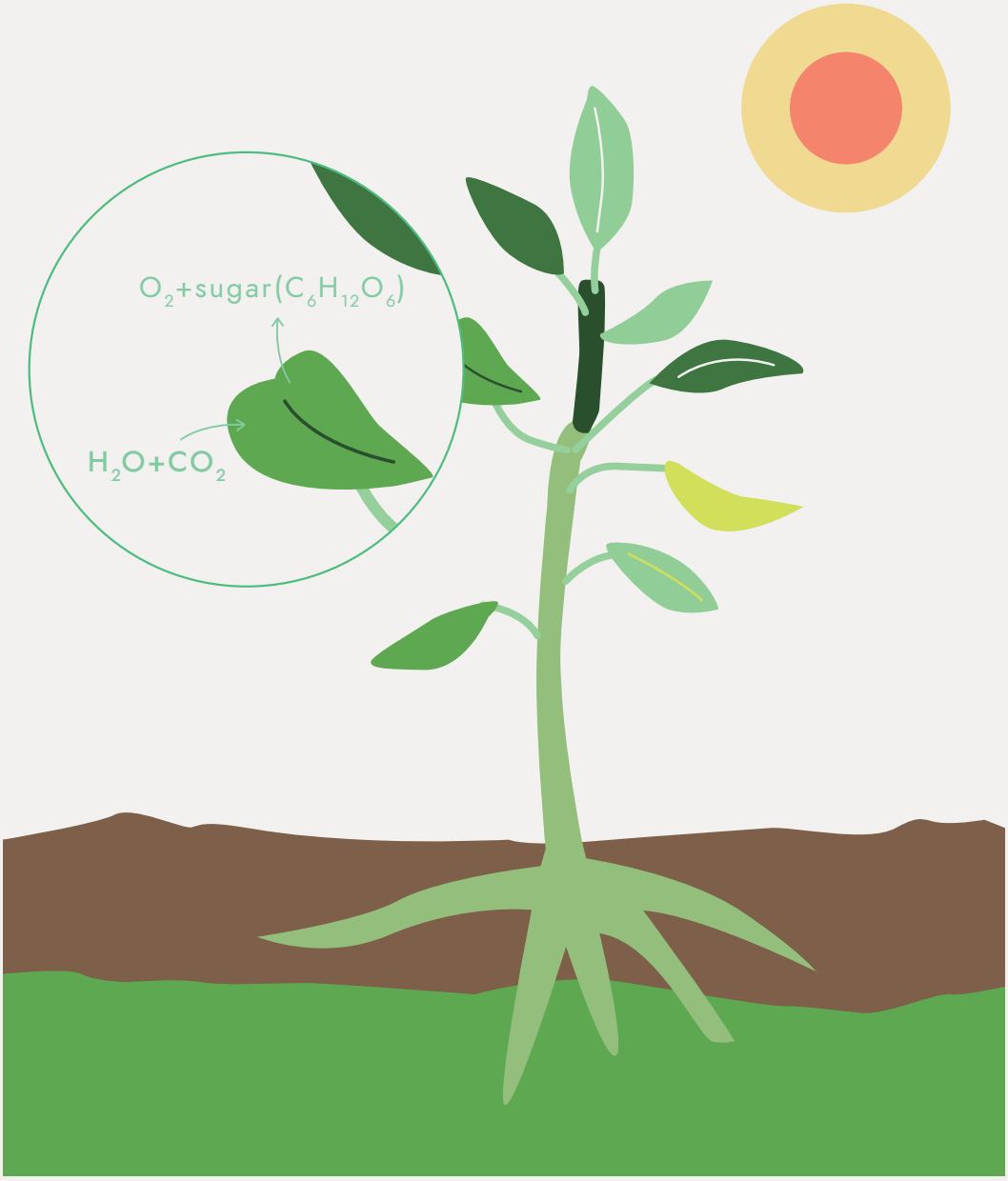
高中自然領域

雙語教學資源手冊

生物科 英語授課用語

A Reference Handbook for Senior High School Bilingual Teachers in the Domain of Natural Sciences (Biology): Instructional Language in English

〔高中選修(II)〕



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■ 前言 Introduction

本章介紹科學家如何研究生物起源的問題，過去人們並不清楚生命究竟從何而來，人們觀察腐肉生蛆、腐草化螢而認為生命來自非生物，究竟是如何經由實驗證明生命必須來自生命呢?單細胞生物如何演化成多細胞生物，以及細胞的營養代謝方式是如何演化而來。語言部份希望透過生命起源相關實驗、學說、演化過程的英文單字及句型學習，更理解如何用英語表達本章節之重要觀念。

1-1 生命的起源
The Origin of Life

■ 前言 Introduction

本節討論現今的生物是從何而來，科學家是由哪些實驗來探討及解答這個問題的呢？過去人們觀察到腐肉生蛆、肉湯發臭腐敗等等現象，便認為生命可以由沒有生命的肉以及肉湯產生，然而現今多數科學家認同的說法是生命必須來自生命。究竟是如何設計實驗解開疑惑的呢？英文部分欲使學生學習發現生命起源實驗的相關單字、學者名字以及句型運用。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
abiogenesis (archigenesis/ archigony)	非生源說	Louis Joblot	約伯勒
biogenesis	生源說	Lazzaro Spallanzani	斯巴蘭贊尼
microorganism	微生物	Louis Pasteur	巴斯德
cork stopper	軟木塞	swan neck flask	鵝頸瓶實驗
Antoni van Leeuwenhoek	雷文霍克		

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ arise from _____.

例句：Abiogenesis holds that living things can **arise from** inanimate materials.
非生源說認為生物可以從沒有生命的物質而產生。

❷ _____, while _____

例句：Aristotle supported the theory of abiogenesis, **while** Redi supported the theory of biogenesis.
亞里斯多德支持非生源說，而雷迪支持生源說。

❸ _____ by V-ing_____.

例句：Leeuwenhoek discovered microorganisms **by observing** water droplets with a homemade microscope.
雷文霍克利用自製顯微鏡觀察水滴發現了微生物。

❹ _____ due to _____.

例句：In Pasteur's retort experiment, microorganisms fell into the bend **due to** gravity, preventing microorganisms in the air from entering the bottle.
在巴斯德鵝頸瓶實驗中，微生物因重力掉落在彎曲處，阻止空氣中的微生物進入瓶內。

❺ prevent _____ from _____.

例句：In Pasteur's Retort experiment, microorganisms fall at the bend due to gravity, **prevent**ing microorganisms in the air **from** entering the bottle.
在巴斯德鵝頸瓶實驗中，微生物因重力掉落在彎曲處，阻止空氣中的微生物進入瓶內。

❻ _____ come from _____.

例句：If organisms only **come from** existing organisms, where did the first organism on earth come from?

如果生物只來自已存在的生物，那地球上第一個生物又是怎麼來的?

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本章節後，學生應習得以下概念：

After completing this section, students should acquire the following concepts:

一、學生了解生物科學史上關於生命起源的重要發現、與這些實驗的方法原理。

Students learn about important discoveries about the origin of life in the history of biological sciences, and the methods and principles of these experiments.

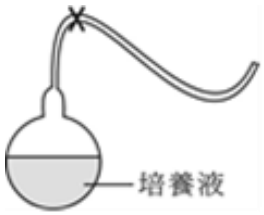
❧ 例題講解 ☙

例題一

說明：了解巴斯德驗證生源說的重要實驗，其實驗原理與結果意義。

Understand Pasteur's important experiments which verified biogenesis, their experimental principles, and the significance of their results.

The picture shows Pasteur's Retort experiment. If the glass tube at location on the swan neck flask marked with an X is cut off and air is allowed to enter the flask, which organisms will be the earliest and most numerous to appear in the cooled culture medium?



(A) producers

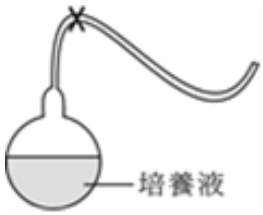
(B) heterotrophs

(C) autotrophs

(D) chemosynthetic microorganisms

圖為巴斯德實驗的鵝頸瓶，若將鵝頸瓶X部位的玻璃管切斷，讓空氣進入瓶中，則其冷卻後的培養液內，最早出現且數量最多的生物為何？

(A)　綠色生產者
(B)　異營微生物
(C)　自營微生物
(D)　化學合成微生物



（96 年指考生物 14）

Teacher: What's in Pasteur's swan neck flask?
Student: It's a solution of yeast and sugar.
Teacher: Yes, this is a highly nutritious substance, and heterotrophic bacteria thrive in it. Imagine what would happen if a piece of meat is not refrigerated.
Student: It will stink.
Teacher: Exactly, it becomes smelly because bacteria break down the nutrients inside and produce bad odors. Both A and C are producers, and they don't necessarily require these organic nutrients to grow. Chemosynthetic autotrophic microorganisms, on the other hand, are organisms that can oxidize inorganic substances to obtain energy. Therefore, they don't rely on organic nutrients to grow.

老師：同學們，請問巴斯德的鵝頸瓶中裝的是什麼？
學生：酵母菌糖液。
老師：對，這是營養非常豐富的東西，異營細菌最喜歡在其中生長。你想像一下，一塊肉不放冰箱會如何？
學生：會臭掉。
老師：對呀，會臭掉正是因為細菌在分解裡面的養分產生臭味。而A、C都是生產者，他們並不一定需要這些有機養分才能生長。而化學合成自營微生物是一種能將無機物氧化而獲得能量的微生物，因此他們一樣不需要依賴有機養分才能生長喔。

例題二

說明：了解各個科學家關於生源說的重要實驗，以及這些實驗證實的事情。

Understand scientists' important discoveries regarding biogenesis and what these experiments confirmed.

Which of the following experiments or phenomena regarding the origin of life supports the theory of spontaneous generation (abiogenesis)?

(A) Meat separated by gauze did not develop maggots.

(B) Boiled nutrient solution exposed to air developed microorganisms, while the solution in unexposed bottles did not.

(C) A boiled and sealed hay infusion developed microorganisms.

(D) No microorganisms appeared in the broth of a swan-neck flask after boiling.

以下關於生命起源的實驗或現象，何者的實驗結果支持自然發生說？

(A) 紗布區隔的腐肉無法長蛆。

(B) 煮沸後的陪養液接觸空氣後出現微生物，而未接觸空氣的瓶中沒有微生物。

(C) 煮沸後密封的乾草浸液出現微生物。

(D) 鵝頸瓶中的液體煮沸後沒有出現微生物。

（91 指考生物 6）

Teacher: Students, let's discuss the question of the origin of life. First, for option (A), the meat separated by gauze didn't develop maggots. Which theory does this support?

Student: It supports biogenesis because without external flies laying eggs, no maggots would appear in the meat.

Teacher: Good. Then, for option (B) microorganisms appeared in the nutrient solution after boiling and exposure to air. What does this mean?

Student: It shows that microorganisms came from the air, and were not spontaneously generated from the solution itself.

Teacher: Right, this contradicts spontaneous generation. Moving on, for option (C), the sealed hay infusion developed microorganisms, which theory might this support?

Student: It seems to support spontaneous generation because the container was sealed, theoretically preventing any external microorganisms from entering.

Teacher: Correct, this is the only result that appears to support spontaneous generation. Lastly, for option (D), no microorganisms appeared in the swan-neck flask experiment. What does this support?

