorbed** by the leafy shoot
  = change in **volume** of water in the measuring cylinder
  = $(V_f - V_i)$ cm^3
  = $(V_f - V_i)$ g (as density of water is about 1 g cm^{-3})

  Amount of water **lost** by the leafy shoot
  = change in **weight** of the whole set-up
  = $(W_f - W_i)$ g
- The amount of water absorbed is slightly greater than the amount of water lost by the leafy shoot. This indicates that **some water is retained in the shoot**. The water is used in photosynthesis, growth and other metabolic activities.

緊貼DSE趨勢

實驗改良 Set-up improvement

★ 實驗裝置改良，更方便設置
★ 配合公開試試題（例如參考 DSE 練習卷 IA Q27 的裝置）

weight potometer 重量蒸騰計

DSE
12(IA)Q11, 14(IA)Q20, 16(IA)Q11, 17(IA)Q14, 15

G Environmental factors affecting the rate of transpiration

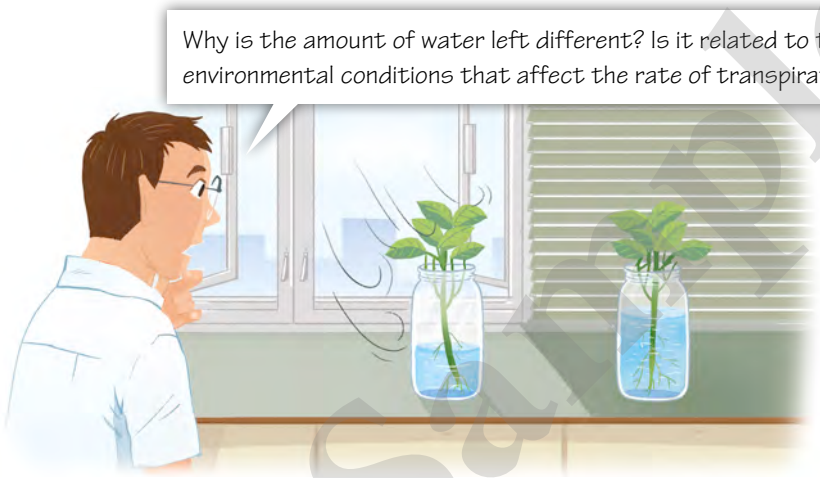
The rate of transpiration is affected by a number of environmental factors. Carry out ***Practical 10.7*** to find out some of these factors and their effects on the rate of transpiration.

Practical 10.7 Design an investigation of the effects of environmental factors on the rate of transpiration

Scenario

In the school laboratory, two similar potted plants are put on the bench. Tommy filled up the two pots with water. Two days later, Tommy found that less water was left in the pot near the window than the other pot.

Simulation 10.7



Task

With reference to ***Practical 10.5*** and ***10.6***, design and carry out an investigation to study the effect of environmental factors on the rate of transpiration. Write a full report of your investigation.

Materials and apparatus

The materials and apparatus you need will depend on the design of your investigation. You may choose from the following:

pipette (1 cm^3)	1	bench lamp	1
stand	1	heater	1
clamp	2	dehumidifier	1
scalpel	1	fan	1
glass tubing		plant with leafy shoots	1
rubber tubing			

Caution
The scalpel is very sharp. Handle it with care.

促進概念理解

課文增潤 Enrichment

★ 更詳盡解釋環境因素如何影響蒸騰速率
★ 設計清楚易讀

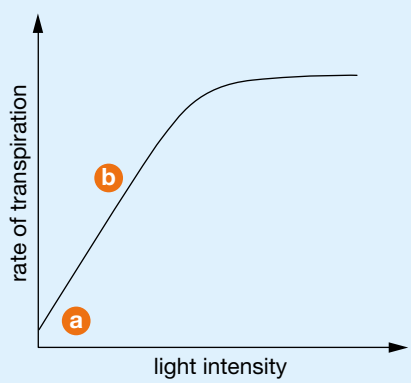
Some environmental factors that affect the rate of transpiration of a plant are discussed below. They affect the rate of transpiration by affecting:

(1) the rate of evaporation of water,

(2) the rate of gas diffusion, and

(3) the degree of opening of stomata.

1 Light intensity



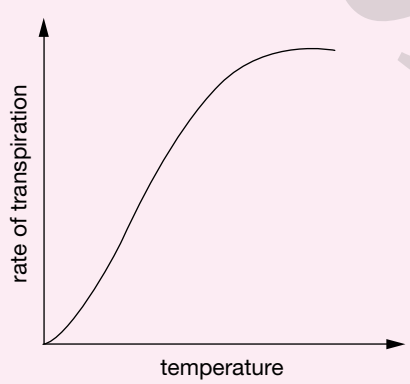
a The rate of transpiration is low in darkness.

Reason: In darkness, **stomata are closed**. Only a very small amount of water vapour can diffuse out of the leaves to the atmosphere.

b The **rate of transpiration increases** when the **light intensity increases**.

Reason: As light intensity increases, the **stomata open wider**. The cross-sectional area for the diffusion of water vapour increases. As a result, water vapour diffuses out of the leaves more rapidly through the stomata.

2 Temperature

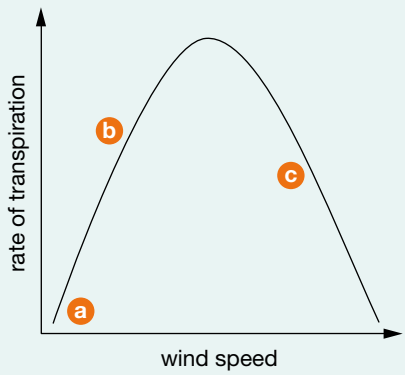


The **rate of transpiration increases** when the **temperature increases**.

Reason: As temperature increases, the **rate of evaporation of water** from the surfaces of mesophyll cells **increases**. The **rate of diffusion** of water vapour also **increases**. Therefore, water vapour diffuses out of the leaves more rapidly through the stomata.

? Suggest why the curve begins to level off at high light intensities and at high temperatures.

3 Air movement



a The rate of transpiration is low in still air.

Reason: In still air, **water vapour** that has diffused out of the leaves **accumulates** around the stomata. This **decreases the concentration gradient of water vapour** between the air space in the leaves and the surrounding air. Therefore, the rate of diffusion of water vapour out of the leaves decreases.

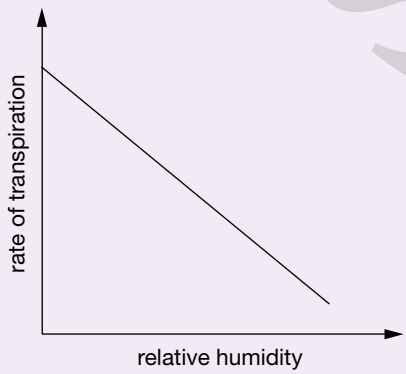
b The **rate of transpiration increases** when the **wind speed increases**.

Reason: Wind blows away water vapour around the stomata. This helps **maintain a steep concentration gradient of water vapour** between the air space in the leaves and the surrounding air. Therefore, water vapour diffuses out of the leaves more rapidly through the stomata.

c The rate of transpiration decreases when the wind becomes too strong.

Reason: Under strong wind, water may be lost from the plant too rapidly. To prevent **dehydration** of the plant, **stomata close**. Therefore, less water vapour diffuses out of the leaves through the stomata.

4 Relative humidity



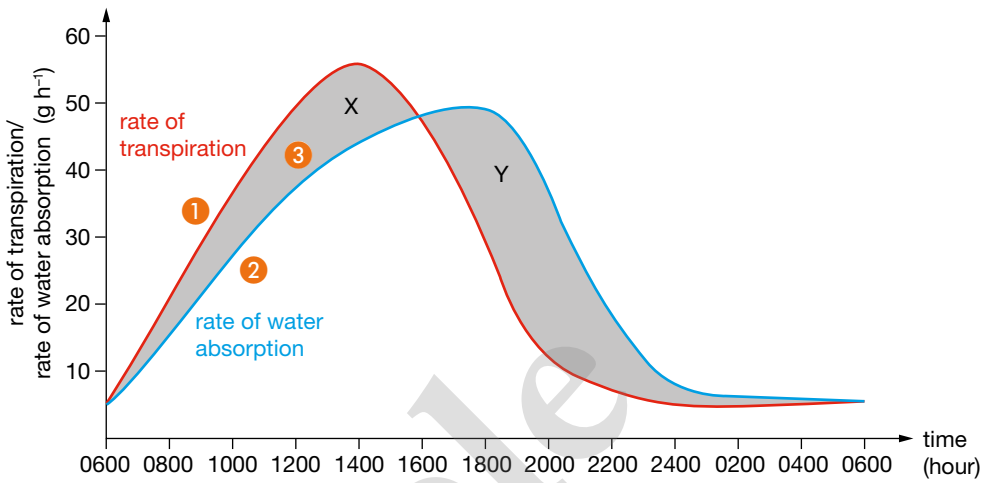
The **rate of transpiration decreases** when the **relative humidity** of the surrounding air **increases**.

Reason: As the air space in the leaves is saturated with water vapour, a **higher relative humidity** of the surrounding air **decreases the concentration gradient of water vapour** between the air space and the surrounding air. Therefore, less water vapour in the air space diffuses out to the atmosphere through the stomata.

In addition to environmental factors, the structure of the plant (e.g. surface area of leaves, thickness of the cuticle and abundance of stomata) also affects the rate of transpiration.

Relationship between rates of transpiration and water absorption of plants

The graph below shows the changes in the rates of transpiration and water absorption of a plant in 24 hours. The changes are related to the variations in environmental conditions throughout the day.



促進概念理解

圖表解讀 Graph reading 新增

★ 幫助學生深入理解圖表，並訓練詮釋圖表的技巧

Graph reading

1. The rate of transpiration increases from 0600 to 1400 hours. Light intensity increases in this period. This causes the stomata to open wider. Temperature also rises in this period. This increases the rate of evaporation of water. As a result, water vapour diffuses out of the leaves more rapidly through the stomata.

2. The curves of water absorption and transpiration are similar in shape. They are interdependent. An increased rate of transpiration results in a larger transpiration pull. This, in turn, causes more water to be absorbed from the soil.

3. Area X represents the net amount of water lost by the plant from 0600 to 1600 hours. Area Y represents the net amount of water absorbed by the plant from 1600 to 0600 hours. Since area Y is larger than area X, this suggests that the plant has a net uptake of water during the 24-hour period. It can be inferred that some water is retained in the plant. The water is likely being used for photosynthesis, formation of new cells and other metabolic activities.

多元評估 鞏固所學

測試站 Checkpoint

- ★ 題目分為程度 1 和 2，方便照顧學習差異
- ★ 增加題目數量
- ★ 另備網上版本，提升課堂互動性

Kahoot! iSolution Google Forms

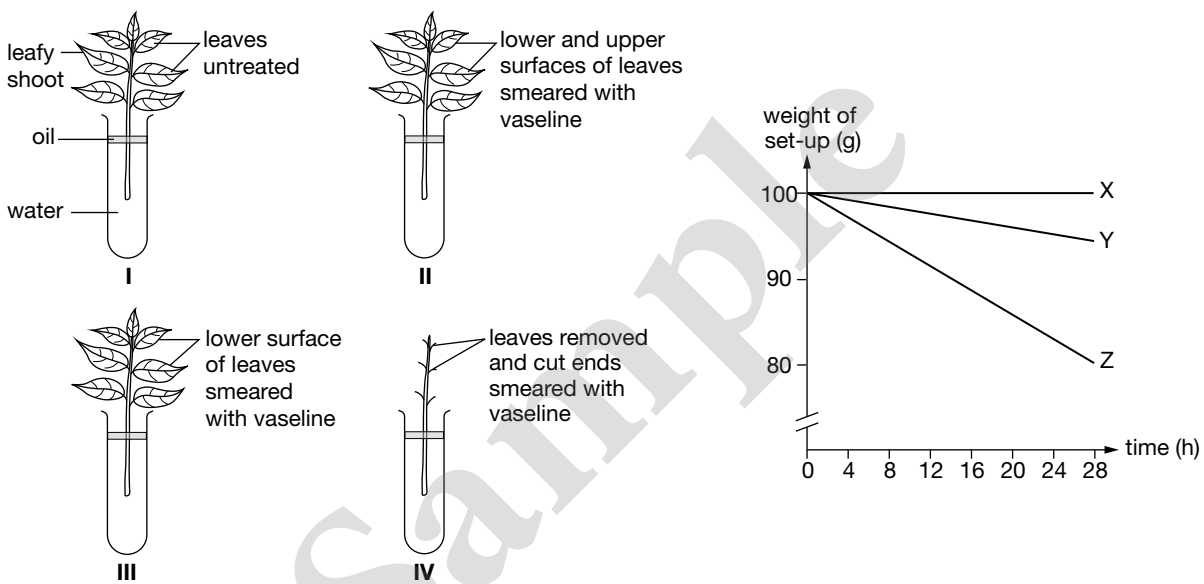
Key learning

How do environmental factors affect the rate of transpiration?

The rate of transpiration increases when light intensity, temperature or wind speed increases. The rate of transpiration decreases when relative humidity of the surrounding air increases.

Checkpoint

Directions: Questions **1** to **3** refer to set-ups I to IV below. The leafy shoots are similar but treated differently. The changes in their weights are measured and shown in the graph on the right.



Level 1

1 Curve X shows the results of set-ups

A I and II only.
B I and III only.
C II and IV only.
D III and IV only.

p. 8

2 How will curves Y and Z change if the set-ups are covered by a bell jar?

A They will become a horizontal line.
B Their slopes will become steeper.
C Their slopes will become less steep.
D They will remain unchanged.

p. 15

Level 2

3 Which of the following can be deduced from the graph?

A The lower epidermis of the leaves has more stomata than the upper epidermis.
B The upper epidermis of the leaves has more stomata than the lower epidermis.
C Stomata are equally distributed on the upper epidermis and the lower epidermis of the leaves.
D The upper epidermis of the leaves does not have stomata.

p. 8

促進概念理解

內容編排 Content organization

★ **編排有序**，例如讓學生於本章學習根部的構造，便可一氣呵成地學習蒸騰拉力如何幫助根吸收水份

10.2 Absorption of water and minerals by roots

Plants continuously absorb water from the soil for activities such as photosynthesis and forming new cells, and also for replacing the water lost in transpiration. Dissolved minerals are absorbed along with water. These absorption processes are carried out in **roots**.

Animation 10.2

A Structure of the root

Fig 10.7 shows the structure of the root of a dicotyledonous plant.

促進概念理解

顯微照片 Photomicrograph

★ 新增**顯微照片**，與圖解相對應，幫助學生認識根的構造

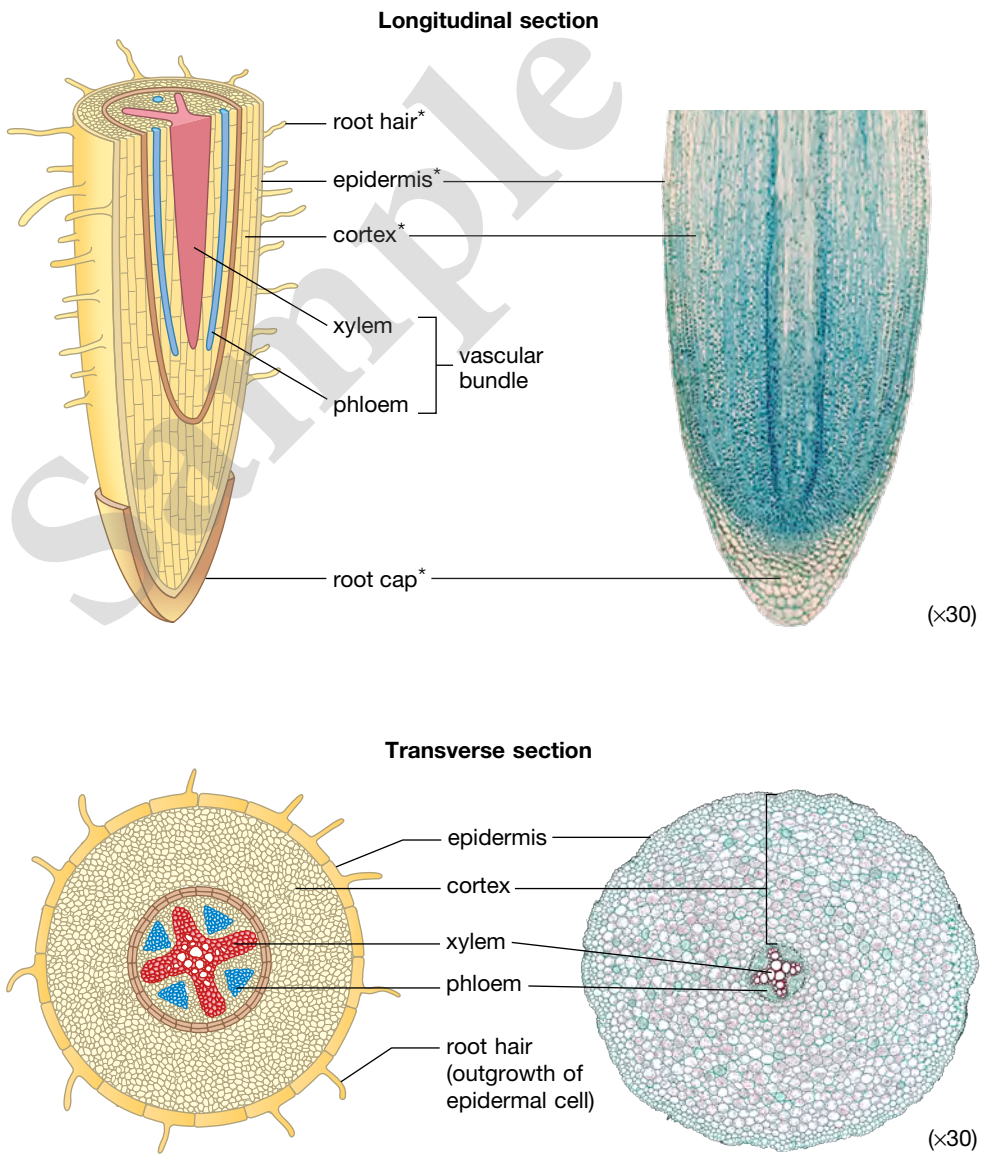


Fig 10.7 Structure of a dicotyledonous root

cortex 皮層　epidermis 表皮　root cap 根冠　root hair 根毛

The root of dicotyledonous plants consists of:

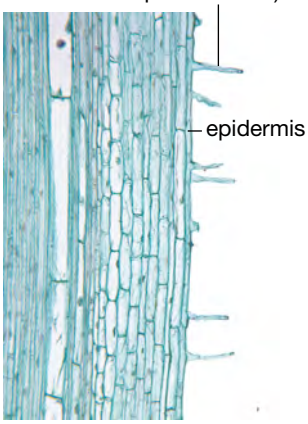


Fig 10.8 Root with root hairs (L.S.) (×50)

1 Epidermis

- It is the outermost layer of the root. It is **not covered by cuticle** so that absorption of water and minerals is not blocked.
- It is made up of a layer of **closely-packed thin-walled cells**.
- It **protects** the inner tissues from injury and infections.
- Some epidermal cells have outgrowths called **root hairs**. The root hairs provide a **large surface area** for absorption of water and minerals from the soil (Fig 10.8).

2 Cortex

- It is the region beneath the epidermis. It is made up of layers of **loosely-packed thin-walled cells**.
- It **stores food** (in the form of starch).
- It **allows** the **passage of water and minerals** across the root.

3 Vascular bundle

- It is located in the centre of the root.
- It contains two types of vascular tissues: xylem and phloem. **Xylem transports water** and **minerals**. **Phloem transports organic nutrients** (mainly sugars).

4 Root cap

- It covers and **protects** the **root tip**.
- Its cells are constantly worn away when the root grows through the soil. They are replaced by new cells produced in the root tip.

提升學習動機

你知道嗎？Did you know?

★ 新增**有趣冷知識**，例如講解棉花糖名字的由來，提高學生的學習興趣

Did you know?

Marshmallow roots

To ease the movement of the root through the soil, the root cap secretes a slimy, gluey substance called mucilage* to lubricate the root tip. In ancient times, people extracted mucilage from the roots of *Althaea officinalis** and used it to make a soft and elastic candy. People named this candy marshmallow as *A. officinalis* is a mallow plant growing in marshes.

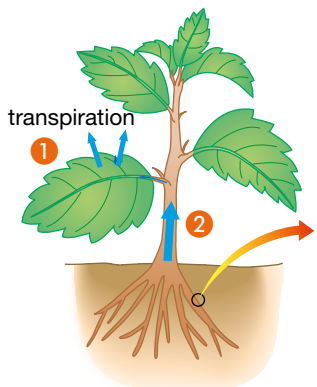
Fig 10.9 Marshmallow was once made from the roots of *Althaea officinalis*

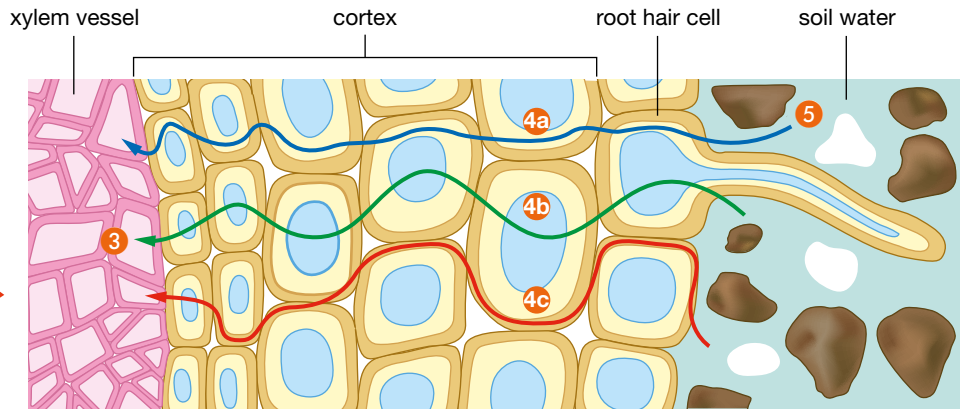
Althaea officinalis 藥蜀葵　　mucilage 黏液

Animation 10.3

B Process of absorption of water by roots

The process of absorption of water by the root is described below:





1. Water is **lost** from the leaves continuously by **transpiration**. This creates transpiration pull.
2. Water is **drawn up the xylem vessels** from the roots to the leaves by the **transpiration pull**.
3. Water in the cortex cells near the xylem vessels of the roots enters the xylem vessels. This decreases the water potential of these cortex cells. A **water potential gradient** is set up across the whole cortex.
4. In the cortex, water travels from cell to cell through three routes:
   a. Water moves along a water potential gradient through the **cytoplasm** of cells by **osmosis** (—— route).
   b. Water moves along the same water potential gradient through the **vacuoles** of cells by **osmosis** (—— route).
   c. Water travels from one cell to another freely through the **cell wall** (—— route).
5. As water is drawn into the inner cells, the water potentials of the root hair cells become lower. As the water potential of the soil is higher than that of the root hair cells, water in the soil enters the root hair cells by **osmosis**.

促進概念理解

課文增潤 Enrichment

★ 課文介紹水在根部皮層的三個移動路徑（圖中以三種不同顏色表示），加深學生的生物學知識

DSE
18(IA)Q24

C Process of absorption of minerals by roots

As the concentrations of minerals in the soil are usually lower than that in the root hair cells, minerals in the soil are mainly absorbed into the roots by **active transport**. They are taken up **against a concentration gradient** using energy from respiration (Fig 10.10). That is why many mitochondria are found in root hair cells.

Active absorption of minerals by root hair cells lowers the water potential of the cells. This helps the absorption of water into the cells by osmosis.

促進概念理解

圖解 Illustration

★ 加入更多生物圖解，幫助學生理解生物學概念（例如右圖可幫助學生理解根怎樣吸收泥土的礦物質）

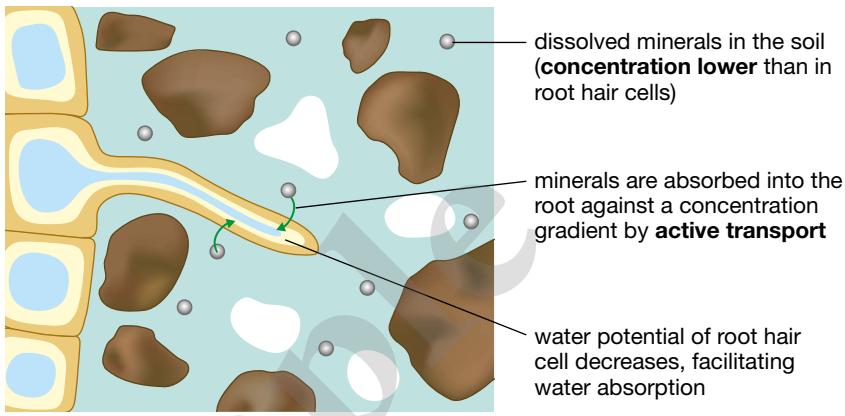


Fig 10.10 Absorption of minerals into the root

On rare occasions, when the concentrations of minerals in the soil are higher than that in the root hair cells, minerals enter the root hair cells down the concentration gradient by diffusion.

Did you know?

Fertilizer burn

Chemical fertilizers contain minerals that promote plant growth. However, applying too much fertilizer to the soil may greatly increase the mineral concentrations and hence lower the water potential of the soil. As a result, water cannot be absorbed into the roots by osmosis. This leads to a condition called fertilizer burn*. Its symptoms include yellow leaves, root damage and even wilting of the plant.

Fig 10.11 Too much fertilizer in soil may affect water absorption by roots

fertilizer burn 肥害

DSE
14(IA)Q23, 16(IA)Q23

D Adaptive features of roots for absorption of water and minerals

Fig 10.12 Root hairs on a root (×50)

Roots are adapted for absorption of water and minerals in several ways:

- The root is **highly branched** and there are **numerous root hairs** on it (Fig 10.12). Both features provide a large surface area for the absorption of water and minerals.
- **Root hairs** are **long** and **fine**. They can easily grow between soil particles. This helps absorb water and minerals around them.
- The epidermis of the root is **not covered by cuticle**. It is made up of **one layer of thin-walled cells** only. This allows water and minerals to pass through the epidermis into the root easily.
- Root hair cells contain **many mitochondria**, ensuring enough energy is supplied to absorb minerals from the soil by active transport.

Key learning

1 *How is water absorbed by roots?*

- Water loss from the leaves creates transpiration pull. The transpiration pull draws water up the xylem vessels.
- In the root, water in the cortex cells near the xylem vessels enters the xylem vessels. A water potential gradient is set up across the cortex of the root. Water then moves inwards from cell to cell through the cytoplasm or vacuoles by osmosis, or along the cell walls.
- As water is drawn into the cells of inner cortex, the water potential of the root hair cells decreases. Thus water in the soil enters the root hair cells by osmosis.

2 *How are minerals absorbed by roots?*

- Most minerals are absorbed into root hair cells by active transport.

3 *What are the adaptive features of roots for absorption of water and minerals?*

Feature of root	Adaptation
The root is highly branched.	This provides a large surface area for the absorption of water and minerals.
There are numerous root hairs on the root.	
Root hairs are long and fine.	This allows root hairs to grow between soil particles to absorb water and minerals.
The epidermis is not covered by cuticle.	This allows water and minerals to easily pass through the epidermis into the root.
Root hair cells contain many mitochondria.	This ensures enough energy is supplied to absorb minerals from the soil by active transport.

緊貼DSE趨勢

新增內容 New content

★ **針對近年DSE 試題新增內容，**例如右方的STSE 內容讓學生認識到用混凝土蓋住樹根對樹木的傷害，相關題材曾在 2018 年 DSE 卷 IA Q24 出現

STSE connections

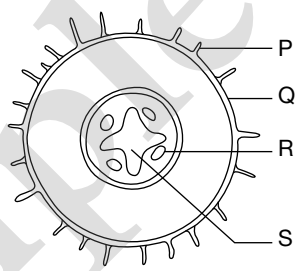
Covering tree roots with concrete

Trees grown in urban areas sometimes have their roots mistakenly covered by concrete on the road surface (Fig 10.13). The concrete forms an impermeable layer, which hinders water and oxygen from reaching the roots. This badly affects gas exchange and absorption of water and minerals in the roots, and hence the health of the plant.

Fig 10.13 Tree roots covered with concrete

Checkpoint

Directions: Questions **1** and **2** refer to the diagram below, which shows the cross section of a dicot root.



Level 1

1 Which of the following are the adaptive features of part P for water absorption?

(1) It is thin-walled.
(2) It is not covered by cuticle.
(3) It has many mitochondria.

A (1) and (2) only **B** (1) and (3) only
C (2) and (3) only **D** (1), (2) and (3)

p. 22

Level 2

2 Which of the following correctly matches the parts of the root and their functions?

	Part	*Function*
(1)	Q	prevents water loss
(2)	R	stores food
(3)	S	transports water

A (1) only **B** (3) only
C (1) and (2) only **D** (2) and (3) only

p. 19

DSE
12(IB)Q3a

10.3 Transport in plants

After being absorbed into the roots, water and minerals are carried up to the leaves and other parts of the plants. On the other hand, food made in the leaves is transported to the parts where the food is used or stored. In this section, we will learn about these processes in flowering plants.

促進概念理解

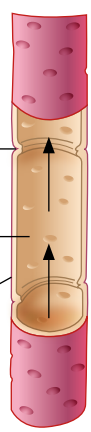
對頁設計 Double-page design

★ 相關內容（如木質部和韌皮部）放左右兩頁，閱讀時無須翻頁，方便比較

A Types of vascular tissues

There are two types of vascular tissues in flowering plants: **xylem** and **phloem**. Their structures are highly adapted for transporting substances.

	Xylem
Function	• It **transports water** and **minerals**. • It **provides support** for plants (to be discussed in ***Section 10.4***).
Adaptive feature	Xylem mainly consists of **xylem vessels*** . Xylem vessels are hollow tubes made up of **dead cells**. They have the following adaptations: 1 **No end walls between cells** • creates a long continuous tube for water transport 2 **No nuclei, cytoplasm and other cell contents** • allows water to flow freely from one cell to another 3 **Cell walls are thick and lignified*** • prevents vessels from collapsing under the great tension of transpiration pull



Transverse section

Fig 10.14 Electron micrograph of xylem (×200)

Longitudinal section

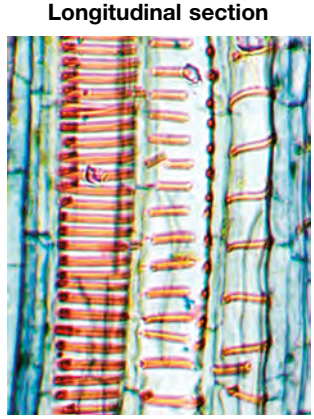


Fig 10.15 Photomicrograph of xylem (×50)

lignified 木質化的　　xylem vessel 木質導管

Extended learning

Thickening in xylem vessels

When xylem cells develop, lignin deposits on their cell walls. This thickens the cell walls so as to prevent the vessels from collapsing. Lignin may deposit on the walls in different patterns such as in rings, spirals or network (Fig 10.16).