Student: It supports biogenesis because even though the flask was exposed to air, the special design of the neck prevented the entry of microorganisms.

Teacher: Well done. So, based on these experiments, which option is the only one that seems to support spontaneous generation?

Student: It's option (C), since microorganisms appeared in the boiled and sealed hay infusion.

Teacher: Exactly. Do you know why microorganisms appeared in the boiled hay infusion?

Student: Is it because boiling can't kill all microorganisms?

Teacher: Yes, especially some microorganisms which can form 'spores,' a state that is very resistant to heat. Thus, normal boiling can't kill them. To achieve complete sterilization, higher temperature and pressure are needed, such as through the use of autoclaves.

老師： 同學們，我們來討論一下這道關於生命起源的問題。首先，選項(A)中的紗布區隔的腐肉沒有長蟲，這支持哪種理論？

學生： 這支持生源論，因為沒有外來的蒼蠅產卵，腐肉就不會長出蛆來。

老師： 很好，那麼選項(B)中煮沸後接觸空氣的培養液出現微生物，這說明了什麼？

學生： 這說明微生物是從空氣中進入的，而不是培養液自己產生的。

老師： 對，這反對自然發生說。接下來，選項(C)中密封的乾草浸液出現微生物，這似乎支持哪種理論呢？

學生： 這似乎支持自然發生說，因為容器是密封的，理論上不應該有外來微生物進入。

老師： 正確，這是唯一支持自然發生說的實驗結果。最後，選項(D)的鵝頸瓶實驗沒有微生物出現，這又支持什麼？

學生： 這支持生源說，因為即使瓶子暴露於空氣中，特殊的瓶頸設計阻止了微生物的進入。

老師： 很好，所以根據這些實驗結果，唯一看似支持自然發生說的是哪一個選項？

學生： 是選項(C)，煮沸後密封的乾草浸液出現微生物的實驗結果。

老師： 沒錯。那你們知道為什麼煮沸後的乾草液中會有微生物出現嗎？

學生： 是因為煮沸不能完全殺死所有微生物嗎？

老師： 對，特別是某些微生物能夠形成「孢子」，這種形態對熱非常耐受，普通的煮沸無法殺死它們。要完全滅菌，通常需要在較高的溫度和壓力下進行，比如使用高壓蒸汽滅菌法。

1-2 生物起源的過程
The Process of Biological Origins

■ 前言 Introduction

地球上第一個生命究竟從何而來？生源說確立了生命來自生命的基礎，但無法解釋最初的生命究竟從何而來。本節介紹許多關於生命起源的理論，科學家們如何透過實驗模擬古老地球的環境，找尋最初的生命產生的可能方式。英文部分則是讓學生理解生命起源如何用物理和化學的方式解釋，而英文在此節又該如何應用。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
organic evolution	有機演化	proteinoid microsphere	類蛋白質微粒
primordial soup	原始湯	ribozyme	核糖核酸酵素
abiogenesis	自然發生說	liposome	微脂體
micromolecular organic compound	小分子有機物	primitive cell	原始細胞
macromolecular organic compound	大分子有機物		

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ was/were born_____.

例句：The earth **was born** about 4.6 billion years ago, when the environment was not suitable for the survival of organisms.
地球約在 46 億年前誕生，當時環境不適合生物生存。

❷ _____ spontaneously synthesize_____

例句：Inorganic substances in the water of primitive Earth could **spontaneously synthesize** micromolecular organic compounds.
原始地球的水中無機物可以自發性合成小分子有機物。

❸ _____ formed through _____.

例句：The first organisms on Earth could have **formed through** organic evolution.
地球上最初的生物可以經由有機演化形成。

❹ _____ have the ability to _____.

例句：The earliest molecules with the characteristics of life should **have the ability to** replicate and catalyze at the same time.
最早的具有生命特性的分子應該具有同時複製和催化的能力。

❺ _____ be separated from _____.

例句：In the hypothesis of primitive cell formation, proteinoid microspheres or liposomes must be able to **be separated from** the surrounding environment and encapsulate RNA to develop into simple primitive cells.
在原始細胞形成的假說中，類蛋白質微粒或微脂體必須能夠與周遭環境隔離，並包裹 RNA，才能發展為簡單的原始細胞。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本章節後，學生應習得以下概念：

After completing this section, students should acquire the following concepts:

一、學生了解目前被多數科學家接受的、關於地球上生命起源的理論。

Students understand the theory accepted by most scientists about the origin of life on Earth.

二、學生了解有氧代謝與無氧代謝的意義、以及利用這些方式代謝的生命會有的生存方式。

Students understand the meaning of aerobic and anaerobic metabolism, and how organisms survive through these methods of metabolism.

❧ 例題講解 ☙

例題一

說明：學生了解目前被多數科學家接受的、關於地球上生命起源的理論。

Students understand the theories accepted by most scientists about the origin of life on Earth.

Which of the following statements about the origin and evolution of life on Earth are correct?

(A) Heterotrophs appeared before autotrophs.

(B) Biogenesis can explain the origins of the earliest life on Earth.

(C) DNA is the earliest genetic material that appeared on Earth.

(D) The gradual accumulation of oxygen concentration in the atmosphere increased the metabolic diversity of organisms on Earth.

(E) The occurrence of genetic variation in a population is a necessary condition for evolution.

下列有關地球上生命起源與演化的敘述，哪些正確？

(A) 異營性生物較自營性生物先出現。

(B) 生源論可說明地球最早的生命的起源。

(C) DNA 是地球上最早出現的遺傳物質。

(D) 大氣中氧濃度逐漸累積後，使地球上生物的代謝歧異度增加。

(E) 族群中遺傳變異的發生是演化的必要條件。

（101 年指考生物 22）

解析 Solution:

要注意這些都是目前被廣為接受的理論，但並不是已被證實的真相，因為不可能回到過去，只能說是可能性非常高、而且沒有被推翻的理論。

It should be noted that these are currently accepted theories, but they are not proven truths. Since it is impossible to go back to the past, they are only very probable theories that have not been disproved.

Teacher: A: Scientists found that inorganic matter could form organic compounds without the presence of other life. So, scientists suggested that the earliest oceans on Earth may have been full of organic compounds called “primordial soup.” They believe that the earliest life came from this primordial soup. The earliest forms of life utilized enzymes to break down organic matter and obtain energy and nutrients in an anaerobic environment.

B: As mentioned in the previous unit, biogenesis does not explain where the first life came from.

C: RNA has the properties of enzymes and genetic material, so what can it also be called?

Student: Ribozyme.

Teacher: Yes. and the textbook also mentions that RNA can replicate spontaneously. Therefore, we believe that RNAs with multiple functions are more likely to play the role of genetic material in the origin of life.

D: At first, the Earth's atmosphere did not contain oxygen, and all life respired anaerobically until photosynthetic life appeared and began to produce oxygen. Oxygen would cause oxidation and lead to the death of anaerobic organisms.

Teacher: However, the appearance of oxygen enabled the emergence of lives with aerobic respiration.

E: Genetic variation allows organisms to have different traits, and only the individuals that adapt to the environment can survive and pass genes onto offspring

老師： A：無機物能夠自發性的合成轉變為有機物，科學家們認為早期地球海洋中很可能累積了大量的有機物而變成原始湯，而最早的生命就是在原始湯中誕生的。我們認為，最早的生命在無氧環境下利用酵素來分解有機物，獲得能量與養分。

B：而在上一單元中就有提到，生源說並不討論第一個生命從何而來。

C：RNA 同時具有酵素(酶)、與遺傳物質的特性，因此他又被稱為什麼？

學生： 核糖核酸酵素。

老師： 是的。而課本中也有提到 RNA 可以自發性複製。因此我們認為具備多種功能的 RNA 較有可能在生命起源時擔任遺傳物質的角色。

D：起初地球的大氣中不含氧氣，所有的生命都行無氧呼吸，直到行光合作用的生命出現，開始產生氧氣，氧氣會使厭氧生物死亡，而氧氣的產生使得行有氧呼吸的生命出現。

E：遺傳變異使得生物間有不同的性狀，而適應環境的個體才能生存並且將基因傳給後代。

例題二

說明：了解有氧代謝與無氧代謝的意義、以及利用這些方式代謝的生命會有的生存方式。
Understand the meaning of aerobic and anaerobic metabolism, and how organisms survive through these methods of metabolism.

In the origin of life on Earth, organisms with different needs for oxygen appeared one after another. Which of the following statements is correct?

(A) The oxygen used by organisms that perform aerobic metabolism mainly comes from anaerobic metabolizing organisms.

(B) Organisms with aerobic metabolism produce more energy than those with anaerobic metabolism.

(C) In today's ecosystems, organisms that perform anaerobic metabolism are consumers.

(D) In today's ecosystems, aerobic organisms are producers.

地球生命起源陸續出現對氧需求不同的生物。下列敘述何者正確？

(A) 行有氧代謝的生物使用的氧主要來自無氧代謝生物。

(B) 行有氧代謝的生物比無氧代謝的生物可產生較多的能量。

(C) 在現今生態系中，行無氧代謝的生物都是消費者。

(D) 在現今生態系中，行有氧代謝的生物都是生產者。

（改編自 109 指考（補考）生物 2）

Teacher: Can you give some examples of organisms that produce oxygen through photosynthesis?

Student: Cyanobacteria, plants, algae...

Teacher: Correct, and these organisms mainly perform aerobic metabolism, so the oxygen we breathe primarily comes from organisms that undergo aerobic metabolism.

Teacher: Please give examples of anaerobic metabolism (anaerobic respiration).

Student: Lactic acid fermentation, alcohol fermentation...

Teacher: Yes. So, what are the steps for producing energy through anaerobic respiration?

Student: Only glycolysis before fermentation produces energy.

Teacher: And how about aerobic respiration?

Student: Aerobic respiration also includes glycolysis. Then more energy is produced through the citric acid cycle and electron transport chain as compared to anaerobic respiration.
Teacher: Some plants also undergo anaerobic metabolism in oxygen-deficient environments.
Teacher: Organisms that undergo aerobic metabolism include producers and consumers.

老師： 同學請舉例哪些生物會行光合作用而產生氧氣。
學生： 藍綠菌、植物、藻類...
老師： 沒錯，而這些生物主要行有氧代謝，因此我們所呼吸的氧主要來自行有氧代謝的生物。
老師： 同學請舉例無氧代謝（無氧呼吸）。
學生： 乳酸發酵、酒精發酵...
老師： 是的，請問同學們無氧呼吸（代謝）時，有哪些步驟會產生能量呢?
學生： 只有發酵作用前的糖解作用產生能量。
老師： 那麼有氧呼吸（代謝）呢？
學生： 有氧呼吸也有糖解作用，在糖解作用之後經由檸檬酸循環與電子傳遞鏈，產生比無氧呼吸更多的能量。
老師： 有些植物在缺氧環境下也會行無氧代謝。
老師： 行有氧代謝的生物包含了生產者與消費者。

1-3 生命形式的演化歷程
The Process of the Evolution of Life Forms

■ 前言 Introduction

科學家推測原始生命的構造應該很簡單，再漸漸演化出複雜的構造。本節介紹生命形式可能的演化過程，營養方式的演化、呼吸方式的演化、 真核細胞的演化、內共生學說等等。英文部分則包含生命演化歷程的重要單字和文法句型，使學生能夠理解及用英文表達本節學習重點。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
semiautonomous organelles	半自主胞器	prokaryote	原核生物
endosymbiotic theory	內共生學說	prokaryotic heterotroph	原核異營生物
cyanobacteria	藍綠菌	prokaryotic autotrophs	原核自營生物
eukaryotes	真核生物		

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ provide _____ with _____.