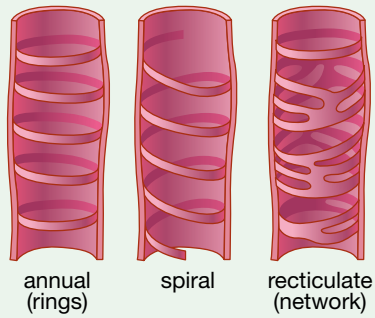


Fig 10.16 Different thickening in xylem vessels

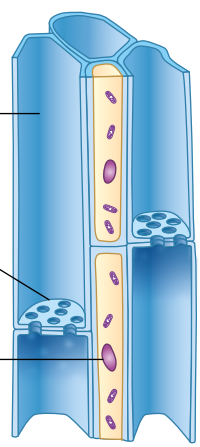
	Phloem
Function	It **transports organic nutrients** (mainly sugars).
Adaptive feature	Phloem mainly consists of **sieve tubes*** and **companion cells***. Sieve tubes are elongated **living cells** joined end to end. Companion cells run along them. Phloem has the following adaptations:

促進概念理解

內容編排 Content organization

★ 課文在適當位置會以點列或表格形式展示，務求學生能快速掌握重點

1. **Sieve tube contains little cytoplasm and no nucleus**
   - allows organic nutrients to move along with little resistance
2. **Sieve plate* has pores**
   - allows organic nutrients to pass through
3. **Companion cell has dense cytoplasm and many organelles** (including nucleus)
   - supports metabolism of the sieve tube



Transverse section

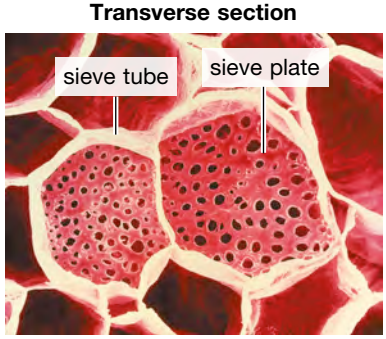


Fig 10.17 Electron micrograph of phloem showing pores in the sieve plate (×300)

Longitudinal section

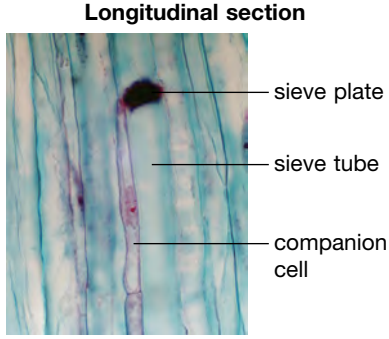


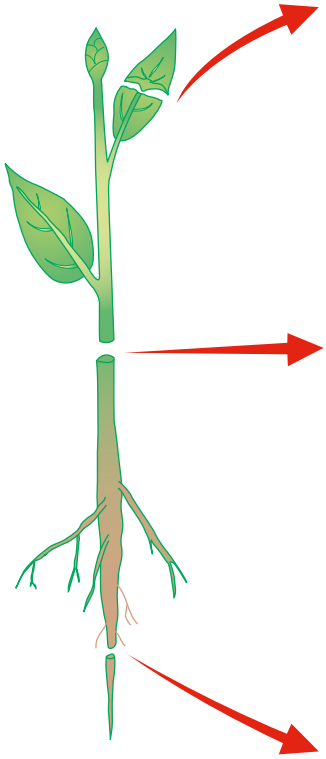
Fig 10.18 Photomicrograph of phloem (×100)

companion cell 伴細胞　sieve plate 篩板　sieve tube 篩管

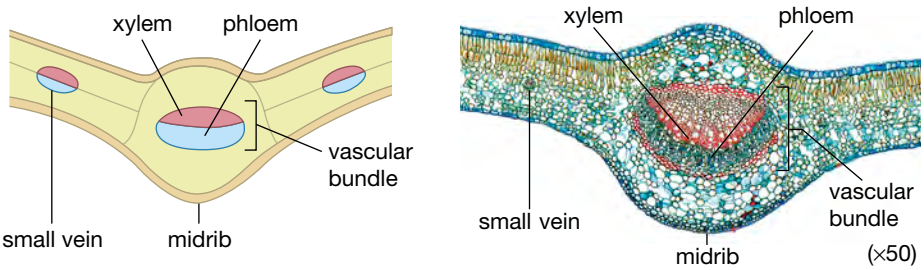
DSE
17(IA)Q16

B Distribution of vascular tissues

Vascular tissues are arranged in long strands called **vascular bundles**. The distributions of vascular bundles in the root, stem and leaf in a young dicotyledonous plant are shown below.

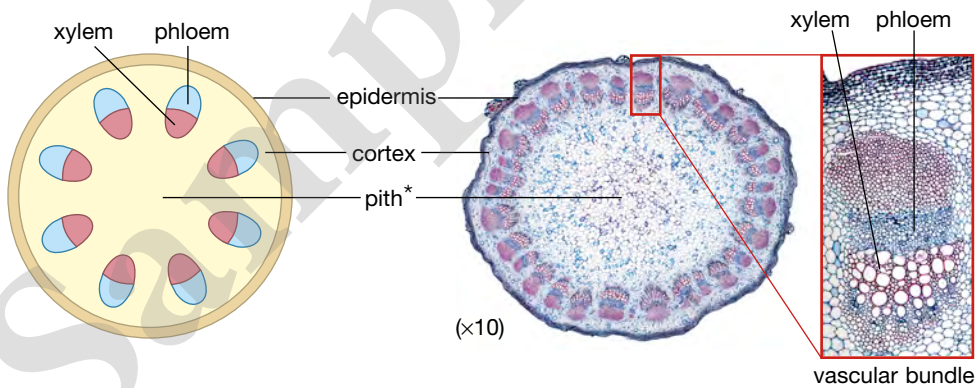


Leaf



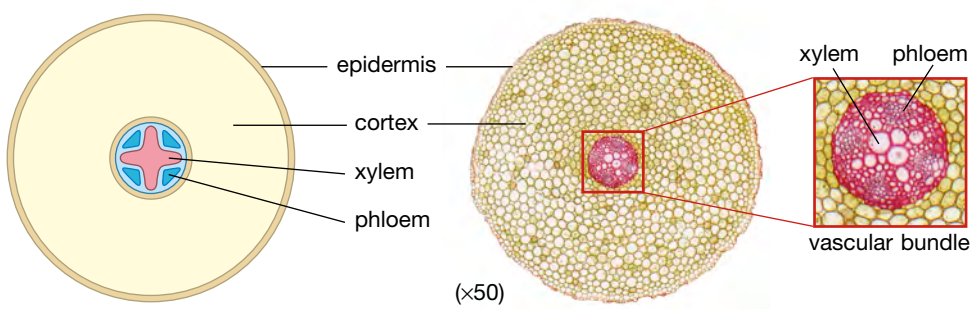
Vascular bundles are found in the large central **midrib** and the network of small **veins**. **Xylem lies on top** of phloem.

Stem



Vascular bundles are arranged in a **ring** at the **periphery**. In each bundle, **xylem** is located in the **inner** region and **phloem** in the **outer** region.

Root



Vascular bundles are located at the **centre**. **Phloem** is found **between** the 'arms' of **xylem**.

pith 髓

Practical 10.8 Examination of the vascular tissues of a young dicotyledonous plant

Procedure

1 Prepare temporary mounts of the transverse sections of the leaf, stem and root of a young dicotyledonous plant. Examine them under low-power magnification.

2 Identify the vascular tissues and their distributions in each section. Draw low-power labelled diagrams of the sections.

Practical 10.8

Animation 10.4

緊貼DSE趨勢

延伸學習 Extended learning

★ 更多進階內容，增進學生知識，有助學生應付 DSE 試題（例如讓學生認識維管束在單子葉植物的分佈）

Extended learning

Distribution of vascular bundles in monocotyledonous plants

The distribution of vascular bundles in the root, stem and leaf in a monocotyledonous plant is different from that in a dicotyledonous plant. Fig 10.19 shows the general difference.

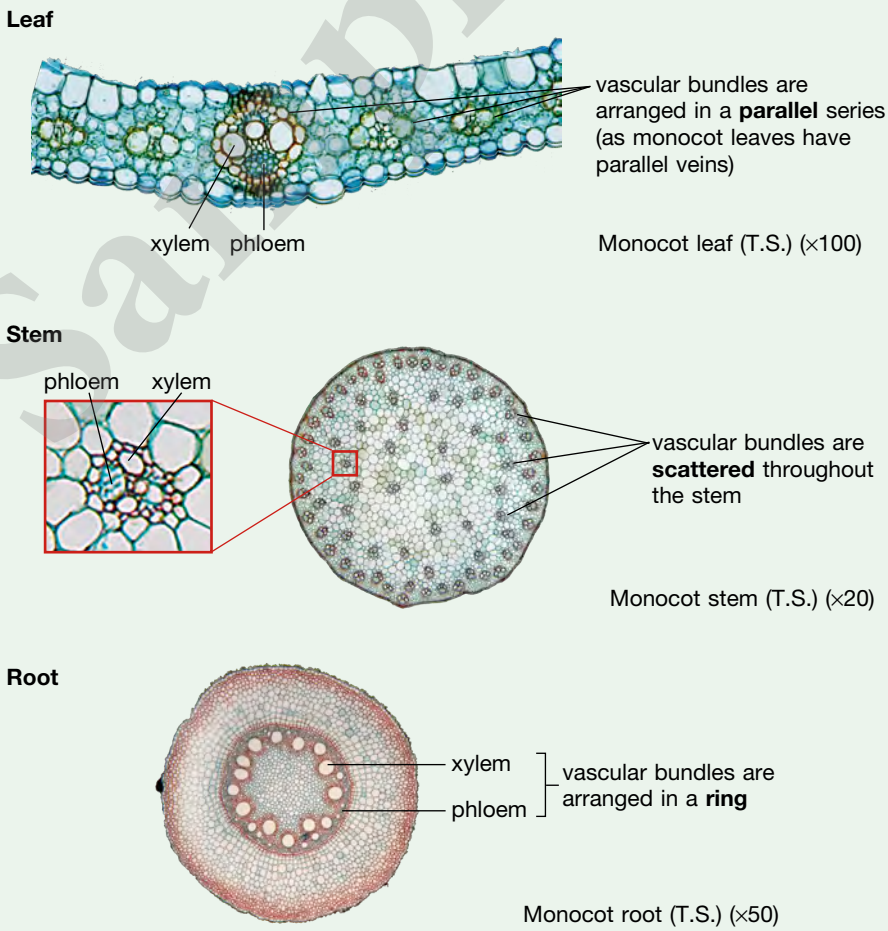


Fig 10.19 Distribution of vascular bundles in monocotyledonous plants

DSE
12(IA)Q3, 15(IA)Q2, 18(IA)Q36

C Process of transport of water and minerals

Transpiration pull is the main force that **draws water up the xylem vessels** from the roots. The continuous hollow tube-like structure of xylem vessels allows a **continuous stream of water** to be formed inside them. Water absorbed into the roots is carried to other parts of the plant through the xylem vessels (Fig 10.20). Since minerals dissolve in soil water, they are transported up the plant along with the water.

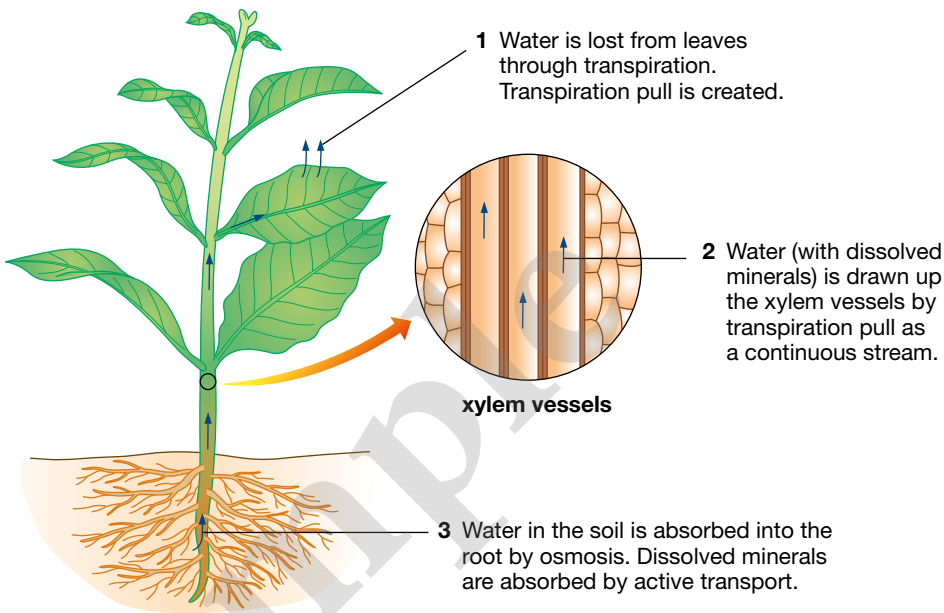


Fig 10.20 Water and minerals are transported up the xylem vessels in plants

Animation 10.5

Historical note

Are living cells required for water transport?

In 1890, Eduard Strasburger carried out an experiment to study water transport in plants. He put the lower end of a plant in a poisonous solution. The solution killed all the living cells in its way when it was transported up the stem. Strasburger found that the plant could still take up the solution for several weeks. He concluded that living cells were not required for the transport of water in the stem.

Fig 10.21 Eduard Strasburger (1844–1912)

Practical 10.9 Identifying the vascular tissue in the stem responsible for water transport

Procedure

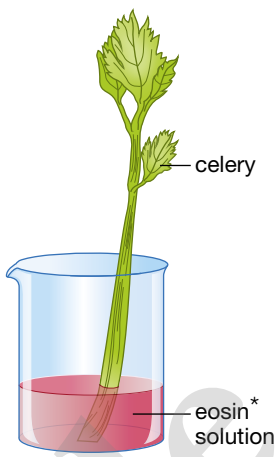
1 Cut off the end of the stem of a herbaceous plant (e.g. celery*, Chinese white cabbage*, flowering Chinese cabbage*) under water.

2 Put the cut end of the stem into an eosin (a red dye) solution or coloured water. Leave the set-up in a well-ventilated and bright environment for about 30 minutes. This can speed up the uptake of water by the plant.

3 Take out the plant and cut across the upper part of the stem.

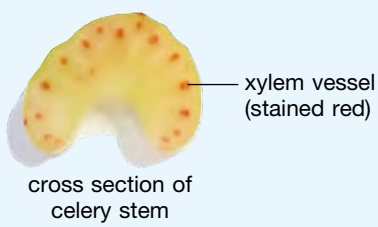
4 Observe the cut end with a hand lens. Identify the tissue that is stained red.

Practical 10.9



Results and discussion

The parts stained red are responsible for transporting water in the plant. They are xylem vessels. They are located at the periphery of the stem.



STEM DIY

Rainbow flowers

Do you like the rainbow flower on the right? The colour of the flower is not natural. It is made by putting the flower stalk in different coloured solutions for a period of time. Watch the video below and then make one by yourself.

https://www.youtube.com/watch?v=WiX32dXmuOY

Fig 10.22 A rainbow rose

提升學習動機

STEM 動手做 STEM DIY 新增

★ 提供創意活動，讓學生利用簡單材料，做出與生物學相關的小製品
★ 另備工作紙

celery 芹菜　Chinese white cabbage 大白菜　eosin 曙紅　flowering Chinese cabbage 菜心

DSE
16(IA)Q22

D Translocation of organic nutrients in plants

Organic nutrients (e.g. sugars and amino acids) are synthesized in the leaves by photosynthesis. They are transported by **phloem** to other parts of the plant where they are used or stored (Fig 10.23). The transport of organic nutrients in plants is called **translocation***.

Unlike the transport of water which is a passive process, translocation is an **active process** (i.e. **requires energy**). However, the exact mechanism of translocation is still unknown today.

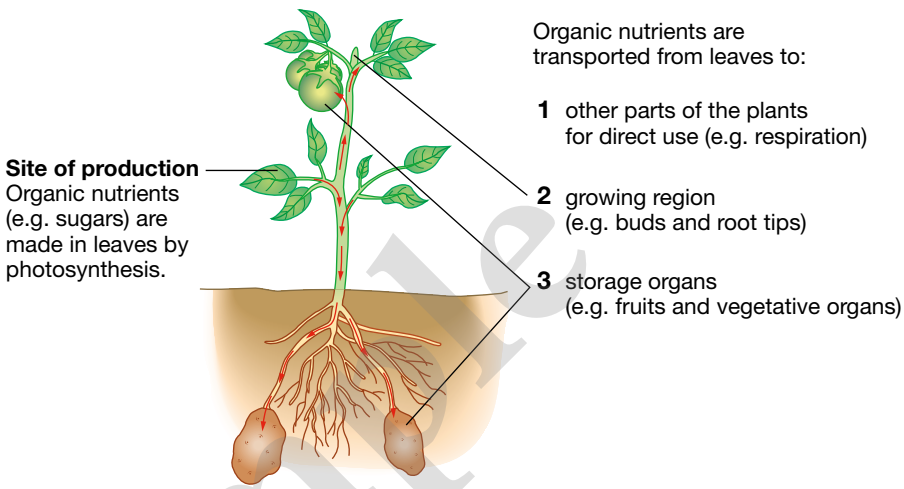


Fig 10.23 Translocation of organic nutrients in plants

Historical note

Discovery of the role of phloem

In 1679, Marcello Malpighi did an investigation by removing a ring of bark (containing phloem) from a tree. After a few weeks, a swelling occurred above the ring. Malpighi suggested that the ring stopped nutrients from moving down the stem and the accumulation of nutrients above the ring caused the swelling (Fig 10.24).

Based on Malpighi's findings, other scientists did further investigations. They found that phloem was the tissue responsible for the transport of nutrients and the nutrients were mainly sugars.

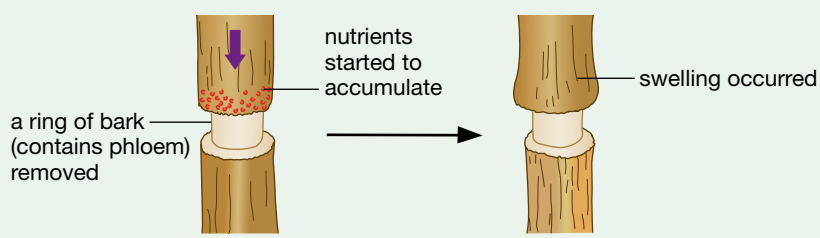


Fig 10.24 Ringing experiment by Malpighi

緊貼DSE趨勢

科學本質 NOS ideas

★ 配合「歷史點滴 Historical note」的內容，列出相關的**科學本質概念**，有助學生作答 DSE 考試中的科學本質題

NOS ideas

Malpighi's investigation demonstrates that:

- Science is a process of ongoing inquiries.
- Scientists build on the work of other scientists.
- Science is based on both observations and inferences.

translocation 輸導

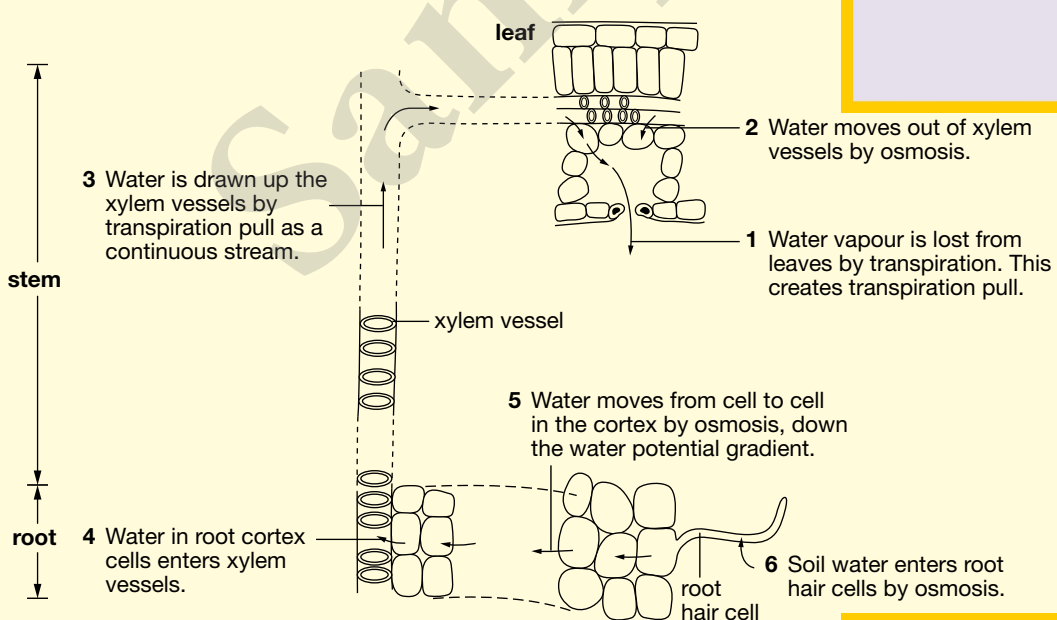
Key learning

1 *What are the differences between xylem and phloem? How are they adapted for transporting substances in plants?*

Xylem	Phloem
It mainly consists of xylem vessels.	It mainly consists of sieve tubes and companion cells.
Xylem vessels are made up of dead cells.	Sieve tubes are made up of living cells.
There are no end walls between cells. This creates a long continuous tube for water transport.	The sieve plates between cells have pores. This allows organic nutrients to pass through.
There is no cell content in the xylem vessels. This allows water to flow freely from one cell to another.	The sieve tubes contain little cytoplasm and no nucleus. This allows organic nutrients to move along with little resistance.
Cells walls are thick and lignified. This prevents the vessels from collapsing.	Cells walls of phloem are not as thick as that of xylem.

2 *How are water and minerals transported in flowering plants?*

- Water, together with dissolved minerals, is transported in xylem from the plant. It is driven by transpiration pull. Below is the pathway of the whole plant.



3 *How are organic nutrients transported in flowering plants?*

- Organic nutrients are transported in phloem from leaves to other par storage. This process is called translocation.

促進概念理解

比較表 Comparison table

★ 加入**大量比較表**,幫助學生比較相似結構或過程的異同

促進概念理解

概念整合圖 Integrated diagram

★ 加入**更多概念整合圖**，幫助學生整合生物學概念（例如上圖可幫助學生概括蒸騰、轉運和吸收的過程）

提升答題技巧

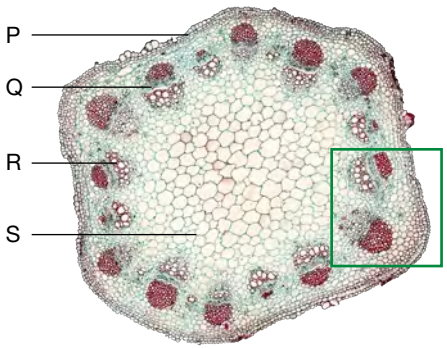
例題解說 Learning through examples

★ 例題全面更新，緊貼 DSE 趨勢（例如 2014 年 DSE 考核生物繪圖的技巧）

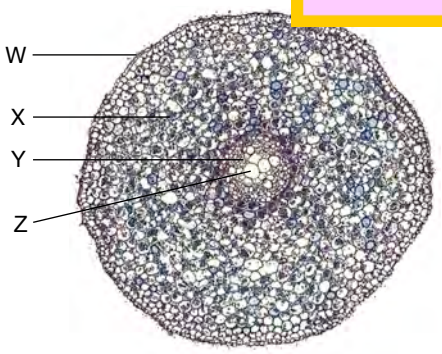
Learning through examples

Skill builder Skill pract

The photomicrographs below show the transverse sections of two different pa
dicotyledonous plant.



Transverse section of Part I (×10)



Transverse section of Part II (×30)

a Draw a labelled low-power diagram of the area bounded by the green box of part I. (5 marks)

b What are parts I and II? (2 marks)

c Which of the tissues (P to S and W to Z) are responsible for the transport of:

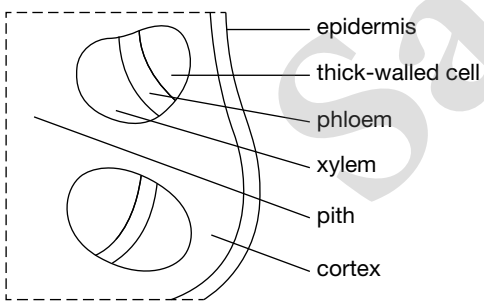
i water? (2 marks)

ii sugars? (2 marks)

d If iodine solution is added to the section of part II, which labelled tissue(s) will turn dark blue? Explain your answer. (2 marks)

Suggested answers

a



Part I of a dicotyledonous plant (T. S.) (×10)

Correct title 1

Resemblance of drawing 1

Correct labels (any three) 3

b Part I: stem; Part II: root 2

c **i** Tissues R and Z 2

ii Tissues Q and Y 2

d Tissue X will turn dark blue 1

because it contains starch. 1

Skill builder

Drawing low-power biological diagrams

Refer to p. 33.

Online tutorial 10.1

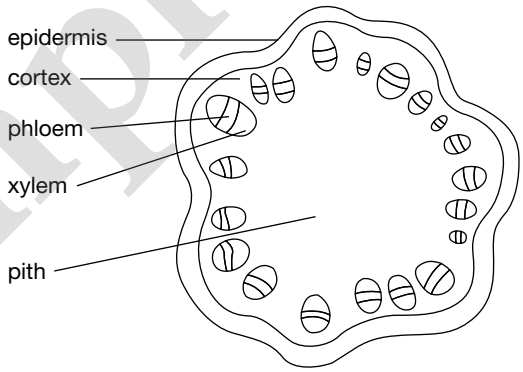
Learning through examples **Skill builder** Skill practi

Drawing low-power biological diagrams

Low-power diagrams aim at showing the distribution and proportion of diffe
outlines of structures are drawn. Note the following when drawing low-pow

- Use a **sharp HB pencil** for the drawing, the labels and the title.
- Draw with **single** and **continuous lines**. Make sure that the different parts are **in proportion**.
- **Do not shade** structures.
- **Draw freehand**. Do not use a ruler or a pair of compasses.
- The drawing should resemble the specimen. Do not copy diagrams from books.
- Put labels on the sides using **straight labelling lines**. The lines must **not cross** one another.
- Write a **title** below the diagram. This should include the **name of the specimen** and the **power of magnification**.
- State how the section is cut if you are drawing a cut surface of a specimen, such as longitudinal section (L.S.) or transverse section (T.S.).

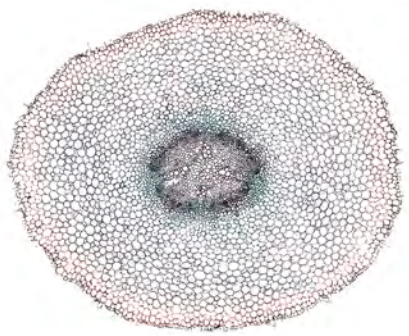
Photomicrograph of a dicot stem (T.S.) (×10)



A dicot stem (T.S.) (×10)

Learning through examples Skill builder **Skill practice**

The photomicrograph on the right shows the transverse section of a dicot root. Draw a labelled low-power diagram of it.
(6 marks)



Photomicrograph of a dicot root (T.S.) (×30)

Check your answers

緊貼DSE趨勢

測試站 Checkpoint

★ 加設更多DSE 題型, 如**配對題**和**顯微照片題**

Checkpoint

Level 1

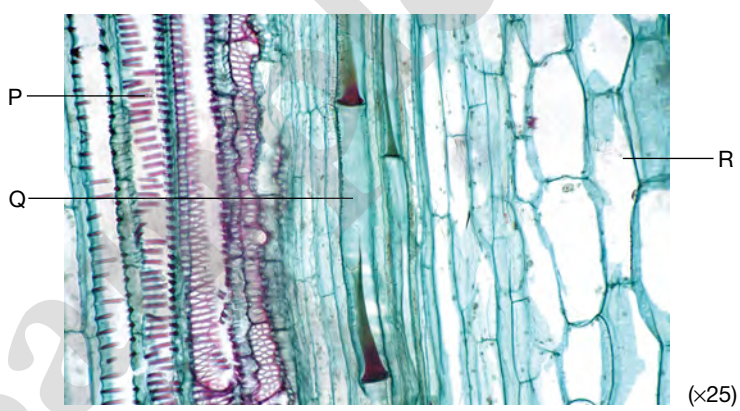
1 For each of the tissues listed in column 1, select from column 2 one phrase that matches it. Put the appropriate letter in the space provided. (3 marks)

Column 1		***Column 2***
Xylem vessel	_____	**A** Has a nucleus
Sieve tube	_____	**B** Carries out photosynthesis
Companion cell	_____	**C** Non-living
		D Has a plate between cells

p. 24, 25

Level 2

Directions: Questions **2** and **3** refer to the photomicrograph below, which shows the longitudinal section of a part of a dicot stem.



(×25)

2 Which of the following combinations about the functions of cell types P, Q and R is correct?

	P	**Q**	**R**
A	water transport	sugar transport	food storage
B	water transport	sugar transport	protection
C	sugar transport	water transport	food storage
D	sugar transport	protection	food production

p. 24–26

3 Compared with cell type R, cell type Q contains

(1) more mitochondria.
(2) less starch.
(3) more sugars.

A (1) and (2) only
B (1) and (3) only
C (2) and (3) only
D (1), (2) and (3)

p. 25

DSE
12(IB)Q3b, 14(IB)Q4, 16(IA)Q21, 17(IA)Q17

10.4 Support in plants

Terrestrial plants usually stand upright and stretch out their branches. This enables:

- the **leaves** to be held in the best position to **receive the maximum amount of sunlight** for photosynthesis
- the **flowers** to be lifted up, **facilitating pollination**
- the **fruits** and **seeds** to be lifted up, **facilitating** their **dispersal**.

Support* in plants is mainly provided by the **turgidity of thin-walled cells** and the **rigidity of thick-walled cells**.

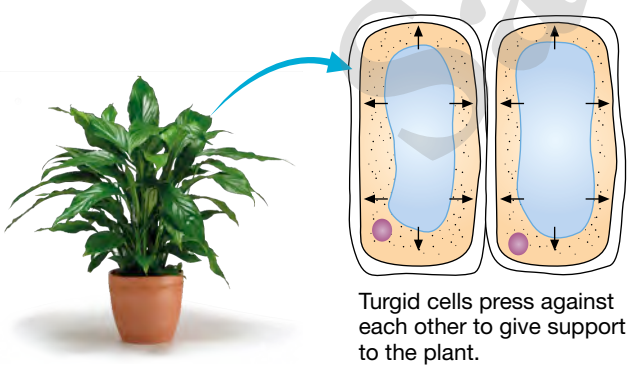
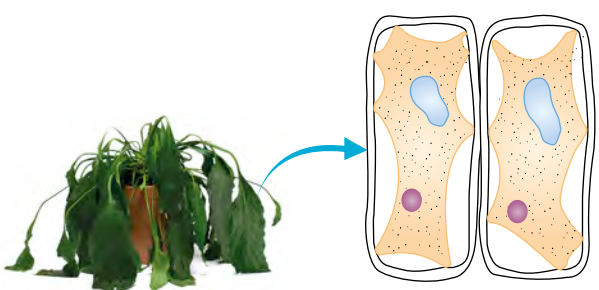
促進概念理解

內容編排 Content organization

★ 課文在適當位置會以點列或表格形式展示，務求學生能快速掌握重點

A Turgidity of thin-walled cells

Leaves, **herbaceous stems** and other **non-woody** plant parts have a large proportion of **thin-walled cells** (e.g. mesophyll cells in leaves, cells in the cortex and pith of stems). The thin-walled cells are closely packed. Their **turgidity** provides support to the plant (see table below).

Adequate water supply	Inadequate water supply
 Turgid cells press against each other to give support to the plant.	 Flaccid cells give no support to the plant.
When water supply is adequate, thin-walled cells in the stems and leaves **gain water** by **osmosis**. The cells become **turgid** and press against each other. The turgidity of the cells makes the whole stem strong enough to **stand upright**.	When water supply is inadequate, thin-walled cells in the stems and leaves **lose water** (as rate of transpiration is higher than rate of water uptake). The cells become **flaccid** and can no longer support the plant. The plant **wilts**. If the plant can take up enough water shortly, the cells will become turgid and the plant will stand upright again.

support 支持

B Rigidity of thick-walled cells

Xylem vessels and the tissue outside each vascular bundle in young dicot stems consist of **thick-walled cells** (Fig 10.25). Their cell walls contain **lignin**, which makes the cells **hard** and **rigid**. The rigidity of these cells helps support the plant.

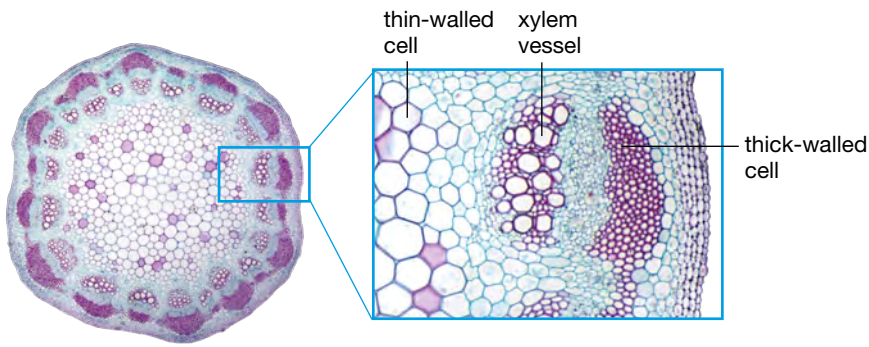


Fig 10.25 Young dicot stem (T.S.) (×100)

In **woody stems**, **more xylem** is formed when the plant grows. The older xylem is pushed inwards by the newly formed xylem (Fig 10.26). More lignin is deposited in the cell walls of the older xylem which finally becomes **wood**. The wood provides great support to the plant.

Cross-link
The growth of xylem in woody stems leads to the formation of annual rings*. This will be discussed in ***Bk 2, Ch 14***.

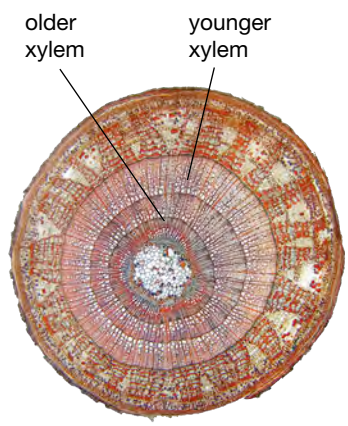


Fig 10.26 Woody stem (T.S.) (×25)

促進概念理解

概念連繫 Cross-link 新增

★ 幫助學生把不同課題的概念連繫起來

Extended learning

Root anchorage

Besides standing upright, terrestrial plants also need to anchor to the ground firmly. This is achieved by the extensive growth of roots under the ground. Moreover, xylem vessels are located at the centre in the root. This increases the tensile strength* to resist the uprooting force produced by the pulling effect of wind.