例句：Photosynthesis **provide**s the atmosphere **with** a source of oxygen.
光合作用為大氣提供了氧的來源。

❷ _____ be converted into _____

例句：Oxygen can **be converted into** ozone through the catalysis of sunlight.
氧在日光的催化下可轉變為臭氧。

❸ _____ produce energy by _____.

例句：Prokaryotes **produce energy by** metabolizing organic matter in their surrounding environment.
原核生物利用周遭環境中的有機物代謝產生能量。

❹ _____ synthesize _____ by _____.

例句：Mitochondria and chloroplasts can **synthesize** required proteins **by** themselves.
粒線體和葉綠體可自行合成所需的蛋白質。

❺ _____ evolved into _____.

例句：In the endosymbiotic theory, aerobic bacteria **evolved into** mitochondria, while cyanobacteria evolved into chloroplasts.
在內共生學說中，好氧菌演化成粒線體，而藍綠菌演化為葉綠體。

❻ _____ from _____ to _____.

例句：In the evolution of life, obtaining nutrients has changed **from** heterotrophic **to** autotrophic; the metabolic method has changed **from** anaerobic metabolism **to** aerobic metabolism.
生命的演化歷程中，獲得營養的方式是從異營到自營；代謝方式從無氧代謝到有氧代謝。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本章節後，學生應習得以下概念：

After completing this section, students should acquire the following concepts:

一、瞭解內共生學說。

Understand endosymbiotic theory.

二、瞭解葉綠體與粒線體與其他胞器不同之處。

Understand how chloroplasts and mitochondria differ from other organelles.

❧ 例題講解 ☙

例題一

說明：瞭解內共生學說。

Understand endosymbiotic theory.

Some of the organelles of eukaryotic cells may come from prokaryotes living independently. They survive after entering the eukaryotic cell and live symbiotically with the cell. Which of the following phenomena can support the theory of endosymbiosis?

(A) Eukaryotic cells have organelles.

(B) There are enzymes in mitochondria.

(C) The replication cycles of chloroplasts and cells are out of sync.

(D) Mitochondria have double membrane.

(E) The DNA in chloroplasts is similar to DNA in cyanobacteria.

真核細胞的胞器中，有些可能來自獨立生活的原核生物，因進入真核細胞與該細胞共生而存留下來，下列哪些現象可以支持內共生說？

(A) 真核細胞具胞器。

(B) 粒線體內有酵素。

(C) 葉綠體與細胞的複製週期不同步。

(D) 粒線體具有雙層膜。

(E) 葉綠體內 DNA 與藍綠菌 DNA 相似。

（101 年指考生物 27）

Teacher: Mitochondria and chloroplasts are distinct from other organelles. They have double membranes and their replication cycle is not synchronized with other cells. They replicate by binary fission like bacteria, and they can synthesize a small number of proteins by themselves. Therefore, they are called semi-autonomous organelles. The researchers proposing an endosymbiotic theory believe that the evolutionary source of chloroplasts and mitochondria may have evolved gradually after cyanobacteria and aerobic bacteria were phagocytosed by eukaryotic cells.

Teacher: Next, look at the options.

A: Both prokaryotic and eukaryotic cells have organelles, but this does not support the theory.

B: Enzymes are also present in other organelles within eukaryotic cells, such as lysates, so this does not support the theory.

C、D: They have been explained already.

E: Endosymbiotic theory states that chloroplasts evolved from cyanobacteria engulfed by eukaryotic cells, so if the DNA in the chloroplast is similar to that of cyanobacteria, the theory can be fully supported.

老師： 粒線體與葉綠體與其他的胞器明顯不同，他們具有雙層膜，他們的複製週期與細胞不同步，像細菌一樣用二分裂方式複製，還可以自行合成所需的少部分蛋白質，被稱為半自主胞器。提出內共生學說的學者認為，葉綠體和粒線體的演化來源，有可能是好氧菌與藍綠菌被真核細胞吞噬之後，逐漸演變而成的。

老師： 接下來我們來看選項。

A 原核細胞和真核細胞都具有胞器，但這個沒辦法支持學說。

B 真核細胞內的其他胞器裡也有酵素，例如溶體，所以這並不能支持學說。

C、D:剛才已經說明了。

E 內共生學說認為，葉綠體是被真核細胞吞噬的藍綠菌所演變而成，所以如果葉綠體內的 DNA 與藍綠菌的 DNA 相似，完全可以支持學說。

例題二

說明：粒線體自帶 DNA，可以連結本單元內共生學說的部分，而其他粒線體功能則可以複習選修生物上，呼吸作用的部分。

The mitochondria have their own DNA, which can link the part of the endosymbiotic theory in this unit, while other mitochondrial functions can be reviewed in the elective biology, the part of respiration.

Which of the following statements about mitochondria is correct?

(A) Mitochondria have their own DNA and do not need to rely on proteins expressed by nuclear DNA.

(B) Mitochondria can express their own RNA.

(C) The citric acid cycle in mitochondria occurs in the intermembrane space.

(D) Glycolysis occurs in mitochondria.

下列對於粒線體的敘述，何者正確？

(A) 粒線體擁有自己的 DNA，不需要依賴細胞核 DNA 所表現出的蛋白質。

(B) 粒線體可表現出自己的 RNA。

(C) 粒線體中的檸檬酸循環發生在膜間腔。

(D) 糖解作用是發生在粒線體中。

（修改自 101 指考生物 7 取符合本單元部分）

Teacher: Mitochondria have their own DNA, but they can only express a portion of the required proteins, while others still need to be produced by cells. Since mitochondria can express proteins, do you think they can also express RNA?

Student: Yes.

Teacher: That's correct. The process of protein expression requires transcription before translation. According to central laws, DNA enables transcription into RNA, which can then be translated into proteins.

Teacher: In option C, the citric acid cycle in the mitochondria doesn't occur in the intermembrane space. Can you tell me where it takes place?

Student: The inner membrane.

Teacher: That's right.

Teacher: Glycolysis doesn't occur in the mitochondria. Can you tell me where it happens?

Student: In the cytoplasm.

老師： 粒線體有自己的 DNA，但它們只能表達部分所需的蛋白質，其他的蛋白質還是需要由細胞製造。既然粒線體可以表達蛋白質，你認為它們也能表達 RNA 嗎？

學生： 是的。

老師： 沒錯。蛋白質的表達過程需要先進行轉錄，再進行轉譯。根據中心法則，DNA 可以轉錄成 RNA，然後 RNA 才能被轉譯成蛋白質。

老師： 在選項 C 中，粒線體的檸檬酸循環不是發生在膜間隙，你知道它在哪裡進行嗎？

學生： 在內膜中。

老師： 沒錯。

老師： 糖解作用不在粒線體內進行。你知道它在哪裡發生嗎？

學生： 在細胞質中。

★ 主題二 植物的形態構造與功能 ★
The Morphology Structures and Functions of Plants

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■ 前言 Introduction

本章由小而大的介紹植物的形態構造與功能，先介紹植物細胞分類、而後是植物的組織，最後介紹植物的營養器官。結合植物的構造及其功能的相關英文字彙以及文法，使學生認識本章內容之英文知識。

2-1 植物體的組成層次
The Hierarchical Structure of A Plant Body

■ 前言 Introduction

本節介紹植物細胞依據細胞壁特徵的分類，以及各種常見的植物組織。英文部分介紹植物的組織、器官、系統等構造的英文字詞和其在植物體中如何組成及排列的相關句型。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
tissue	組織	primary tissue	初生組織
organ	器官	secondary tissues	次生組織
tissue system	組織系統	vascular cambium	維管束形成層
parenchyma cell	薄壁細胞	cuticular layer / cuticle	角質層
collenchyma cell	厚角細胞	guard cell	保衛細胞
sclerenchyma cell / sclereid	厚壁細胞	stoma	氣孔
woody fibers	木質纖維	xylem	木質部
bast fiber	韌皮纖維	phloem	韌皮部
fibrous cell	纖維細胞	vessel element	導管細胞
stone cell	石細胞	tracheid	管胞

meristem / meristematic tissue	分生組織	pit	壁孔
dermal tissue	表皮組織	perforation plate	穿孔板
vascular tissue	維管束組織	sieve tube element	篩管細胞
growth point	生長點	companion cell	伴細胞

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ form _____.

例句：In plants, tissues **form** tissue systems, and tissue systems form organs.
植物體內，組織形成組織系統，組織系統再形成器官。

❷ ____ be loosely arranged ____.

例句：The parenchyma cells **are loosely arranged**, and they have different functions in different parts.
薄壁細胞排列較疏鬆，不同部位的薄壁細胞具有不同功能。

❸ ____ have different _____ in different _____.

例句：The parenchyma cells are loosely arranged, and they **have different** functions **in different** parts.
薄壁細胞排列較疏鬆，不同部位的薄壁細胞具有不同功能。

❹ _____ be arranged in _____.

例句：The collenchyma cells **are arranged in** fascicles and have a supporting function.
厚角細胞排列成束狀，具有支持的功能。

❺ ___ be tightly packed ____.

例句：Sclerenchyma cells **are tightly packed** and have primary and secondary cell walls.
厚壁細胞排列緊密，且具有初生細胞壁和次生細胞壁。

❻ _____ differentiate into ____.

例句：The cells of the meristem can **differentiate into** cells of other tissues.
分生組織的細胞可行細胞分裂，並分化產生其他組織的細胞。

❼ _____ have the function of _____.

例句：Vessel elements and tracheids **have the function of** transporting water and minerals.
導管細胞和管胞具有運輸水和礦物質的功能。

❽ _____ be composed of _____.

例句：The ground tissue **is composed of** parenchyma cells, collenchyma cells and sclerenchyma cells.
基本組織由薄壁細胞、厚角細胞及厚壁細胞所組成。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本章節後，學生應習得以下概念：

After completing this section, students should acquire the following concepts:

一、了解植物組織與細胞的特性。

To learn about the characteristics of plant tissues and cells.

❧ 例題講解 ☙

例題一

說明：瞭解植物不同組織細胞的構造與功能。

To understand the structures and functions of different tissue cells in plants.

Which of the following statements about plant tissues is correct?

(A) Meristems have thicker cell walls than mesophyll cells.

(B) The cork cambium is differentiated from epidermal cells.

(C) The mesophyll cells that carry out photosynthesis is called sclerenchyma cells.

(D) Stomas are formed by intercellular spaces.

下列有關植物組織的敘述何者正確？

(A) 分生組織的細胞壁比葉肉細胞厚。

(B) 木栓形成層由表皮細胞分化而成。

(C) 具有光合作用的葉肉細胞是屬於厚壁細胞。

(D) 氣孔是由細胞間隙形成。

（110 年指考生物 14）

解析 Solution:

A 分生組織是未分化的薄壁細胞，兩者細胞壁厚度相近。

B 木栓形成層是由皮層細胞分化而成。

C 葉肉細胞屬於薄壁細胞。

A: The meristems are undifferentiated parenchyma cells, and their cell wall thickness is similar.