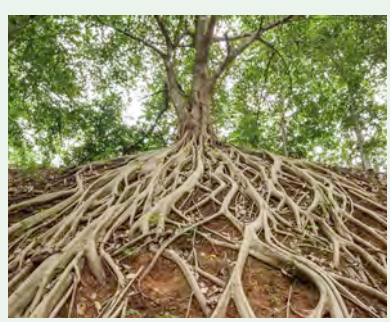


Fig 10.27 Roots help anchor the tree to the ground

annual ring 年輪　　tensile strength 拉伸強度

Key learning

How are plants supported?

Plant parts	Major means of support
Leaves, herbaceous stems and other non-woody plant parts	By the turgidity of thin-walled cells (e.g. mesophyll cells in leaves, cells in cortex and pith in stems)
Woody stems	By the rigidity of thick-walled cells (e.g. xylem vessels)

Checkpoint

Directions: Questions **1** and **2** refer to the photographs below, which show the appearance of a potted plant at 10:00 am and 2:00 pm on a hot sunny day.

10:00 am 2:00 pm

Level 1

1 Which of the following tissues give(s) support to the leaves of the plant at 10:00 am?

(1) xylem vessels
(2) mesophyll
(3) epidermis

A (2) only
B (1) and (2) only
C (1) and (3) only
D (1), (2) and (3)

p. 35, 36

Level 2

2 Which of the following may account for the appearance of the plant at 2:00 pm?

A The rate of photosynthesis is higher than the rate of respiration.
B The rate of transpiration is higher than the rate of water uptake.
C The xylem vessels in the plants become flaccid.
D All the stomata in the leaves are closed.

p. 35, 36

促進概念理解

新增內容 New content

★ 加入更多**跨課題內容**，學生可透過比較來理解不同生物學概念的關係

10.5 Comparison of transport in humans and flowering plants

We have learnt the structure of the transport system and the mechanism of transport in both humans (***Ch 8***) and flowering plants. The table below gives a brief comparison between them.

Key learning

What are the similarities and differences between the structure of the transport system and the mechanism of transport in humans and flowering plants?

		Humans	Flowering plants
Structure of transport system	Similarities	Two systems of vessels are involved. In humans: blood vessels and lymph vessels In plants: xylem and phloem	
	Differences	The lymph vessels join the veins near the neck.	Xylem and phloem are completely separated.
		Both blood vessels and lymph vessels consist of living cells.	Xylem consists of dead cells. Phloem consists of living cells.
		The diameter of blood vessels and lymph vessels can be changed.	The diameter of xylem vessels and sieve tubes are fixed.
		Valves are present in veins and lymph vessels.	Sieve plates are present in sieve tubes.
Mechanism of transport	Similarities	A driving force is provided to move substances along the vessels.	
	Differences	The heart actively pumps blood around the body.	No special organ is developed to generate a driving force. Water is transported in xylem vessels mainly by transpiration pull.
		The elastic walls of arteries recoil to help move blood forward.	The walls of xylem vessels and sieve tubes are inelastic and cannot recoil.
		Valves are present in veins and lymph vessels to prevent backflow of blood and lymph.	No special structures in xylem and phloem to prevent backflow of fluid.
		Contraction of skeletal muscles surrounding the veins and lymph vessels squeeze blood and lymph forward.	No contraction of tissues in plants.

促進概念理解

比較表 Comparison table

★ 加入**大量比較表**,幫助學生比較相似結構或過程的異同

Skill builder

Answering essay questions

Sometimes we are asked to answer a question by writing a short essay. In the essay, we should express our ideas in a clear and logical manner. Below are some tips for writing an essay.

Step 1 **Understanding the question**

To help understand the question, underline the key points and circle the command words (e.g. compare, explain, etc.) in the question.

Example:

Compare the structure of the transport system and the mechanism of transport in humans and flowering plant

Step 2 **Organizing our ideas**

Use a mind map, a flow chart or a table to organize our ideas. The table

Step 3 **Writing the essay**

The essay can be divided into three parts:

1 Introduction
Briefly describe the main theme of the essay. Avoid too much background information.

Humans and flowering plants both have a transport system. The structure of their transport system and the mechanism of transport are unique but they are similar in some ways.

2 Body
Write in paragraphs. Each paragraph should have a main point and the point is explained and elaborated.

Both humans and flowering plants have two systems of vessels, i.e. blood vessels and lymph vessels in humans, and xylem and phloem in plants. However, the lymph vessels join the veins near the neck while xylem and phloem are completely separated. Vessels in humans consist of living cells but in plants, xylem consists of dead cells and phloem consists of living cells. Moreover, the diameter of vessels in humans can be changed but that in plants is fixed.

In both humans and plants, a driving force is provided to move substances along vessels. In humans, the heart actively pumps blood around the body. Moreover, the elastic walls of arteries recoil to help move blood forward. Valves are present in veins and lymph vessels to prevent backflow of blood and lymph. Contraction of skeletal muscles helps squeeze blood and lymph towards the heart. In plants, the transport of water is driven by the transpiration pull. There is no special structure to push fluid forward or prevent its backflow.

3 Conclusion
Sum up the points and restate the main theme.

Although the transport systems in humans and plants are somewhat different, they play an important role in carrying useful substances to different parts of the body.

提升答題技巧

技巧教室 Skill builder 新增

★ 講解學生作答論述題的策略

STEM Project

Self-irrigation system

Problem

Mary will take a trip for one week. She is worrying about her lovely potted plants.

Can you help Mary design and make a self-irrigation system using simple

提升學習動機

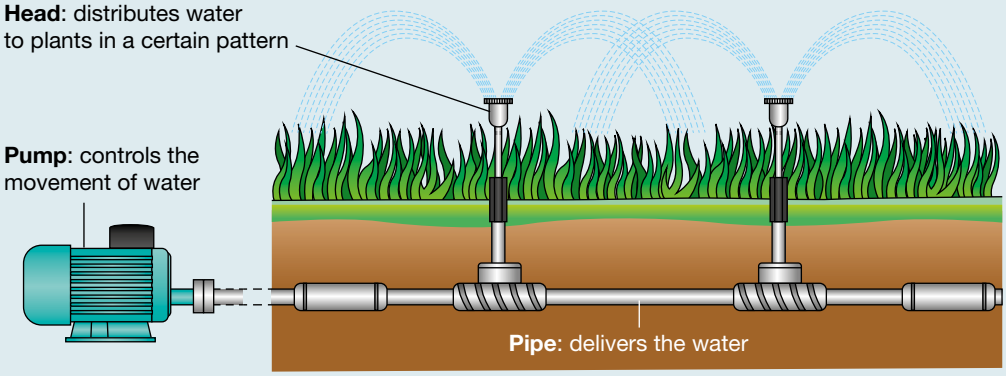
STEM 專題活動 STEM project

新增

- ★ 專題活動讓學生應用跨學科知識，設計物品以解決生活難題
- ★ 附詳盡的活動指引
- ★ 另備工作紙

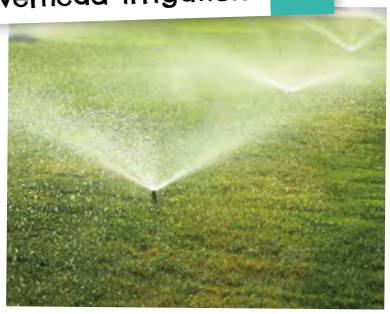
Research

Irrigation systems have been developed for thousands of years. They move water from a source (e.g. rivers and lakes) to where it is needed. The basic parts of an irrigation system are shown below.



There are many different types of irrigation systems. Below are some of them.

Overhead irrigation



Water is sprayed into the air through sprinklers. It is similar to natural rainfall.

Drip irrigation

Drops of water are delivered at or near the root of plants.

Surface irrigation

Water is distributed over the soil surface by gravity. No mechanical pump is needed.

Search for more information about irrigation. Below is a useful website.
https://www.cdc.gov/healthywater/other/agricultural/types.html

Design

Design a self-irrigation system to solve Mary's problem with reference to the suggested materials and guiding questions below. Show your plan to your teacher. After getting approval from your teacher, **make a model** according to your plan.

Plastic tubing (3 m)	1	Pin	1	Adhesive tape
Large plastic bottle	1	Scissors	1	Blu-tack
Plastic tray	1	Water		

Guiding questions

1 How can water be carried to plants in different places without using a pump?

2 How can you make sure plants in different places get the same amount of water?

3 How can you control the amount of water supplied to the plants?

Test

Test your model and evaluate the result.

1 Can water in the source be carried to different places? ☐ Yes ☐ No

2 Is the amount of water distributed appropriate? ☐ Yes ☐ No

3 Can different places get the same amount of water from the source? ☐ Yes ☐ No

4 Can the system work automatically for one week? ☐ Yes ☐ No

Improve

Compare your system with those of other groups. Which group got the best result? What are the special features of their system? Modify your system and test again.

Recall *'Think about...'* (p. 1)

1 Roots absorb water and minerals from the soil. They also anchor the plant to the ground.

2 The concrete shell restricts the growth of roots. It also hinders gas exchange in the roots. These cause the roots to grow poorly and the roots can no longer anchor the trees firmly to the ground. As a result, the trees collapse easily in strong winds.

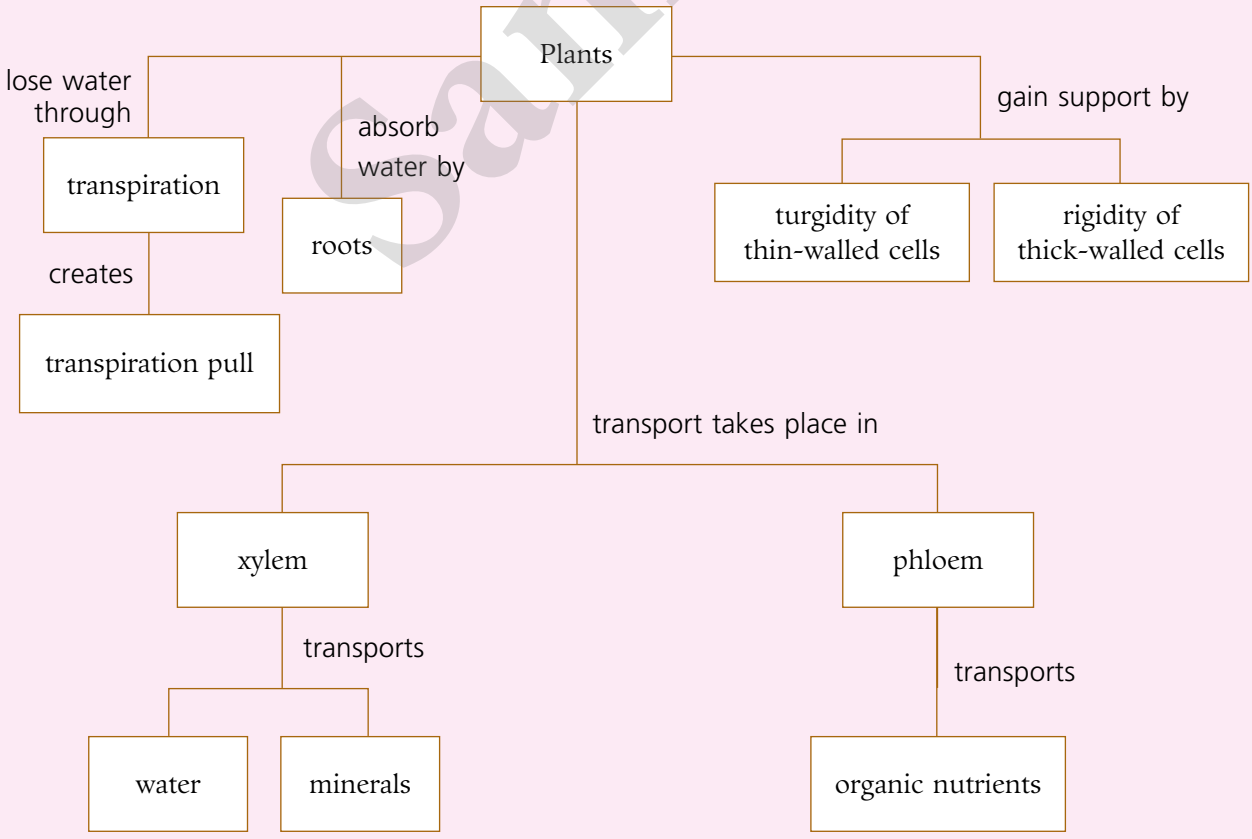
Suggested answers to ?

p. 14 Some other factors limit the rate of transpiration.

Key terms

1 companion cell 伴細胞
2 cortex 皮層
3 lignin 木質素
4 phloem 韌皮部
5 pith 髓
6 potometer 蒸騰計
7 root cap 根冠
8 root hair 根毛
9 sieve plate 篩板
10 sieve tube 篩管
11 stoma 氣孔
12 translocation 輸導
13 transpiration 蒸騰
14 transpiration pull 蒸騰拉力
15 vascular bundle 維管束
16 vascular tissue 維管組織
17 xylem 木質部
18 xylem vessel 木質導管

Concept map



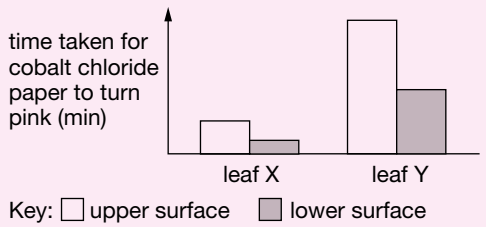
Exercise

Section 10.1

Level 1

MC

1 Dry cobalt chloride papers of the same size were stuck onto the upper and lower surfaces of two leaves. The graph below shows the time taken for the paper to turn pink.



Which leaf surface has more stomata?

A upper surface of leaf X
B lower surface of leaf X
C upper surface of leaf Y
D lower surface of leaf Y

p. 9

DSE Bio 2015 IA Q17, 18

多元評估 鞏固所學

練習 Exercise

- ★ 新增大量題目
- ★ 題目按課節分類，方便安排家課
- ★ 分為程度 1-3，照顧學習差異
- ★ 涵蓋至 DSE 2019 最新試題

（題目因版權關係而無法顯示，請參看樣書）

MC

3

（題目因版權關係而無法顯示，請參看樣書）

MC

4 DSE Bio 2014 IA Q22

（題目因版權關係而無法顯示，請參看樣書）

Level 2

DSE Bio 2012 IA Q10, 11

（題目因版權關係而無法顯示，請參看樣書）

MC
6

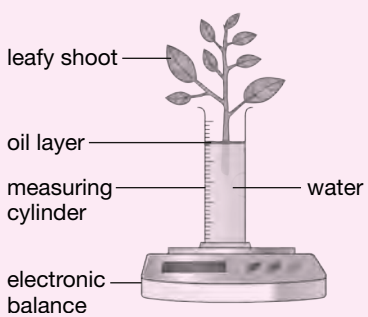
（題目因版權關係而無法顯示，請參看樣書）

DSE Bio 2014 IA Q20, 21

（題目因版權關係而無法顯示，請參看樣書）

（題目因版權關係而無法顯示，請參看樣書）

9 The diagram below shows a weight potometer used to study the transpiration of a leafy shoot.



The leafy shoot was left in the laboratory for 4 hours. The table below shows the results.

Change in reading of the balance (g)	1.5
Change in reading of the measuring cylinder (cm^3)	2

a What can be deduced from the difference between the readings of the balance and the measuring cylinder? Explain the significance of this difference to the growth of the plant. (3 marks)

b If the experiment was repeated with all the leaves of the shoot removed. How would the results be different? Why? (3 marks)

⬅ p. 3, 16

10 DSE Bio 2013 IB Q6

（題目因版權關係而無法顯示，請參看樣書）

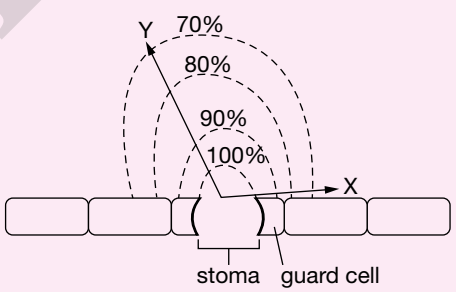
Level 3

MC

11 DSE Bio 2012 IA Q12

（題目因版權關係而無法顯示，請參看樣書）

12 The diagram below shows the percentage saturation of air with water vapour near a stoma.



a The cell wall of the guard cells has uneven thickness. How does this feature relate to the function of the guard cells? (4 marks)

b In which direction, X or Y, does water vapour diffuse faster out of the leaf? Explain your answer. (3 marks)

⬅ p. 4, 6

13 DSE CS Sample paper B Q9

（題目因版權關係而無法顯示，請參看樣書）

Section 10.2

Level 1

MC

14 Which of the following correctly matches the structures in the plant roots with their functions?

	Structure	*Function*
A	epidermis	protects inner cells
B	cortex	absorbs minerals from soil
C	xylem	absorbs water from soil
D	phloem	transports minerals to leaves

⬅ p. 19

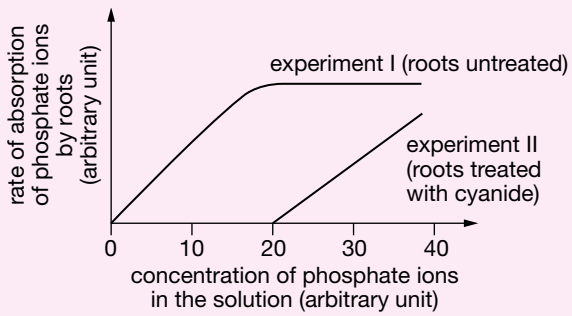
Level 2

MC

15 DSE Bio 2014 IA Q23

（題目因版權關係而無法顯示，請參看樣書）

16 A scientist put the roots of plants in solutions with different concentrations of phosphate ions. The rate of absorption of phosphate ions by the roots was measured. He repeated the experiment by using roots treated with cyanide. Cyanide is a chemical that can inhibit respiration. The graph below shows the results of the two experiments.



a Describe the results of experiments I and II when the concentration of phosphate ions in the solution is below 20 arbitrary units. (2 marks)

b Account for the difference in the results of experiments I and II mentioned in your answer to **a**. (4 marks)

c Explain the shape of the curve in experiment I when the concentration of phosphate ions in the solution is higher than 20 arbitrary units. (2 marks)

⬅ p. 21

Section 10.3

Level 1

MC

17 DSE Bio 2012 IA Q3

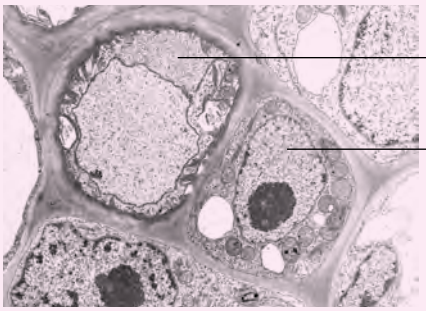
（題目因版權關係而無法顯示，請參看樣書）

MC

18 DSE Bio 2019 IA Q32

（題目因版權關係而無法顯示，請參看樣書）

19 The electron micrograph below shows part of the transverse section of a phloem tissue.



a Identify cells X and Y. Give reasons for your identification. (3 marks)

b State the roles of cells X and Y. (2 marks)

⬅ p. 25

Level 2

DSE Bio 2017 IA Q14–16

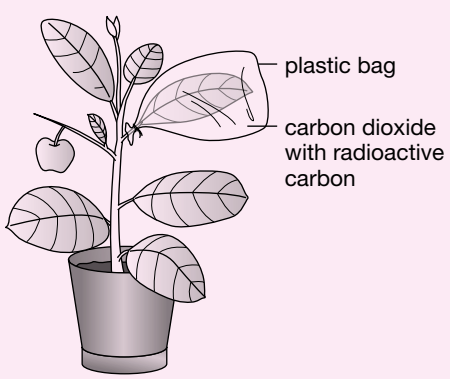
（題目因版權關係而無法顯示，請參看樣書）

（題目因版權關係而無法顯示，請參看樣書）

（題目因版權關係而無法顯示，請參看樣書）

（題目因版權關係而無法顯示，請參看樣書）

23 The diagram below shows a potted plant. One of its leaves was enclosed in a plastic bag containing carbon dioxide with radioactive carbon. The plant was put under sunlight for two hours. Then, the radioactivity in different parts of the plant was measured. The table on the opposite page shows the results.



Plant part	Radioactivity (arbitrary unit)
Shoot tip	1250
Fruit	8930
Root	900

a Why is radioactivity detected in the shoot tip, fruit and root of the plant? (2 marks)

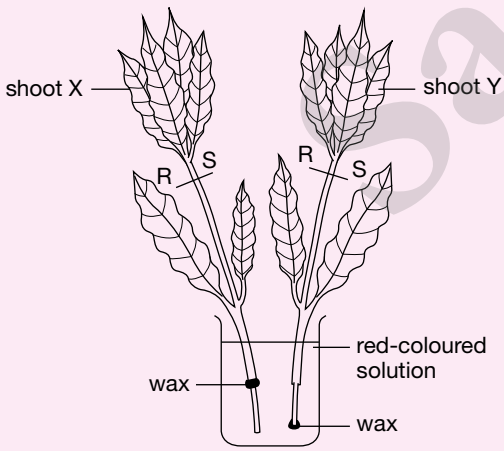
b How does the experiment show that the translocation of organic food in the plant is bidirectional? (1 mark)

c Both the shoot tip and the fruit require a larger amount of organic food for growth. However, the radioactivity in the shoot tip is much lower than that of the fruit. Suggest a reason for this difference. (2 marks)

p. 30

Level 3

Directions: Questions **24** and **25** refer to the diagram below, which shows two woody shoots. A ring of bark was removed from the stems and wax was applied to the stems at different positions. The ends of both shoots were put in a red-coloured solution for one hour.



MC

24 Which of the following would be observed at the end of the experiment?

A The stem in X would become swollen.
B The leaves in X would remain upright.
C The stem in Y would bend.
D The leaves in Y would turn red.

p. 28, 30

MC

25 Stems of both X and Y were cut across at RS. Which of the following can be observed in their cut surfaces?

A X:  Y:  Key: ■ stained red

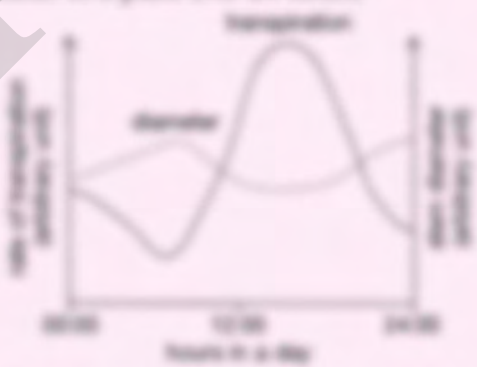
B X:  Y: 

C X:  Y: 

D X:  Y: 

p. 26

26 DSE Bio 2019 IB Q10

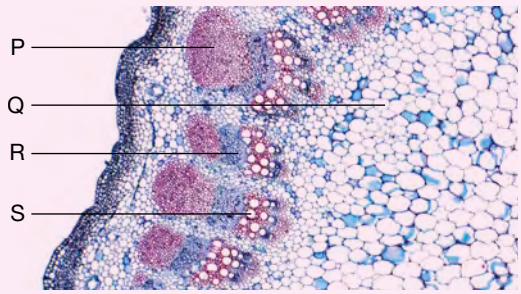


（題目因版權關係而無法顯示，請參看樣書）

Section 10.4

Level 1

Directions: Questions **27** and **28** refer to the photomicrograph below, which shows the cross section of a part of a dicotyledonous stem.



MC

27 Which of the following comparisons between the cells in parts R and S is correct?

	Cells in R	*Cells in S*
A	does not contain water	contains water
B	contains minerals	does not contains minerals
C	does not carry out photosynthesis	carries out photosynthesis
D	carries out respiration	does not carry out respiration

⬅ p. 24–26

MC

28 Cells in which of the following parts provide support to the plant?

A P and R only **B** Q and S only
C P, Q and S only **D** P, Q, R and S

⬅ p. 35, 36

Level 2

MC

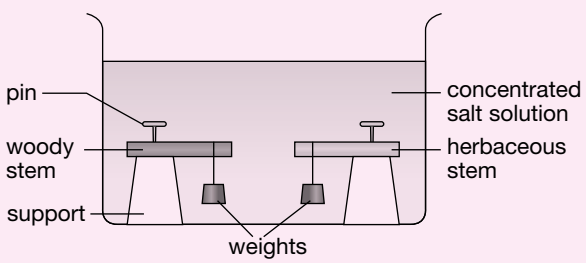
29 **DSE Bio 2017 IA Q17**

（題目因版權關係而無法顯示，請參看樣書）

30 **DSE Bio 2012 IB Q3**

（題目因版權關係而無法顯示，請參看樣書）

31 The diagram below shows two stem tissues obtained from a herbaceous plant and a woody plant. The stems were immersed in a concentrated salt solution.



a Suggest the appearance of the stems after 24 hours. (2 marks)

b Explain your answer in **a**. (5 marks)

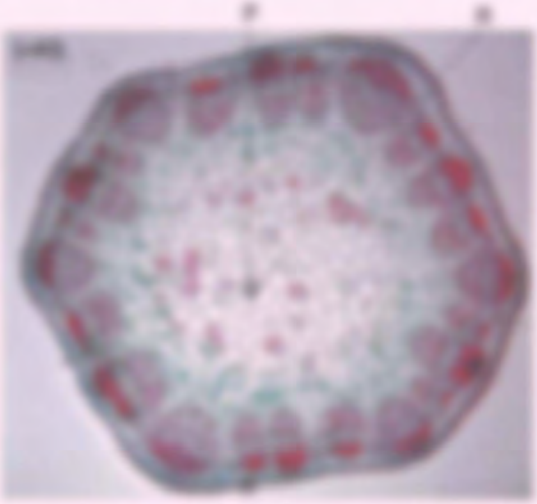
c If the experiment was repeated using distilled water instead of concentrated salt solution, what will happen to the appearance of the stems? Explain your answer. (2 marks)

⬅ p. 35, 36

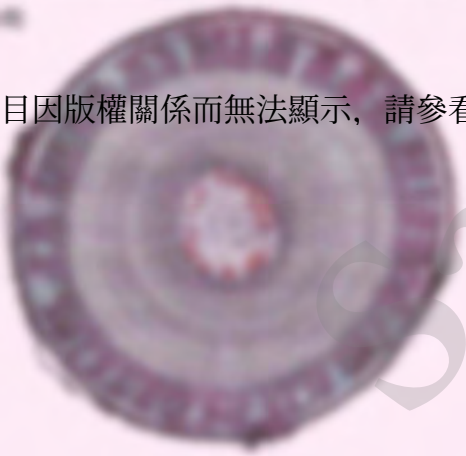
32 DSE Bio 2014 IB Q4

Cross sections of the stems from two different dicotyledonous plants, A and B, are shown in Photomicrograph A and Photomicrograph B.

Photomicrograph A – Stem of plant A



Photomicrograph B – Stem of plant B



（題目因版權關係而無法顯示，請參看樣書）

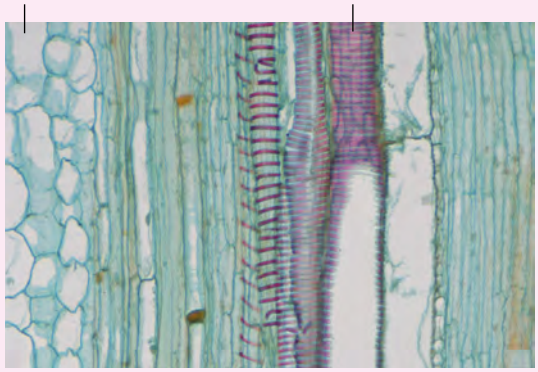
a With reference to Photomicrograph A, draw a labelled low-power diagram of sector PQR. (3 marks)

b With reference to the photomicrographs, deduce the major means of support in plants A and B. (4 marks)

p. 33, 35, 36

Level 3

33 The photomicrograph below shows the longitudinal section of a part of a young stem.



(×25)

a The cell wall of cell type Q is deposited with lignin.

i Suggest the functional significance of the lignified cell wall in cell type Q. (3 marks)

ii The lignin is usually deposited as rings in the young stem. What is the significance of this arrangement to the growth of the young stem? (1 mark)

b Cell type P usually has a relatively low water potential. Suggest why this is important in providing support to the plant. (2 marks)

c A certain fungus can grow inside cell type Q and eventually block the cell. If a plant is infected with this fungus, the leaves above the infected site will become yellow and even wilt. Give a possible reason for this. (4 marks)

Hint (p. 51)

p. 24, 35, 36

Hints

Q26 Tension is created in xylem vessels during transpiration.

Q33 Leaves will become yellow and even wilt if they cannot receive enough minerals and water.

Reading to learn

STEM

Read the article below and answer the questions.

Electronic roses

Can you imagine that the colour of plant leaves can be controlled through electric circuits? A few years ago, a team of scientists successfully created living rose plants with electric circuits inside. The colour of the leaves can be changed by applying an electric current to the plant.

The scientists introduced a conductive substance called PEDOT into the vascular systems of rose plants. They did it by placing cut rose stems into a PEDOT solution. The solution was absorbed by the stems and finally reached the leaves. The PEDOT stayed in the vascular tissues, forming electric circuits in the plant. With further treatment, when an electric current is applied and flows through the leaves, the leaf colour changes.

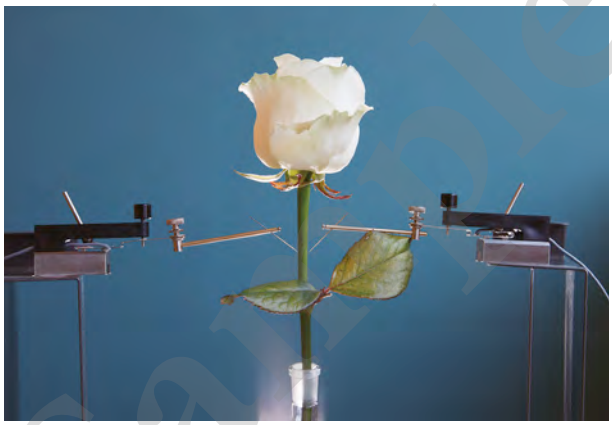


Fig 10.28 Scientists are growing roses with electric circuits in their vascular systems

Changing the leaf colour is not the main purpose of the research. The scientists are exploring potential uses of electronic plants, e.g. making green antennas by building electric circuits in trees, controlling plants to produce useful substances by electric circuits, using photosynthesis to produce energy, etc.

Questions

1 State the vascular tissue through which PEDOT was transported from the stems to the leaves. (1 mark)

2 What feature of the vascular system in plants did the scientists make use of to create electric circuits inside the plant body? (1 mark)

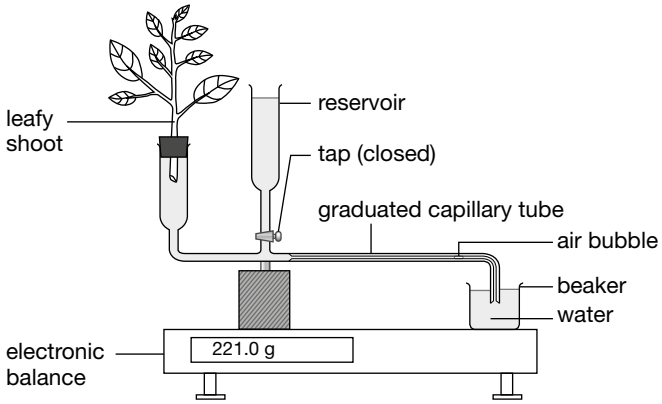
3 The scientists encountered problems when choosing the conductive substance to be introduced into the rose plant. Suggest ***two*** of these problems. (2 marks)

Self test

Time allowed: 15 minutes Total: 10 marks

Section A (1 mark each)

Directions: Questions **1** and **2** refer to the diagram below, which shows a set-up used to measure the water uptake and water loss of a plant.



1 To calculate the rate of transpiration of the plant, we should record

(1) the distance travelled by the air bubble.
(2) the change in the reading of the balance.
(3) the duration of the experiment.