B: The cork cambium is differentiated from the cortex.

C: The mesophyll cells are also parenchyma cells.

Teacher: Common plant cell types can be divided into parenchyma cells, collenchyma cells, and sclerenchyma cells according to their cell wall characteristics. Please tell me, what is the order of cell wall thickness of these three cells from thick to thin?

Student: The parenchyma cell is the thinnest; the collenchyma cell has an uneven wall thickness, so it's the second thickest and the sclerenchyma cell is the thickest.

Teacher: Correct. Please tell me which of the above are the meristem cells and the mesophyll cells?

Student: Meristems are undifferentiated parenchyma cells, and mesophyll cells are parenchyma cells.

Teacher: As a result, they both have similar cell wall thicknesses.

Teacher: If the cork cambium is not differentiated from epidermal cells, then from what kind of cells is it differentiated from?

Student: The cells of the cortex.

Teacher: That's right!

老師： 常見的植物細胞類型，可依據細胞壁特徵，分為薄壁細胞、厚角細胞及厚壁細胞。孩子們，請告訴我，這三種細胞的細胞壁厚度由厚到薄依序為何？

學生： 薄壁細胞最薄，厚角細胞壁厚度不均勻、居中，厚壁細胞最厚。

老師： 是的。請告訴我分生組織的細胞與葉肉細胞分別屬於上述哪一種呢？

學生： 分生組織是未分化的薄壁細胞，葉肉細胞是薄壁細胞。

老師： 所以他們倆者的細胞壁厚度相近。

老師： 木栓形成層並不是由表皮細胞分化而成的，請問是由何種細胞分化而成呢？

學生： 皮層細胞。

老師： 沒錯喔！

例題二

說明：學生了解維管束形成層。

To understand the vascular cambium.

Which of the following statements about the vascular cambium is correct?

(A) It is found only in the dicot stem and can make the stem thicker.

(B) The bark of perennial woody plants refers to all the tissues surrounding the vascular cambium of the stem.

(C) It is a parenchyma cell and can divide and differentiate into different cell types.

(D) After cell division, the lateral cells differentiate into xylem and the medial cells into phloem.

下列有關維管束形成層之敘述，哪些正確？

(A) 只存在於雙子葉植物的莖部，可使莖加粗。

(B) 多年生木本植物的樹皮是指莖部維管束形成層外圍的所有組織。

(C) 是薄壁細胞，可以分裂並分化出各種類型的細胞。

(D) 在細胞分裂後，外側的細胞會分化成木質部，內側的細胞則分化為韌皮部。

（修改自 99 指考生物 31）

Teacher: The vascular cambium is not only found in the stem of dicotyledonous plants, think about it, where else is the part of the plant that thickens as it grows?

Student: The root.

Teacher: Yes.

Teacher: The cambium of the vascular bundle will constantly divide and differentiate, forming two types of cells. Do you know what these two types are?

Student: Xylem and phloem.

Teacher: That's right, the xylem forms inwards and the phloem forms outwards.

老師： 維管束形成層不只存在於雙子葉植物的莖部，請想一想，植物會隨著成長而加粗的部位還有哪裡？

學生： 根部。

老師： 是的。

老師： 維管束形成層會不停的分裂分化，形成兩種類型的細胞，請問是哪兩種呢？

學生： 木質部與韌皮部。

老師： 沒錯，向內形成木質部，向外形成韌皮部。

2-2 營養器官的形態構造與功能
The Morphological Structure and Functions of Food Storage Organs

■ 前言 Introduction

本節介紹學植物的營養器官的形態、構造與功能。融合植物營養器官如根莖葉的詳細構造英文名詞介紹和其特質描述以學習本節相關英文知識。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
root	根	lenticel	皮孔
taproot system	軸根系	phelloderm	栓皮層
fibrous root system	鬚根系	bark	樹皮
root cap	根帽	periderm	周皮
epidermis	表皮	heartwood	心材
cortex	皮層	sapwood	邊材
stele	中柱	early wood/springwood	早材
Casparian strip	卡氏帶	late wood/summer wood	晚材
endothelium/endodermis	內皮	annual ring	年輪
pith/medulla	髓	blade/leaf blade	葉片

pericycle	周鞘	vein	葉脈
vascular bundle	維管束	petiole	葉柄
stem	莖	stipule	托葉
apical bud	頂芽	reticular vein	網狀脈
articulation	節	parallel vein	平行脈
lateral bud	側芽	leaf sheath	葉鞘
herbaceous stem	草質莖	guard cell	保衛細胞
woody stem	木質莖	palisade tissue	柵狀組織
phellogen	木栓形成層	spongy tissue	海綿組織
cork layer	木栓層		

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ from bottom to top _____.

例句：The longitudinal section of the root can be divided **from bottom to top** into root cap, growth point, elongation zone, and maturation zone.
根的縱切由下而上依序可分為根帽、生長點、延長區和成熟區。

❷ ____ undergo cell division ____.

例句：Growth points **undergo cell division** and differentiate into root caps and elongation zones.
生長點會行細胞分裂，分化產生根帽和延長區。

❸ _____ be capable of _____.

例句：The parenchyma cells of the pericycle **are capable of** cell division.
周鞘的薄壁細胞具有細胞分裂的能力。

❹ ___ be arranged in ____.

例句：In the roots of dicots, the xylem and phloem **are arranged in** a radial mosaic.
在雙子葉植物的根中，木質部和韌皮部成輻射狀鑲嵌排列。

❺ ___ be arranged in a ring structure.

例句：In the roots of monocots, the xylem and phloem **are arranged in a ring structure.**
在單子葉植物的根中，木質部和韌皮部成環狀排列。

❻ ____ be divided into ____.

例句：According to the texture of the stem, it can **be divided into** herbaceous stems and woody stems.
依據莖的質地可分為草質莖和木質莖。

❼ ___ from the inside out.

例句：The bark contains phloem, cortex, phelloderm, cork cambium, and cork layer **from the inside out.**
樹皮由內而外包括了韌皮部、皮層、栓皮層、木栓形成層、木栓層。

❽ The more/-er _____, the more/-er_____.

例句：**The closer** the xylem is to the center, **the older** the stem is.
越接近莖中心的木質部越老。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本章節後，學生應習得以下概念：

After completing this section, students should acquire the following concepts:

一、學生了解植物的營養器官構造與功能。

Students will learn about the structures and functions of the nutritive organs of plants.

❧ 例題講解 ☙

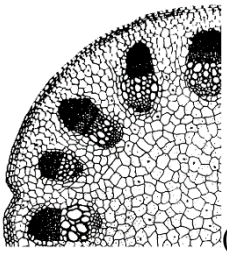
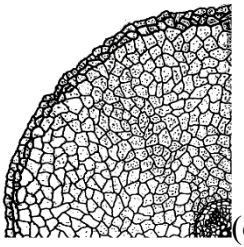
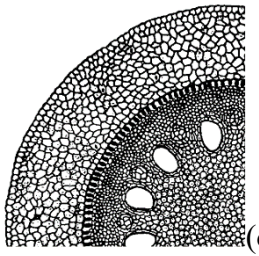
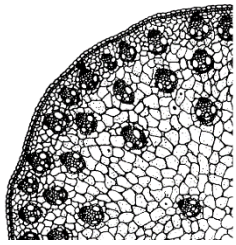
例題一

說明：能辨別單子葉與雙子葉植物根或莖的橫切面構造。

Students will learn to distinguish the cross section of roots and stems of dicots and monocots.

In the following cross sections of roots or stems of monocots and dicots, which of the following options shows structures from the same plant?

下列單子葉與雙子葉植物根或莖的橫切面中，哪一選項中的構造可能來自同一植物？

(a)  (b)  (c)  (d) 

(A) ac　(B) ad　(C) bc　**(D) cd**

（96 年指考生物 19.）

Teacher: We need to judge whether these pictures are of dicots or monocots, roots or stems. The vascular bundles of dicot stems are arranged in a ring structure, and we can see that the xylem and phloem are separated by the cambium. The vascular bundles of monocot stems are scattered. Do you know which two pictures show the stems of monocots and dicots?

Student: (a) is a dicot stem；(d)is a monocot stem.

Teacher: Yes.

Teacher: The vascular bundles of dicot roots gather in the center of the root; the vascular bundles of monocot roots are arranged in a ring structure. Do you know which two pictures show monocot and dicot roots?

Student: (b)is a root of dicot；(c)is a root of monocot.

Teacher: That's right. In option D, (c) and (d) are pictures of monocots, so we can choose D.

老師： 我們需要判斷這些圖片分別是雙子葉植物或單子葉植物、是根或莖。雙子葉植物莖的維管束呈現環狀排列，而且可以看到木質部與韌皮部中間由形成層分開；而單子葉植物莖的維管束是散生的。請問雙子葉與單子葉植物莖分別是哪兩張圖呢？

學生： (a)是雙子葉植物莖，(d)是單子葉植物莖。

老師： 是的。

老師： 雙子葉植物根的維管束會聚集在根的中心；而單子葉植物根的維管束則會呈現環狀排列。問雙子葉與單子葉植物根分別是哪兩張圖呢？

學生： (b)是雙子葉植物根，(c)是單子葉植物根。

老師： 沒錯。選項 D 中，(c)、(d)皆為單子葉植物的圖片，因此應選 D。

例題二

說明：學生了解植物的營養器官構造與功能。

Students will understand the structures and functions of the plant nutrition organs.

Which of the following statements about how plants transport nutrients is correct?

(A) The root cap can protect the growth point, but the cells are easily detached by friction with the soil, so they need to regenerate frequently.

(B) Perennial dicots have an active cambium that allows for constant stem elongation.

(C) The leaves of aquatic plants have a thick cuticle that keeps water from infiltrating the plant body.

(D) Monocots have phloem in the vascular bundles on the lateral side of the stem, and the xylem on the medial side of the stem.

下列有關植物的營養器官與功能之敘述，何者正確？

(A) 根帽可保護生長點，但細胞與土壤摩擦易脫落，需經常補充。

(B) 多年生的雙子葉植物具有活躍的形成層，使莖不斷伸長。

(C) 水生植物的葉片具有很厚的角質層，可防水分不斷滲入植物體。

(D) 單子葉植物位於莖外部的維管束有韌皮部，位於莖內部者具有木質部。

（100 指考生物 15）

Teacher: The root cap is located at the top of the root tip, and the growth point of the root tip will not only lengthen the root itself, but also continue to produce the root cap to protect the growth point.

Teacher: The cambium cells keep dividing, but they do not grow. So, what is it growing?

Student: The width of the stem.

Teacher: That's right.

Teacher: The function of the waterproof cuticle is to prevent water loss. Since aquatic plants do not have to worry about this situation, the cuticle should be more developed in terrestrial plants.

Teacher: The vascular bundles of monocots are dispersed, so it is possible to find phloem or xylem near the center or periphery of the cross-section of the stem.

老師： 根帽位於根尖最頂端的地方，根尖的生長點除了使根本身變長以外，也會不停的增生根帽來保護生長點。

老師： 形成層細胞會不斷分裂，但並不是增長，請問是增加甚麼呢？

學生： 增加植物莖的寬度。

老師： 沒錯。

老師： 防水的角質層功能是防止水分散失，水生植物比較不需要擔心這種情況，角質層應該會在陸生植物身上比較發達。

老師： 單子葉植物的維管束是呈現散生散生狀，所以莖橫切面的靠近中心處或外圍，都有可能找到韌皮部或木質部。

★ 主題三 植物體的物質吸收、合成與運輸★
Substance Absorption, Synthesis and Transportation in Plants

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國立彰化師範大學英語學系 林之曦

■ 前言 Introduction

本章介紹植物如何吸收、運輸、合成各種物質，這些物質來自哪裡、由植物的那些部位運輸，在植物體哪裡合成哪些物質。語言則聚焦於植物所吸收物質，合成作用等英文名稱及對其描述的文法使用方式。

3-1 水和礦物質的吸收與運輸
Absorption and Transportation of Water and Minerals

■ 前言 Introduction

本節介紹植物如何吸收水分與礦物質，礦物質會溶在水中，因此吸收、運輸會與水分一起。英語部分則是關於水分與礦物質運輸涉及之作用相關英文名稱和句型表達方式。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
mineral	礦物質	guttation	泌溢現象
essential elements	必須元素	capillarity	毛細現象
absorb	吸收	cohesive force	內聚力
osmotic pressure	滲透壓	adhesive force	附著力
root hair	根毛	surface tension	表面張力
symplast pathway	共質體路徑	transpiration	蒸散作用
apoplast pathway	質外體路徑	transpiration stream	蒸散流
root pressure	根壓	stomata	氣孔

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ make up _____.

例句：Essential elements are components that **make up** plant structures or metabolites.
必需元素是組成植物體構造或代謝物的成分。

❷ ____ contained in ____

例句：Elements such as C, and O **contained in** gases like CO_2 can enter the plant through the stomata.
C、O 等元素可以 CO_2 氣體形式由氣孔進入植物體。

❸ _____ is/are responsible for V-ing _____.

例句：The maturation zone of a plant's roots **is responsible for** absorb**ing** water and minerals.
植物根部的成熟區負責吸收水和礦物質。

❹ _____ differentiate into _____.

例句：The maturation zone of a plant's roots **differentiates** from outside to inside **into** epidermis, cortex, endothelium, and stele.
根部成熟區由外向內分化為表皮、皮層、內皮、中柱等構造。

❺ _____ from outside to inside.

例句：The maturation zone of a plant's roots differentiates **from outside to inside** into epidermis, cortex, endothelium, and stele.
根部成熟區由外向內分化為表皮、皮層、內皮、中柱等構造。

❻ ____ is/are transported to _____ through _____.

例句：Minerals dissolved in water **are transported to** the stele **through** the symplast pathway.
溶於水中的礦物質藉由共質體路徑運輸至中柱。

❼ _____ absorbed by _____ through _____.

例句：Minerals in the ionic state in soil are mainly **absorbed by** roots **through** active transport.
土壤中離子狀態的礦物質主要由根以主動運輸方式吸收。

❽ ____ is/are affected by ____.

例句：Transpiration **is affected by** environmental factors such as temperature, humidity, wind speed, and light intensity.
蒸散作用受溫度、濕度、風速與光照強度等環境因素影響。

■ 問題講解 Explanation of Problems

學習目標

在學習完本章節後，學生應習得以下概念：
After completing this section, students should acquire the following concepts:
一、學生熟知植物運輸水分的方式。
Students are familiar with the way plants transport water.

例題講解

例題一

說明：學生了解泌液作用、根壓、蒸散作用的原理，以及三者之間的關聯。

Students understand the principles of guttation, root pressure, and transpiration, and the relationship among the three.

In which of the following situations are it more likely that guttation will be observed?

(A) Root pressure exceeds transpiration

(B) When respiration increases

(C) When photosynthesis increases

(D) In windy environments

(E) In humid environments

在下列哪些情況下，較可能觀察到植物的泌液（溢）作用？

(A) 根壓超過蒸散作用

(B) 呼吸作用增強時

(C) 光合作用增強時

(D) 強風的環境

(E) 潮濕的環境

（101 年指考生物 23）

Teacher: When plants transport water, there are three kinds of forces that are considered to be sources of power. Can you remember which they are?

Student: The pushing force of root pressure, capillarity in vessels and tracheids, and the pulling force of transpiration.

Teacher: Yes. Root pressure and transpiration are relatively large forces. Guttation occurs when the root pressure exceeds the transpiration, and usually occurs in the early morning or night when the humidity is high, because the transpiration is weak at this time.

Student: Ok.

Teacher: But the force of root pressure is not strong, so this phenomenon can only be found in dwarf plants.

老師： 植物運輸水分時，有三種力量被認為是動力來源，同學們記得是哪三個嗎？

學生： 根壓的推力、導管與管胞中的毛細現象、蒸散作用的拉力。

老師： 沒錯，而其中根壓與蒸散作用是相對較大的力量。而泌液現象是根壓超過蒸散作用時引起的現象，通常在溼度高的清晨或夜晚發生，因為此時蒸散作用微弱。

學生： 原來如此。

老師： 但是根壓的力量不大，所以這現象只能在矮小的植物發現。

例題二

說明：學生了解植物如何吸收、運輸水分。

Students learn how plants absorb and transport water.

Which of the following statements about water absorption and transport in plants is correct?

(A) Guttation directly helps plants to transport water

(B) Tall plants can transport water like a pump to the top of the tree canopy through root pressure

(C) The pulling force generated by transpiration promotes the continuous upward transport of the water in the xylem

(D) The water and inorganic salts absorbed by root hairs can be transported along the cell wall and intercellular space to the stele

下列有關植物體內水的吸收與運輸之敘述，何者正確？

(A) 泌溢作用（溢水作用）可直接幫助植物體運輸水分。

(B) 高大的植物可藉由根壓將水像唧筒抽水般輸送至樹冠頂。

(C) 蒸散作用產生的拉力促使木質部內的水柱不斷的往上輸送。

(D) 根毛吸收的水和無機鹽可沿著細胞壁和細胞間隙輸送逕入中柱。

（99 指考生物 17）

Teacher: Let's look at option (A). The phenomenon of guttation is caused by root pressure exceeding transpiration, and is not the main driving force of water transport. What are the sources of these driving forces?

Student: Driving forces include root pressure, capillary action in the xylem vessels and tracheids, and the pull force created by transpiration.

Teacher: That's correct!

Teacher: Now let's look at options (B) and (C). The force of root pressure can only push the water in the xylem a few meters, and cannot send water to the top of tall plants. So, what is the main driving force for transporting water in plants?

Student: The pull force of transpiration.

Teacher: That's right, only by the pull force generated by transpiration can the water in the xylem rise to a sufficient height. And let's see option (D), before entering the stele, water encounters the Casparian strip. What is the function of the Casparian strip?

Student: To prevent water penetration.

Teacher: That's right, so when water enters the endodermis along the cell wall and intercellular spaces, it is blocked by the Casparian strip. At this point, water must take another route, entering the endodermal cell through the water channel proteins on the endodermal cell membrane, in order to enter the stele.

老師： (A)，泌液現象是根壓超過蒸散作用時引起的現象，並不是運輸水分的主要動力。請問動力來源有那些呢？

學生： 根壓的推力、導管與管胞中的毛細現象、蒸散作用的拉力。

老師： 沒錯！

老師： (B)、(C)，根壓的力量只能將木質部的水推移數公尺，無法將水送到高大的植物頂端。請問同學們，植物中輸送水分的最主要動力是什麼呢？

學生： 蒸散作用的拉力。

老師： 沒錯，靠著蒸散作用產生的拉力，才能使木質部的水分上升足夠的高度。(D)，水分在進入中柱之前會先遇到卡氏帶，請問卡氏帶的作用是什麼呢？

學生： 阻止水的滲透。

老師： 沒錯，所以水沿著細胞壁和細胞間隙要進入內皮時，會被卡氏帶阻擋下來。此時水必須走另一條路，透過內皮細胞膜上的水通道蛋白進入內皮細胞，才能進入中柱。

3-2 光合作用 Photosynthesis

■ 前言 Introduction

本節介紹植物如何透過光合作用來獲得養分以維持生命，光合作用包含兩個階段：光反應吸收光能轉換成化學能，和固碳反應利用能量將 CO_2 轉變為醣類。本節欲使學生學習光合作用如何運作的相關英文以及其中物質轉換之相關字彙和文法應用。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
photosynthesis	光合作用	photosynthetic pigment	光合色素
light reaction	光反應	photosystem	光系統
carbon fixation reaction	固碳反應	chemiosmotic theory	化學滲透機制
enzyme	酵素	environmental factor	環境因子
thylakoid	類囊體	Calvin cycle	卡爾文循環
chloroplast	葉綠體		

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ take place in _____.

例句：Photosynthesis **takes place in** chloroplasts.
植物的光合作用在葉綠體中進行。

❷ ___ is/are converted into ____

例句：Luminous energy **is converted into** chemical energy, and CO_2 is converted into carbohydrates.
光能轉變為化學能，CO_2 轉變為醣類。

❸ _____ drives _____.

例句：Light is the main source of energy that **drives** photosynthesis.
光是驅動光合作用的主要能量來源。

❹ ____ fix(es) ____ on _____.

例句：Carbon fixation **fixes** CO_2 **on** organic compounds.
固碳作用將 CO_2 固定至有機物中。

❺ ___ be separated as ____.

例句：The energy released by electrons can **be separated as** activation energy for specific electron carriers located on the thylakoid membrane.
電子釋放的能量可以作為活化能，作用於位於類囊體膜上的特定電子載體。

❻ As _____.

例句：**As** the concentration of CO_2 increases, the rate of photosynthesis also increases.
隨著 CO_2 的濃度增加，光合作用速率也會隨之增加。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本章節後，學生應習得以下概念：

After completing this section, students should acquire the following concepts:

一、學生熟知光合作用的參與構造與反應過程。

Students are familiar with the structures and reaction processes involved in photosynthesis.

❧ 例題講解 ☙

例題一

說明：學生了解光合作用光反應的過程。

Students learn about the process of light reactions during photosynthesis.

Before the synthesis of glucose molecules, the energy generated by photosynthesis will be temporarily stored in which of the following molecules?

合成葡萄糖分子前，光合作用所產生的能量會暫存在下列哪些分子中？

(A) NADH

(B) NADPH

(C) ATP

(D) ADP

(E) AMP

（101 年指考生物 29）

Teacher: In the light reactions of photosynthesis, we know that photosynthetic pigments absorb light energy. Which kind of energy is converted into which other kind of energy for storage?

Student: Light energy is converted into chemical energy.

Teacher: That's right! When chlorophyll a in the reaction center receive energy, it will excite high-energy electrons and enter the electron transfer chain. With the energy released when the electrons are transferred between different carriers, what will be driven into the thylakoid lumen by active transport?

Student: H^+.

Teacher: Correct! In addition, what other molecular decomposition will produce H^+ to accumulation in the thylakoid lumen?

Student: H_2O .

Teacher: That's right! After the thylakoid lumen accumulates a high concentration of H^+, H^+ moves from the thylakoid lumen to the chloroplast stroma along the concentration gradient. When H^+ flows through the ATP synthase on the thylakoid, it can be activated. What can the activated ATP synthase stored in the stroma be synthesized into in order to store energy?

Student: Phosphorylates ADP to synthesize ATP.

Teacher: Very good! This is the formation of the first energy molecule. After the high-energy electrons released by P700 enter the electron transfer chain, what will receive the electrons in the end? What kind of molecules are reduced to store energy?