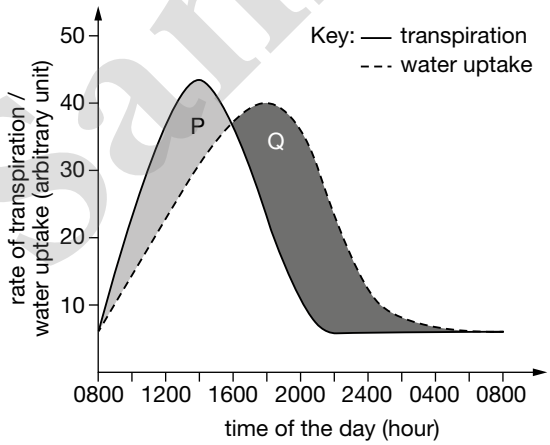
A (1) and (2) only **B** (1) and (3) only
C (2) and (3) only **D** (1), (2) and (3)

2 Which of the following can improve the accuracy in measuring the water uptake of the plant in the above set-up?

A using a capillary tube with a smaller diameter
B using a leafy shoot with more leaves
C covering the set-up with a transparent box
D using a more accurate electronic balance

Section B (8 marks)

3 The graph below shows the rates of transpiration and water uptake of a plant during a 24-hour period.



a Describe and explain the following changes of the plant from 0800 to 1400 hour:

i rate of transpiration (4 marks)

ii rate of water uptake (2 marks)

b Explain why area Q is usually larger than area P in a healthy plant. (2 marks)

Check your answers

Cross-topic exercise 4 (Chapters 1 to 10)

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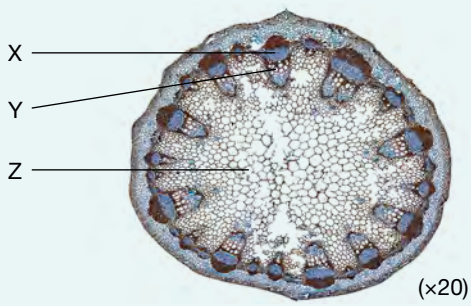
跨課練習 Cross-topic exercise

- ★ 每數章後提供綜合練習，幫助學生整合不同課題的概念，應付DSE 的跨課題試題
- ★ 每題清楚列出涵蓋的課題

Multiple-choice questions

Transport in plants, food tests

Directions: Questions **1** and **2** refer to the photomicrograph below, which shows a cross section of a stem of a dicotyledonous plant:



1 Which of the following correctly identifies parts X, Y and Z?

	X	*Y*	*Z*
A	xylem	phloem	pith
B	phloem	xylem	pith
C	pith	phloem	xylem
D	pith	xylem	phloem

2 Given that sugar is transported in the form of sucrose in this plant. A student collected the content of X and carried out Benedict's test and iodine test on it. Which of the following correctly describes the test results?

	Benedict's test	*Iodine test*
A	no precipitate forms	turns blue-black
B	no precipitate forms	remains brown
C	brick-red precipitate forms	turns blue-black
D	brick-red precipitate forms	remains brown

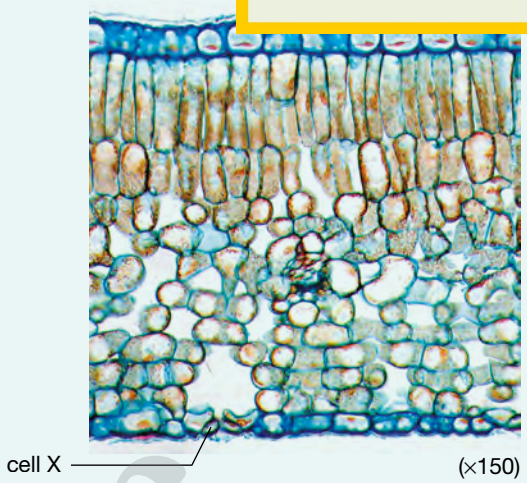
Absorption in plants, active transport, osmosis

3 A plant absorbed less water when an inhibitor of an enzyme involved in respiration was added to it. This is probably because

- **A** the xylem vessels were blocked.
- **B** the root hair cells lost water by osmosis.
- **C** the root hair cells could not absorb minerals from soil by active transport.
- **D** less water was lost by transpiration.

Gas exchange, transpiration

Directions: Questions **4** photomicrograph below a leaf of a woody plant:



4 Which of the following is the main function of cell X?

- **A** for controlling the size of the stoma
- **B** for preventing water loss from the leaf
- **C** for absorbing water from the air
- **D** for protecting the inner layers of cells

5 Which of the following statements about cell X is correct?

- **A** Cell X is also present on the stem of the plant.
- **B** Cell X has a thick cell wall to support the leaf.
- **C** Cell X carries out photosynthesis in the daytime.
- **D** Cell X carries out mitotic cell division to produce new cells.

Gas exchange, human nutrition, transport in plants

6 DSE Bio 2015 IA Q2

（題目因版權關係而無法顯示，請參看樣書）

Gas exchange, transport and support in plants

7 DSE Bio 2018 IA Q24

（題目因版權關係而無法顯示，請參看樣書）

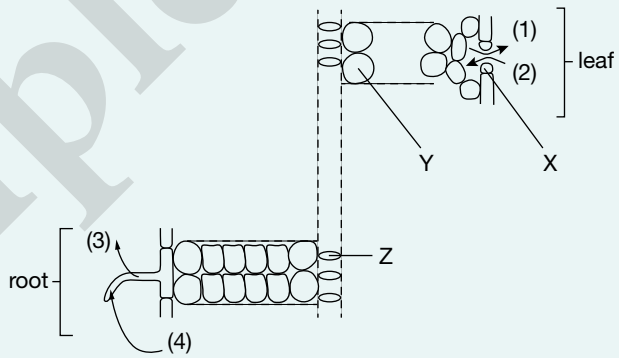
Transport in plants, osmosis

8 It is advised that many chemical fertilizers for plants should only be used every 8 to 10 days. What is the possible consequence if a chemical fertilizer is used too frequently?

A The roots will grow too fast, affecting the growth of other parts of the plant.
B The roots will absorb too much salt, poisoning the plant.
C The roots will lose a large amount of water, causing dehydration of the plant.
D The roots will be damaged by the high concentration of minerals in the fertilizer.

Gas exchange, support in plants

Directions: Questions **9** and **10** refer to the diagram below, which shows a diagrammatic representation of the root and the leaf of a herbaceous plant:



9 Which arrow(s) correctly show(s) the direction of oxygen diffusion in the daytime?

A (2) only
B (4) only
C (1) and (4) only
D (2) and (3) only

10 Which cell types play a role in supporting the plant?

A X and Y only
B X and Z only
C Y and Z only
D X, Y and Z

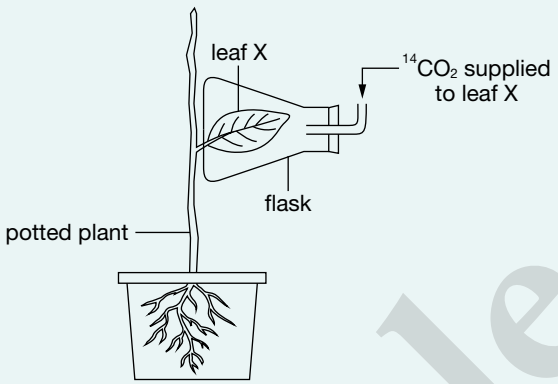
Short questions

Gas exchange in plants and humans

11 Humans have a circulatory system that is very efficient in transporting oxygen to different parts of the body. Flowering plants do not have such a specialized system. However, flowering plants can still survive well. Suggest reasons for this. (5 marks)

Gas exchange, transport in plants

12 Susan carried out an experiment to investigate the translocation in plants. The set-up is shown below:



a Describe the uptake of radioactive carbon dioxide ($^{14}CO_2$) by the cells of leaf X. (2 marks)

b After two hours, the radioactivity at the roots was measured to be 1758 counts/min.

i If the whole set-up had been put in a black box, how would the measured value have been different? Explain briefly. (2 marks)

ii If a ring of bark had been removed from the plant stem before the experiment, how would the measured value have been different? Explain briefly. (2 marks)

Scientific method, transpiration, osmosis

13 **OCR GCSE 2008**

Look at Kate's results.

	Mass at start in g	Mass after 24 hours in g
A	810	760
B	810	760
C	720	720

a Explain the difference between the results for A and B. (2 marks)

b Why did Kate set up flask C? (1 mark)

c Kate repeats the experiment, but in a warmer room.
Here are her results.

	Mass at start in g	Mass after 24 hours in g
A	810	770
B	810	730
C	720	720

Explain the difference between these results and her first set of results. (3 marks)

d The diagram shows a cell from one of the plants.

（題目因版權關係而無法顯示，請參看樣書）

After the experiment, the plants are left until there is no water in the flasks. The diagram below shows the same cell when there is no water left in the flasks.

i What word describes the cell now? (1 mark)

ii What is in the area marked X? (1 mark)

Structured questions

Gas exchange, support in plants

14 **CE Bio 2011 IB Q10b**

（題目因版權關係而無法顯示，請參看樣書）

15 CE Bio 2010 IA Q2

The photomicrographs below show a section of a leaf of a flowering plant and the mammalian lung.

Section of a leaf of a flowering plant

Section of the mammalian lung

（題目因版權關係而無法顯示，請參看樣書）

a State the process by which oxygen enters into air spaces 1 and 2 respectively from the atmosphere at night. (2 marks)

b The table below lists the fate of oxygen after it enters into air spaces 1 and 2. Complete the table by indicating the cell type(s) involved using the letters given in the photomicrographs. (2 marks)

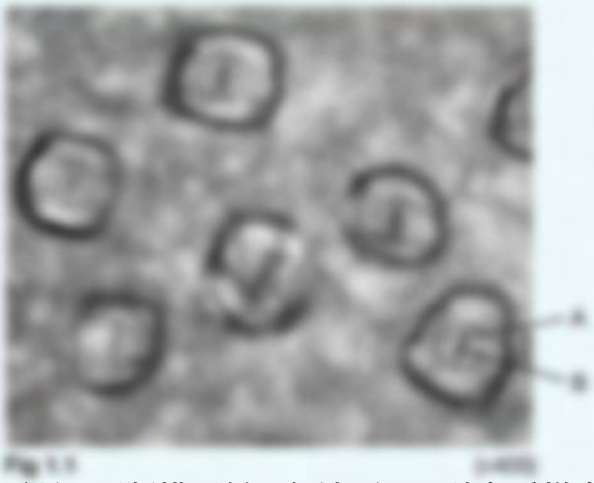
Fate of oxygen	Cell type(s) involved
Absorbed and used in respiration	i
Transported to other parts	ii

c The oxygen concentration in air space 1 in daytime is much higher than that at night. Explain this phenomenon. (3 marks)

d Describe how the loss of water vapour from air space 1 to the atmosphere leads to the movement of water from cell type A to cell type B. (3 marks)

Scientific method, gas exchange in plants

16 **Cambridge O Level Biology 5090 Paper 6 Q1 a–b November 2009**



（題目因版權關係而無法顯示，請參看樣書）

Essays

Absorption of nutrients in humans and plants

17 Both the roots in flowering plants and the small intestine in humans take part in absorption. Compare their roles in absorption and their adaptive features for the process. (10 marks)

Transport in humans and plants

18 The circulatory system in humans and the vascular system in flowering plants play an important role in transport. Compare the structures and transport mechanisms of these two systems. (12 marks)

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點擊 QR 碼

6.4 Digestion

After ingestion, the food is moved along our alimentary canal and [illegible]. Digestion occurs **physically** and **chemically**.

翻轉課堂 Flipped classroom 新增

- ★ 設有生動影片講解生物學概念，鼓勵學生自主學習
- ★ 影片附有中英文字幕
- ★ 備有自動批改練習

p. 6-10

A Physical digestion and chemical digestion

1 Physical digestion

Physical digestion* is the breaking down of food into **smaller pieces** by **physical actions**. It does not change the chemical structure of the food, but it **increases the surface area** of the food for digestive juices to act on.

Fig 6.11 Physical digestion

The resultant food pieces in physical digestion are not yet small enough for absorption. They must be further broken down into small molecules by chemical digestion.

2 Chemical digestion

Chemical digestion* involves **chemical reactions** in which large, complex food molecules are broken down into **small**, **soluble molecules**. The reactions are catalysed by **digestive enzymes***.

Carbohydrases, **lipases** and **proteases** are three main types of digestive enzymes in our digestive system. They break down carbohydrates, lipids and proteins respectively into small soluble molecules that are ready for absorption (Fig 6.12). Small food substances like **water**, **vitamins** and **minerals** do not need chemical digestion and can be absorbed directly.

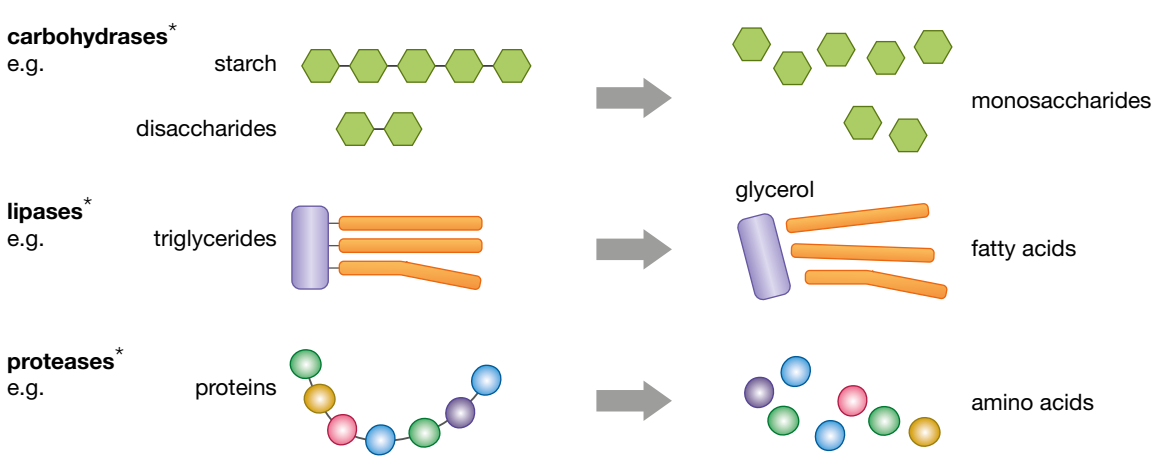
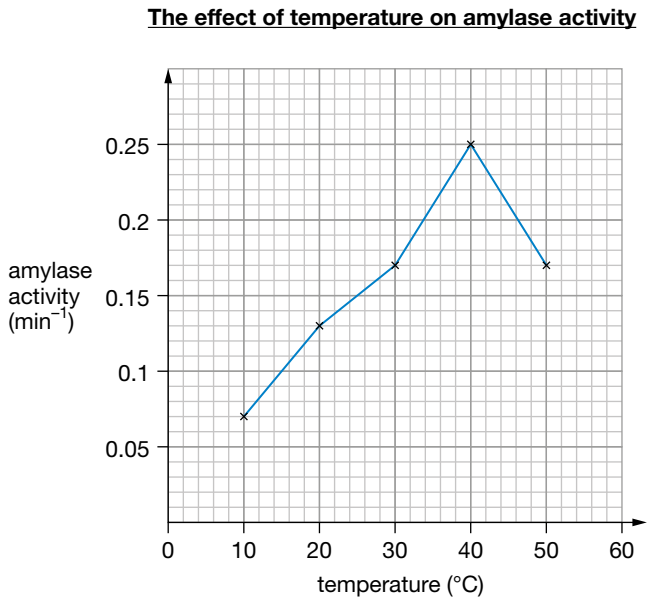


Fig 6.12 Chemical digestion catalysed by carbohydrases, lipases and proteases

carbohydrase 碳水化合物酶　chemical digestion 化學消化　digestive enzyme 消化酶　lipase 脂肪酶
physical digestion 物理消化　protease 蛋白酶



Skill builder

Drawing a line graph

Refer to p. 17.

Online tutorial 4.1

點擊 QR 碼

Learning through examples **Skill builder** Skill practi

Drawing a line graph

A line graph shows the relationship between two variables. Data points, each representing a set of data for two variables, are marked on graph paper. By joining the data points, a clearer trend can be shown. You should always draw your line graph on graph paper.