Student: $NADP^+$ receives electrons and is reduced to NADPH.

Teacher: That's right! This is the formation of the second energy molecule.

Teacher: So, students, do you know the energy source for the carbon fixation reaction before glucose is synthesized?

Student: ATP and NADPH produced by light reactions.

老師： 光合作用的光反應中，我們知道藉由光合色素吸收光能，並將什麼能量轉換成什麼能量儲存？

學生： 光能轉換成化學能。

老師： 沒錯！反應中心的葉綠素 a，接受能量後會激發出高能電子，並進入電子傳遞鏈中，隨著電子在不同載體間的傳遞時所釋放出得能量，會促使什麼主動運輸進入類囊體腔中？

學生： H^+（氫離子）。

老師： 正確！除此之外，還有什麼分子的分解會產生 H^+ 累積於類囊體腔中？

學生： H_2O。

老師： 沒錯！類囊體腔蓄積了高濃度的 H^+ 後，促使 H^+ 順著濃度梯度由類囊體腔向葉綠體基質移動，當 H^+ 流經於類囊體上的 ATP 合成酶時可將其活化，活化的 ATP 合成酶可以將基質中的什麼合成為什麼儲存能量？

學生： 將 ADP 磷酸化，以合成 ATP。

老師： 非常好！這即是第一種能量分子的形成。由 P700 釋出的高能電子進入電子傳遞鏈後，最終又由誰來接收電子？並還原為什麼分子儲存能量？

學生： NADP+接收電子，並被還原為 NADPH。
老師： 沒錯！這即是第二種能量分子的形成。
老師： 因此同學們，我們知道在合成葡萄糖前，也就是固碳反應的能量來源是什麼呢？
學生： 光反應產生的 ATP 和 NADPH。

例題二

說明：學生了解植物進行光合作用的過程。
Students learn about the process of photosynthesis in plants.

Which of the following statements about photosynthesis is correct?
(A) The efficiency of plants' utilization of red, blue, and green light is not the same.
(B) Most of the chlorophyll is directly involved in the transfer of electrons in light reaction.
(C) The final product glucose is produced in grana.
(D) Water molecules are split in photosystem I to produce H^+, e^- and O_2.

下列有關光合作用的敘述，何者正確？
(A) 植物利用紅光、藍光及綠光的效率並不相同。
(B) 大部分的葉綠素直接參與光反應中電子的傳遞。
(C) 最終產物葡萄糖在葉綠餅中產生。
(D) 水分子在光系統 I 被裂解產生 H^+、e^- 及 O_2。

（103 年指考生物 9）

Teacher: Photosynthetic pigments in plants are mainly divided into two types: chlorophyll and carotenoids. Do you remember which color of light can be absorbed by chlorophyll a, chlorophyll b and carotenoids?
Student: Chlorophyll a and chlorophyll b mainly absorb red and blue-violet light, and carotenoids mainly absorb purple and blue light.
Teacher: Correct! So, we know that (A) plants have different utilization efficiencies for red light, blue light and green light.
Teacher: During the photoreaction process, the electrons lost in the reaction center are supplied by electrons decomposed from H_2O, then H^+ and O_2 are generated. Does this happen in Photosystem II or Photosystem I?

Student: Photosystem II.
Teacher: Right, so (D) occurs in Photosystem II.
Teacher: Then let's look at option (B). Does most of the chlorophyll directly participate in the transfer of electrons during photoreaction?
Student: No, chlorophyll a molecules are directly involved in the transfer of electrons during photoreaction.
Teacher: Right! So, for the option (C), the final product glucose is produced in the carbon fixation reaction. Where does the carbon fixation reaction occur?
Student: In the stroma of chloroplasts.
Teacher: So (C) glucose is produced in the chloroplast stroma.

老師： 植物體內的光合色素主要分為葉綠素和類胡蘿蔔素兩類，同學們還記得葉綠素 a、葉綠素 b 以及類胡蘿蔔素主要吸收哪種顏色的光嗎？
學生： 葉綠素 a 和葉綠素 b 主要吸收紅光和藍紫光，類胡蘿蔔素主要吸收紫光和藍光。
老師： 正確！因此我們可以知道(A)植物對於紅光、藍光及綠光有不同的利用效率。
老師： 光反應過程中，反應中心所流失的電子由 H_2O 分解出電子補充，並生成 H^+及 O_2，請問這是發生於光系統 II 還是光系統 I 中？
學生： 光系統 II。
老師： 沒錯，因此(D)是發生於光系統 II 中。
老師： 那麼(B)大部分的葉綠素有直接參與光反應中電子的傳遞嗎？
學生： 沒有，葉綠素 a 分子才直接參與光反應中電子的傳遞。
老師： 沒錯！(C)最終產物葡萄糖是生成於固碳反應中，請問固碳反應的位置在哪裡？
學生： 葉綠體的基質中。
老師： 所以(C)葡萄糖在葉綠體基質中產生。

3-3 有機養分的運輸
Transportation of organic nutrients

■ 前言 Introduction

本節介紹植物有機養分的運輸管道、主要運送的物質、運輸的機制與方向。語言部分將介紹植物養分運輸相關構造、學說、物質等單字以及描述運輸過程或原理之英文句型。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
organic nutrients	有機養分	source	供給部
phloem	韌皮部	sink	匯集部
conducting tissues	輸導組織	sieve tube	篩管
Pressure Flow Hypothesis	壓力流假說	sucrose	蔗糖

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ flows from _____ to _____.

例句：The material in the sieve tube passively **flows from** higher pressure areas **to** the lower pressure areas.

篩管內物質由壓力較高處被動的流向壓力較低處。

❷ ____ depend(s) on ____

例句：The rate of pressure flow **depends on** the sucrose concentration in the sap.
壓力流動的速率主要取決於汁液中的蔗糖濃度。

❸ _____ requires _____.

例句：Nutrient transport in the phloem **requires** energy.
韌皮部的養分運輸需要消耗能量。

❹ _____ is/are transported to_____.

例句：During the growth period, the leaves are the source of sucrose, which **is transported to** the roots for storage.
在生長期，葉是蔗糖的供給部，蔗糖被運輸到根部儲存。

❺ _____ sometimes _____ and sometimes _____.

例句：The same organ of a plant may differ depending on the season, **sometimes** it is the source, **and sometimes** it is the sink.
植物的同一器官會因季節的不同，有時為供給部，有時為匯集部。

❻ _____ rely/relies on _____.

例句：Pressure flow **relies on** the assistance of a transpiration stream in the vessel.
壓力流需要依賴導管中蒸散流的幫助。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本章節後，學生應習得以下概念：

After completing this section, students should acquire the following concepts:

一、學生熟知有機養分的運輸方式。

Students are familiar with the transportation methods of organic nutrients.

❧ 例題講解 ☙

例題一

說明：學生了解植物養分產生和運輸的方式。

Students understand the ways in which plants produce and transport nutrients.

Which of the following statements about the production and transportation of nutrients in plants is correct?

(A) Nutrients are produced by meristematic tissue.

(B) The main nutrient transported in the phloem is sucrose.

(C) Organic nutrients in the stem are transported upward.

(D) Nutrient transport in the leaves does not depend on the sieve tubes.

下列有關植物養分的產生與運輸，何者正確？

(A) 植物養分由分生組織產生。

(B) 篩管內運輸的主要養分是蔗糖。

(C) 莖部的有機養分向上輸送。

(D) 葉片中運輸養分無需靠篩管。

（修改自 101 年指考生物 18）

Teacher: Option (A), nutrients in plants are not produced by meristematic tissue, but by tissue that contains chloroplasts. Can anyone give examples of cells that have chloroplasts?

Student: Mesophyll cells and guard cells.

Teacher: That's right! Therefore, nutrients are produced by the guard cells in the epidermal tissue and the mesophyll cells in the ground tissue. Look at option (B), What is the main nutrient transported in the sieve tubes?

Student: Sucrose.

Teacher: Yes, therefore option (B) is correct. And for option (C), what is the direction of organic nutrient transportation in the stem?

Student: According to the different positions of the source and sink, organic nutrient transport in the stem can occur in either an upward or downward direction.

Teacher: Great job! In option (D), what type of cells in the sieve tubes transport nutrients in the leaf?

Student: Sieve tube cells.

Teacher: Correct, therefore for option (D), nutrient transport in the leaf still requires the function of sieve tubes for transportation.

老師： (A) 植物的養分不是由分生組織產生的，而是由具有葉綠體的組織產生，請問同學們可以舉出有哪些細胞具有葉綠體呢？

學生： 葉肉細胞跟保衛細胞。

老師： 沒錯！因此養分是由表皮組織的保衛細胞跟基本組織的葉肉細胞產生的。(B)篩管內運輸的主要養分是什麼？

學生： 蔗糖。

老師： 正確，因此(B)選項是對的。(C)莖部的有機養分運輸方向為何？

學生： 根據供給部和匯集部的位置不同，莖部有機養分的運送可以由上而下，也可以由下而上。

老師： 非常好！(D)葉片中養分是藉由韌皮部的什麼細胞運輸？

學生： 篩管細胞。

老師： 沒錯，因此(D)葉片中運輸養分仍需要篩管執行運輸功能。

例題二

說明：了解植物體有機養分的運輸、了解植物細胞的構造與功能。

Understanding the transportation of organic nutrients in plants and the structure and function of plant cells.

Which of the following is true about plant nutrient and water transportation?

(A) The sap that flows out from the stylet of aphids mainly contains amino acids and hormones.

(B) Plasmodesmata provide a transport pathway for carbohydrates produced by leaf mesophyll cells.

(C) The Pressure Flow Hypothesis can be used to explain the transport mechanism of nutrients in the phloem.

(D) Plant nutrients can be transported from the roots upward.

(E) The chloroplasts in the cytoplasm of *Egeria densa* move by diffusion.

下列有關植物養分與水分運輸哪些正確？

(A) 蚜蟲口針（器）流出的韌皮部汁液主要為胺基酸及激素。

(B) 原生質絲提供葉肉細胞生產之醣類運輸管道。

(C) 壓力流學說可以用來解釋養分在韌皮部中的運輸機制。

(D) 植物的養分可從根部往上運送。

(E) 水蘊草細胞質中的葉綠體是靠擴散方式移動。

（110 年指考生物 34）

Teacher: What is the main substance transported by the phloem sap in option (A)?

Student: Sucrose.

Teacher: Correct! Therefore, the answer to (A) is water and sugars (sucrose), with very few hormones in the phloem sap excreted by the aphid stylet. What are the methods that for transporting sugars produced by leaf mesophyll cells?

Student: Sugars can be transported into the sieve tubes through diffusion, cytoplasmic streaming, or active transportation with the help of companion cells.

Teacher: Correct! Therefore, the answer to (B) is that the plasmodesmata can provide transport channels for the sugars produced by the leaf mesophyll cells. What hypothesis does the mechanism of organic nutrient transport in the phloem of plants rely on?

Student: Pressure flow theory.

Teacher: Correct! Therefore, in option (C), we can use this theory to explain how the nutrients produced by plants are transported to other parts. And for option (D), what is the direction of nutrient transport, upward or downward?

Student: It can be either downward or upward, depending on the sink, which is the location where the nutrients are required.

Teacher: Good job! And in (E), do the chloroplasts in the cytoplasm of *Egeria densa* move by diffusion?