1 Give a **title** to your graph.

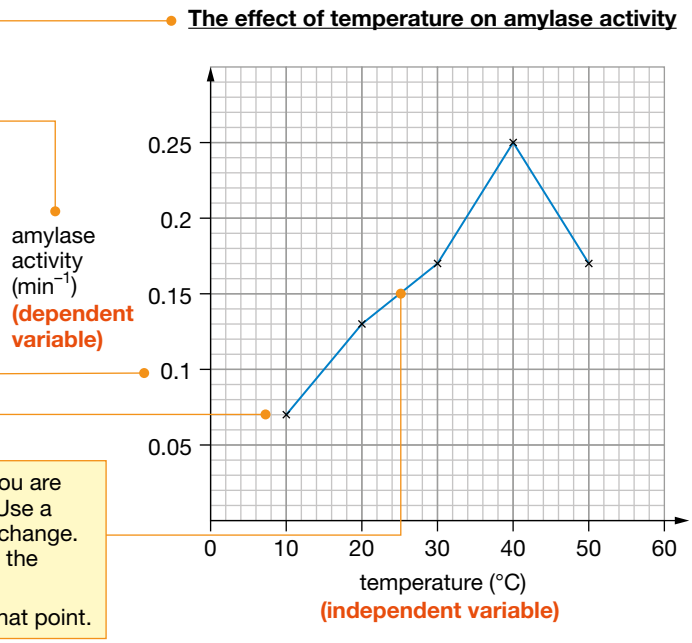
2 Put the **independent variable** on the **x-axis**, and the **dependent variable** on the **y-axis**. Write down the **units**.

3 Use **uniform** scales which cover the entire range of measurements. The plots should cover at least half of the graph paper.

4 Draw a cross (×) to represent each data point.

5 Join the points with **short straight lines** when you are uncertain about the values between the points. Use a **smooth curve** only when you predict a gradual change. Draw a **line of best fit** instead if you expect that the variables have a linear relation.

Don't join the origin if you do not have data for that point.



擴增實境 AR

新增

★ 透視生物結構，了解機理
★ 使用AR卡提高學習趣味，加深印象

點擊 QR 碼

p. 17-18

B Action of opposing muscles

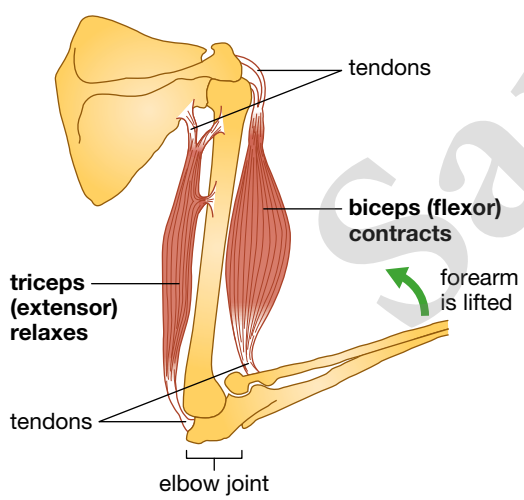
When a muscle contracts, it exerts a pulling force on a bone and moves it in one direction. To move the bone in the opposite direction so that the bone returns to its original position, contraction of another muscle is needed. This means that muscles **work in pairs** and each member of the pair acts in the opposite direction to the other. These muscle pairs are called **opposing muscles*** (or **antagonistic muscles***).

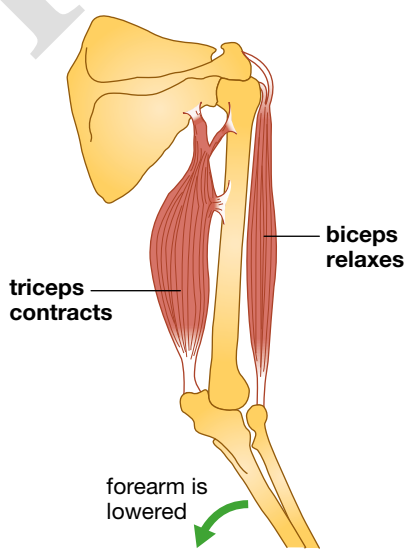
In a pair of opposing muscles, the muscle that **bends** a limb when it contracts is called a **flexor***, while the muscle that **straightens** the same limb when it contracts is called an **extensor***.

Animation 17.1

Below is an example illustrating how the actions of a pair of opposing muscles (**biceps*** and **triceps***) bring about movement of the forearm. In this case, the biceps is the flexor and the triceps is the extensor.

Bending the arm	Straightening the arm
The **biceps contracts** and the **triceps relaxes** to **bend the arm** at the elbow joint (i.e. the forearm is lifted).	The **triceps contracts** and the **biceps relaxes** to **straighten the arm** at the elbow joint (i.e. the forearm is lowered).





Right and wrong

✗ When the biceps contracts and the triceps relaxes, the bone is straightened.

✓ When the biceps contracts and the triceps relaxes, the arm (i.e. the limb) is straightened.

antagonistic muscles 拮抗肌　biceps 二頭肌　extensor 伸肌　flexor 屈肌　opposing muscles 拮抗肌　triceps 三頭肌

VR 19.2 點擊 QR 碼

虛擬考察 VR 新增

★ 隨時隨地進行生態考察或實地參觀活動
★ 支援各類流動裝置

p. 19-14

ii) Mangroves

Most **mangroves** are located in **sheltered bays**. They are subject to **tidal actions**. There is a continuous exchange of water from the river and the sea. Therefore, the **salinity** of the mud **fluctuates** throughout the day.

Mangroves are protected from wave action. **Organic matter** can easily **accumulate** in the **soft mud** and the **oxygen level** in the mud is **low**. **Specialized forms of roots** are developed in some mangrove trees for obtaining oxygen from the air. The roots are raised above the mud (Fig 19.19). Some mangrove trees can **excrete excess salt** absorbed through their leaves (Fig 19.20).

Fig 19.19 (a) The knee joint* of *Kandelia** and (b) the pneumatophores* of Black Mangrove* are raised above the mud to obtain oxygen from the air

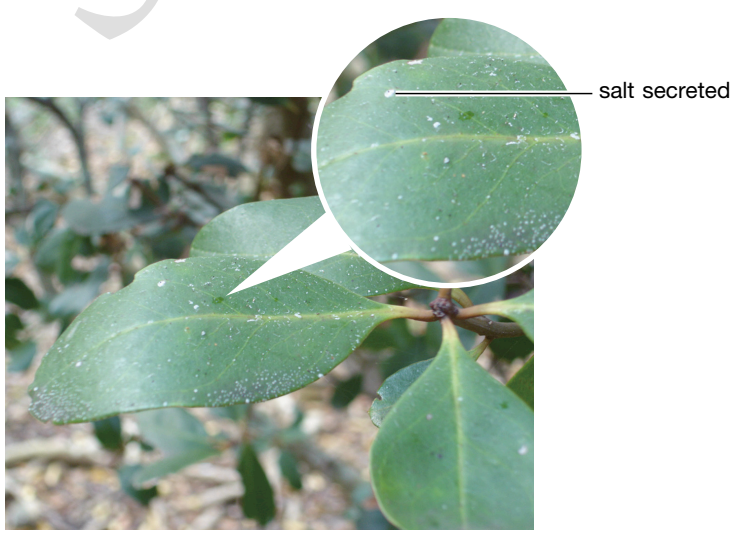


Fig 19.20 The leaves of *Aegiceras corniculatum** possess salt glands to excrete the excess salt

Aegiceras corniculatum 蠟燭果　Black Mangrove 海欖雌 / 白骨壤　*Kandelia* 秋茄樹 / 水筆仔　knee joint 膝狀根
pneumatophore 出水通氣根

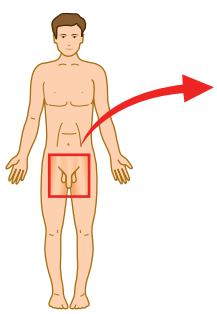
DSE
12(IA)Q28, 13(IA)Q35

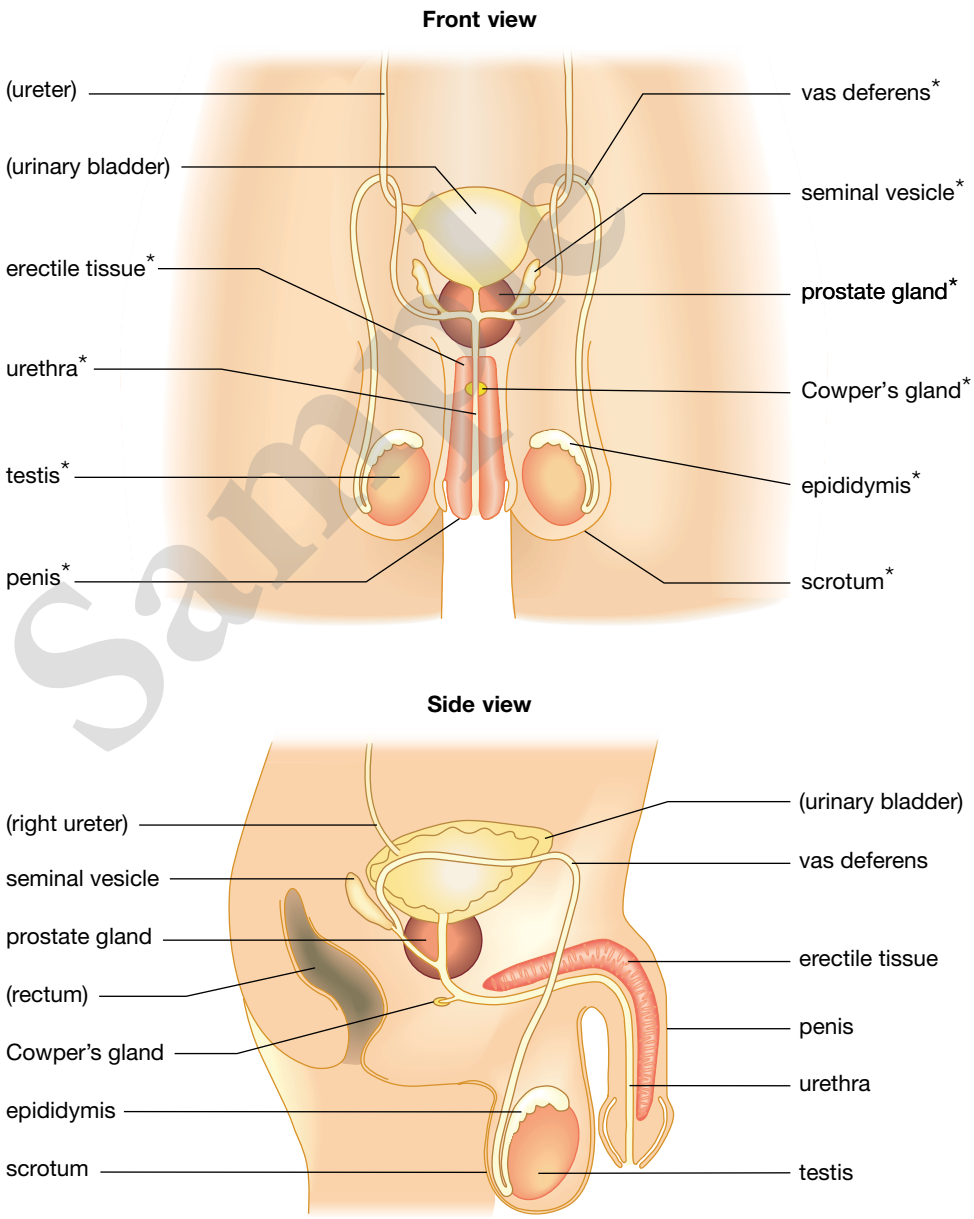
13.1 Human reproductive system

We learnt that flowering plants can reproduce sexually and/or asexually. How about humans? Humans carry out **sexual reproduction only**. Their reproductive systems are specialized for this way of reproduction.

A Male reproductive system

Fig 13.1 shows the front and side views of the male reproductive system.





* ctures in brackets do not belong to the reproductive system

Fig 13.1 Male reproductive system in humans

3D模型 3D model

- ★ 模型中各個主要構造均有詳細標註
- ★ 支援各類流動裝置
- ★ 增設練習，讓學生鞏固所學

p. 13-2

3D model 13.1

點擊 QR 碼

Cowper's gland 高柏氏腺 epididymis 附睾 erectile tissue 勃起組織 penis 陰莖 prostate gland 前列腺 scrotum 陰囊
seminal vesicle 精囊 testis 睾丸 urethra 尿道 vas deferens 輸精管

1.2 How can we study biology?

A Scientific method

Scientists study the natural world using the **scientific method***. There is no single scientific method, but it usually involves a few basic steps.

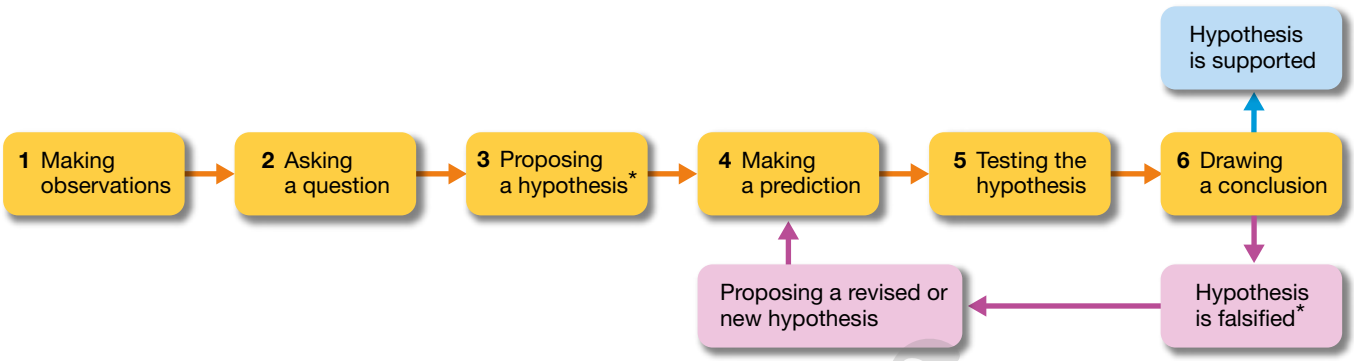


Fig 1.8 Basic steps of the scientific method

動畫 Animation

★ 深入淺出地闡釋生物學概念

點擊 QR 碼

p. 1-6

These steps are explained below using an investigation of bats carried out by Lazzaro Spallanzani in the 1790s.

1 Making observations

Scientists are curious about things in nature. They make observations of these things by using one or more of their five senses (e.g. sight, smell or touch).

1 Making observations 2 Asking a question

falsify 證偽　hypothesis 假說　scientific method 科學方法

Practical 4.2 Investigation of the effect of temperature on enzyme activity

Introduction

In this practical, we will use amylase* to investigate the effect of temperature on enzyme activity. Amylase catalyses the breakdown of starch into maltose*.

Practical 4.2

$$\text{starch} \xrightarrow{\text{amylase}} \text{maltose}$$

The rate of an enzymatic reaction can be determined by measuring

- the rate at which a substrate is broken down, or
- the rate at which a product is formed.

We will use the first method in this practical. We will determine the rate of the enzymatic reaction by measuring the time required for all the starch in the reacting mixture to break down. The shorter the time, the higher the activity of amylase.

模擬實驗 Simulation

★ 支援各類流動裝置，隨時隨地進行模擬實驗

點擊 QR 碼

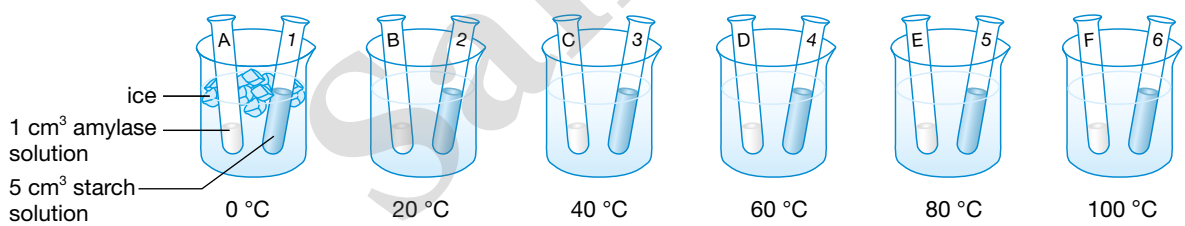
p. 4-11

Procedure

1 Add 1 cm^3 of amylase solution to six test tubes, A to F. Add 5 cm^3 of starch solution to another six test tubes, 1 to 6.

? Why is it important to incubate the two solutions before mixing them together?

2 Put the test tubes into beakers of water at different temperatures for 10 minutes, as shown below.

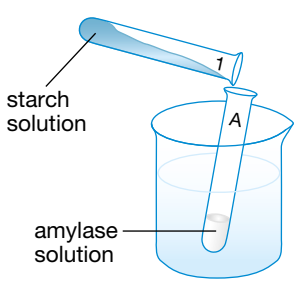


3 Add a drop of iodine solution into each of the wells of a spot plate.

4 For each beaker, start the reaction by pouring the starch solution into the amylase solution. Shake well and put the tube of mixture back into the beaker. Record the time as zero.

Caution

Iodine solution is an irritant. Avoid contact with skin.



cont.

amylase 澱粉酶　　maltose 麥芽糖