Student: No, they move by cytoplasmic streaming.

Teacher: That's right! Strictly speaking, it is the role of the cytoskeleton that allows chloroplasts to move.

老師： (A) 韌皮部運送的物質主要為何？

學生： 蔗糖。

老師： 沒錯！因此(A)蚜蟲口針（器）流出的韌皮部汁液主要為水分與醣類（蔗糖），激素量非常少。請問同學們有哪些方式提供葉肉細胞生產之醣類運輸？

學生： 可以經由擴散作用、原生質流或伴細胞的主動運輸協助運送進入篩管。

老師： 沒錯！因此(B)原生質絲是可以提供葉肉細胞生產之醣類運輸管道的。植物韌皮部有機養分的運輸機制建立於哪個假說之上？

學生： 壓力流假說。

老師： 正確！因此(C)我們可以用這個學說解釋植物產生的養分是如何被運輸至其他部位的。(D)養分的運輸方向是向上還是向下的？

學生： 可以向下，也可以向上，依據匯集部也就是需求的部位而定。

老師： 非常好！(E)水蘊草細胞質中的葉綠體是靠擴散方式移動嗎？

學生： 不是，是靠水蘊草原生質流移動的。

老師： 沒錯！而嚴格講起來則是細胞骨架的作用讓葉綠體移動的。

★ 主題四 植物體的生殖、生長與發育 ★
Reproduction, Growth and Development in Plants

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■ 前言 Introduction

本章介紹植物的生殖方式與生殖器官，植物的生殖方式分為有性生殖與無性生殖，有性生殖器官包含花、果實、種子。接著介紹植物有性生殖過程，種子萌發與幼苗的生長，以及植物激素對於植物個體生長發育的影響，和植物對於外在環境刺激的反應。語言部份則著重植物生殖器官、相關反應的英文名稱以及如何描述植物生長發育過程的句型和文法。

4-1 植物的生殖
Plant reproduction

■ 前言 Introduction

本節介紹植物生殖的方式依是否有受精作用，區分為無性生殖與有性生殖，以及植物的生殖器官－花、果實、種子。有性生殖涉及孢子體與配子體的世代交替，此方法能使子代產生較高的基因多樣性。無性生殖方式有能完全保留植物的基因的特性，因此衍生出利用此特點的技術，如扦插法、壓條法等等。本節英文部分介紹植物各式生殖方式的英文詞彙和其生殖過程的英文敘述方式。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
gamogenesis / sexual reproduction	有性生殖	diagenesis/alternation of generations	世代交替
asexual reproduction	無性生殖	sporophyte	孢子體
vegetative reproduction	營養繁殖	gametophyte	配子體
cuttage	扦插法	bisexual flower / perfect flower	兩性花
style grafting method	嫁接法	unisexual flower	單性花
layerage	壓條法	angiosperm	被子植物
high pressure method	高壓法	fertilization	雙重受精
tissue culture	組織培養	spore	孢子
totipotency	全潛能性	gamete	配子

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ be accomplished by _____.

例句：Plant reproduction is the production of new offspring in plants, which can **be accomplished by** sexual or asexual reproduction.

植物繁殖是植物產生新的後代，可以通過有性或無性繁殖來完成。

❷ ____ give rise to ____

例句：Totipotency is the ability of a plant cell to **give rise to** an entire new plant.

全潛能性是植物細胞產生完整新植物的能力。

❸ _____ grow into _____.

例句：Callus can differentiate and **grow into** a complete plant.

療傷組織能分化長成完整植株。

❹ _____ unite(s) with _____

例句：Double fertilization is a chief trait of flowering plants in which one female gamete **unites with** two male gametes.

雙重受精是開花植物的主要特徵。在這種現象中，一個雌性配子與兩個雄性配子結合。

❺ _____ be spread by _____.

例句：Some fruits have wings and can **be spread by** the wind.

有些果實具有翅，可以藉風力傳播。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本章節後，學生應習得以下概念：

After completing this section, students should acquire the following concepts:

一、學生熟知被子植物的有性生殖。

Students are familiar with the sexual reproduction of angiosperms.

❧ 例題講解 ☙

例題一

說明：學生了解被子植物的生活史。

Students understand the life history of angiosperms.

In the life history of angiosperms, which of the following is diploid?

(A) Megaspores

(B) Endosperm mother cells (endosperm nucleus)

(C) Microsporocytes

(D) polar nuclei

在被子植物的生活史中，下列何者是雙倍體？

(A) 大孢子

(B) 胚乳母細胞（胚乳核）

(C) 小孢子母細胞

(D) 極核

（104 年指考生物 12）

Teacher: In which stage of the life cycle of a plant body are angiosperms commonly seen? And what is its ploidy?

Student: Sporophyte, diploid (2n).

Teacher: That's right! After the sporophyte matures, it will undergo meiosis to produce spores. For example, there are pollen sacs in the anther of the stamens, and there are microsporocytes (2n) in the sacs. How many microspores will be produced after meiosis? And what is the ploidy of spores?

Student: 4 microspores, haploid (n).

Teacher: Let's see another example, there are ovules in the ovary of the pistil, and there are megasporocytes (2n) in the nucellus. After meiosis, 4 daughter cells will be produced, 3 of which will degenerate. How many will develop into megaspores? What is the ploidy?

Student: Only 1 develops into a megaspore and it is haploid (n).

Teacher: Therefore, we can know that for option (C) the microsporocyte is diploid (2n) and for (A) the megaspore is haploid (n).

Teacher: Next, spores can undergo mitotic division to develop into a multicellular gametophyte. For example, megaspores undergo three rounds of mitotic division to form an embryo sac (female gametophyte) consisting of seven cells and eight nuclei. In addition to the egg (female gamete), the embryo sac also contains a central cell. How many polar nuclei are present in the central cell, and what is their ploidy?

Student: 2 polar nuclei, haploid of n+n.

Teacher: That's right! When the central cells of two polar nuclei and a sperm cell are fertilized to form endosperm mother cells, what is the ploidy of endosperm mother cells at this time?

Student: Triploid.

Teacher: Very good! So we know that option (D), polar nuclei are haploid and (B) endosperm mother cells (endosperm nuclei) are triploid.

老師： 平常所見的被子植物，其植物體為生命週期的哪一個階段？是幾倍體？

學生： 孢子體，二倍體(2n)。

老師： 沒錯！在孢子體成熟後會進行減數分裂產生孢子，例如雄蕊的花藥內具有花粉囊，囊內具有小孢子母細胞(2n)，減數分裂後會產生幾個小孢子？是幾倍體？

學生： 4 個小孢子，單倍體(n)。

老師： 再舉一個例子，雌蕊的子房內具有胚珠，珠心內有大孢子母細胞(2n)，減數分裂後會產生 4 個子細胞，其中 3 個退化，只有幾個發育成為大孢子？為幾倍體？

學生： 只有 1 個發育成為大孢子，是單倍體(n)。

老師： 因此我們知道(C)小孢子母細胞 是二倍體(2n)，(A)大孢子是單倍體(n)。

老師： 接著，孢子可行有絲分裂分育成多細胞的配子體，例如大孢子行 3 次有絲分裂，形成 7 個細胞 8 個核的胚囊(雌配子體)，胚囊中除了有卵(雌配子)，還有中央細胞，請問中央細胞有幾個極核？為幾倍體？

學生： 2 個極核，為 n+n 的單倍體。

老師： 沒錯！當兩個極核的中央細胞和一個精細胞受精而形成胚乳母細胞，請問此時胚乳母細胞為幾倍體？

學生： 3 倍體。

老師： 非常好！因此我們知道(D)極核為單倍體，(B)胚乳母細胞(胚乳核)為 3 倍體。

例題二

說明：了解被子植物的有性生殖過程。

Understand the sexual reproduction process of angiosperms.

Seeds develop from which of the following structures?

(A) ovules

(B) ovaries

(C) polar nuclei

(D) egg cells

種子是由下列何種構造發育而成？

(A) 胚珠

(B) 子房

(C) 極核

(D) 卵細胞

（103 指考生物 20）

Teacher: What is inside the ovary of the pistil?

Student: Ovule.

Teacher: The periphery of the ovule is called the integument and the integument surrounds the nucellus. There are megasporocytes in the nucellus. Can anyone tell me what will be formed by meiosis?

Student: Megaspores.

Teacher: When meiosis occurs three times in the megaspore, it forms an embryo sac with seven cells and eight nuclei. What does the embryo sac contain?

Student: One egg and a central cell with two polar nuclei.

Teacher: That's right! Next, double fertilization occurs. What is formed when one sperm cell fertilizes the egg cell? And what is formed when the other sperm cell fertilizes the central cell?

Student: When a sperm cell fertilizes the egg cell, a zygote is formed. When the other sperm cell fertilizes the central cell, an endosperm mother cell is formed.

Teacher: After undergoing mitosis, what do the zygote and the endosperm mother cell develop into?

Student: Embryo and endosperm.

Teacher: Seeds include embryos, endosperms and seed coats. So, what structure do seeds develop from?

Student: (A), ovule.

Teacher: What do (B) ovary, (C) polar nuclei and (D) egg cells develop and form respectively?

Student: Fruit, endosperms, and embryos.

老師： 雌蕊的子房內具有什麼？

學生： 胚珠。

老師： 胚珠外圍稱為珠被，珠被包裹珠心，珠心內有大孢子母細胞，行減數分裂會形成什麼？

學生： 大孢子。

老師： 大孢子行 3 次有絲分裂，會形成 7 個細胞 8 個核的胚囊，胚囊中含有什麼？

學生： 一個卵和具有 2 個極核的中央細胞。

老師： 沒錯！接下來進行雙重受精作用，1 個精細胞與卵細胞結合會形成什麼？另外 1 個精細胞與中央細胞結合會形成什麼？

學生： 精細胞與卵細胞結合會形成合子；精細胞與中央細胞結合會形成胚乳母細胞。

老師： 合子和胚乳母細胞行有絲分裂以後又會發育成為什麼？

學生： 胚和胚乳。

老師： 種子就包括胚、胚乳以及種皮。因此種子由什麼構造發育而成？

學生： (A)胚珠。

老師： (B)子房、(C)極核和(D)卵細胞分別發育形成什麼？

學生： 果實、胚乳和胚。

4-2 種子的萌發與幼苗的生長
Germination of Seeds and Growth of Seedlings

■ 前言 Introduction

本節介紹種子的萌發以及其養分的來源、影響種子休眠的外在與內在的因子，以及雙子葉植物與單子葉植物幼苗的生長過程。語言部分介紹單子葉雙子葉植物的構造和特性之英文表達方式。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
seed	種子	dormancy	休眠
germination	萌發	plumule/germ	胚芽
monocotyledon (monocot)	單子葉植物	coleoptile	芽鞘
dicotyledon (dicot)	雙子葉植物	embryonal axis	胚軸
endosperm	胚乳		

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ persists in _____.

例句：In monocotyledons, the endosperm **persists in** mature seeds and stores nutrients.
在單子葉植物中，胚乳存在於成熟的種子中並儲存養分。

❷ ___ play(s) a crucial role in _____

例句：The polarity of the embryonal axis **plays a crucial role in** the differentiation and growth patterns of embryonic cells during development.
胚胎軸的極性在指導胚胎細胞發育過程中的分化和生長模式方面起著至關重要的作用。

❸ _____ assist(s) in _____.

例句：Water can **assist in** the transportation of substances and participates in the hydrolysis of macromolecular nutrients.
水可以協助物質的運輸並參與大分子養分的水解。

❹ ____ participate(s) in _____.

例句：Water can assist in the transportation of substances and **participates in** the hydrolysis of macromolecular nutrients.
水可以協助物質的運輸並參與大分子養分的水解。

❺ _____ is affected by _____.

例句：Seed germination **is affected by** the external environmental and internal physiological factors.
種子萌發受到外在環境和內在生理因素影響。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本章節後，學生應習得以下概念：

After completing this section, students should acquire the following concepts:

學生熟知種子的萌發與幼苗的生長過程。

Students are familiar with the process of seed germination and seedling growth.

❧ 例題講解 ☙

例題一

說明：能了解植物幼苗生長並能根據圖表作解釋、歸納。

Able to understand the growth of plant seedlings and explain and make a summary based on graphs.

Figure 3 shows the seed germination process of general dicotyledonous plants. The relative weights of epicotyl, hypocotyl and cotyledons vary considerably. Which diagram of most reasonably illustrates these three relationships?

（ ····· epicotyl, ——— hypocotyl, —·— cotyledons）

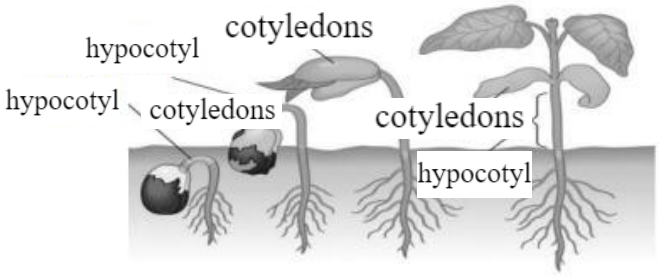


Fig. 3.

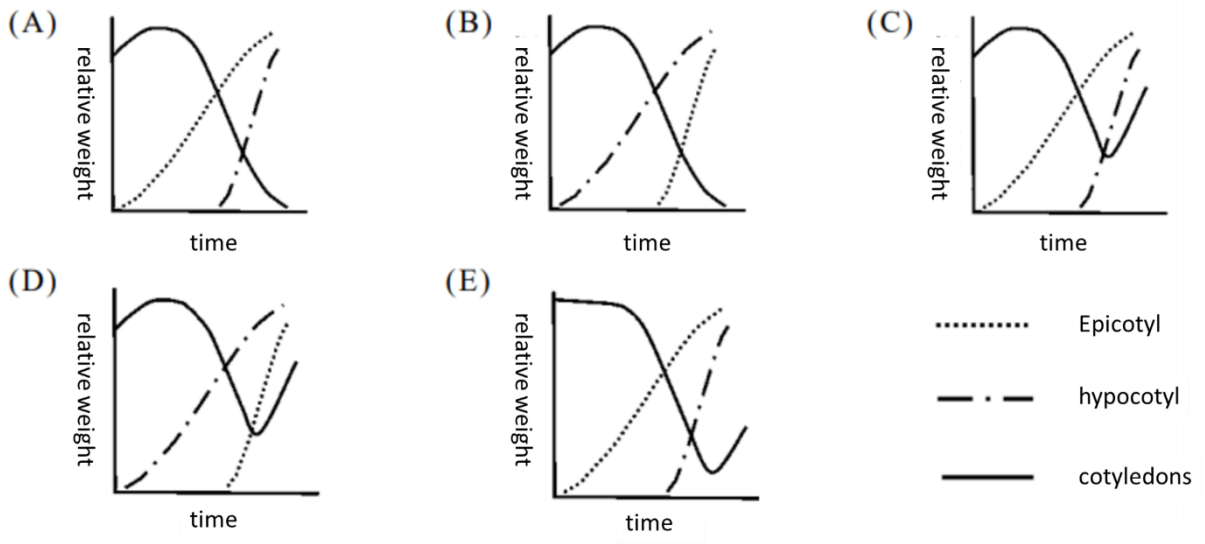


圖 3 為一般雙子葉植物的種子萌發過程，其上胚軸、下胚軸以及子葉的相對重量變化相當大。下列選項的三者關係圖（ ····· 上胚軸，——— 下胚軸，—·— 子葉），何者最合理？

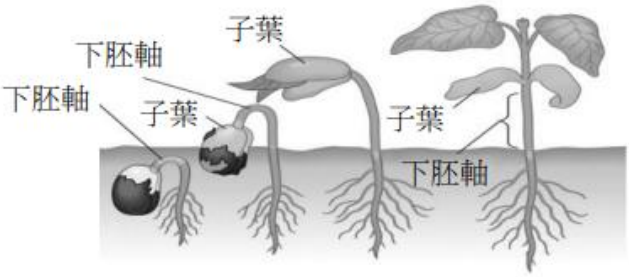
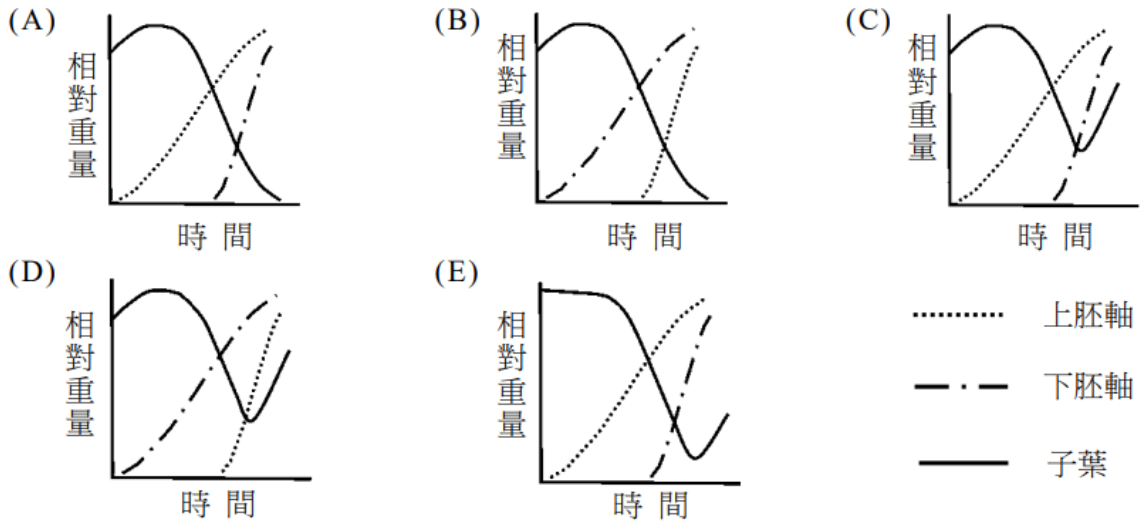


圖 3



（108 年學測生物 12）

Teacher: Before answering the question, what is the part between the cotyledon and the radicle called?

Student: Hypocotyl.

Teacher: That's right! Then what is the part protruding from the embryo axis on the cotyledons called?

Student: Epicotyl.

Teacher: Correct! When the seed first germinates, which part has the heaviest relative weight?

Student: Cotyledons.

Teacher: That's right! In the early stages of development of angiosperm plants, cotyledons serve as the main source of nutrients, gradually supplying nutrients for the development of the plant body. They gradually decrease in weight until they eventually wither and fall off. Which of the curves in these graphs best matches the relative weight changes of the cotyledons?

Student: Option A and B.

Teacher: That's correct! In the process of seed germination, the first step is breaking through the seed coat. Then, the cotyledons and embryonic shoot emerge from the soil in a hooked shape. Which embryo axis extends and grows during this process?

Student: Hypocotyl.

Teacher: Correct! Hypocotyls grows faster than epicotyls, so they pull the cotyledons out of the ground. The cotyledons turn green after being exposed to light and accumulate nutrients through photosynthesis and swell. Therefore, we should select option (B).

Teacher: After the hypocotyl breaks through the soil and is exposed to light, the epicotyl straightens as it starts to grow and develop. Therefore, how does the relative weight of the epicotyl change?

Student: The relative weight of the epicotyl is 0 at the beginning, and then it gradually extends and grows. The relative weight grows at the same time.

老師： 在回答題目前，請問同學依子葉附著點為分界，子葉和胚根之間的部分稱為？

學生： 下胚軸。

老師： 沒錯！那麼子葉上方突出胚軸的部分則稱為？

學生： 上胚軸。

老師： 正確！那麼請問種子剛萌芽時，哪一部位的相對重量最重呢？

學生：　子葉。

老師：　沒錯！子葉在被子植物體發育初期為主要營養來源，慢慢供給養分給植物體發育利用，並逐漸減少變輕，最終萎縮而掉落，這些圖中的曲線哪些最符合子葉相對重量的變化？

學生：　(A)跟(B)。

老師：　沒錯！在種子萌芽過程中，首先突破種皮，呈現鉤狀將子葉與胚芽頂出土壤，並延伸生長的是上胚軸還是下胚軸？

學生：　下胚軸。

老師：　正確！下胚軸延伸速率較上胚軸快，故會將子葉拉出地面，子葉經光照後會轉綠，並進行光合作用累積養分而膨大，故選(B)。

老師：　下胚軸突破土壤後照光，上胚軸才拉直開始生長發育，因此上胚軸的相對重量應為怎麼樣改變？

學生：　上胚軸一開始相對重量為０，之後逐漸延伸生長，相對重量一路成長。

例題二

說明：了解單子葉植物種子的構造、形態。

Understand the structure and morphology of monocot seeds.

Figure 1 is a schematic diagram of the structure of a corn seed. Which part in the picture is the "cotyledon" or "cotyledon disc"?

(A) A **(B) B** (C) C (D) D (A is 甲; B is 乙; C is 丙; D is 丁)

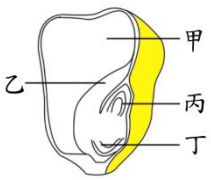
圖一為玉米種子的構造示意圖，試問圖中的哪一部位為「子葉」或 稱「子葉盤」？

(A)甲

(B)乙

(C)丙

(D)丁



圖一

（94 年指考生物 10）

Teacher:　Which part is the cotyledon?

Student:　(B).

Teacher:　That's right! Cotyledons are also called cotyledon discs, so the correct answer is (B). Which part is the endosperm?

Student: (A)

Teacher: Correct! Then what are the structures of C and D?

Student: C is the germ, and D is the radicle.

老師： 請問同學們，子葉代號為何？

學生： 乙。

老師： 沒錯！子葉又稱為子葉盤，故正確答案選(B)。那麼胚乳代號為何？

學生： 甲。

老師： 正確！代號丙和丁又分別為什麼構造？

學生： 丙為胚芽，丁為胚根。

4-3 植物激素
Plant Hormones

■ 前言 Introduction

本節介紹植物激素的特性，以及在被子植物中常見的激素種類與功能。語言則介紹各種植物激素和其功能作用的英文名稱。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
plant hormone	植物激素	abscisic acid	離層酸
auxin	生長素	ethylene	乙烯
gibberellin	吉貝素	apical dominance	頂芽優勢
cytokinins	細胞分裂素	antagonism	拮抗作用

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ play(s) a crucial role in _____.

例句：Phytohormones (PHs) **play a crucial role in** the regulation of various physiological and biochemical processes.

植物激素 (PHs) 在調節各種生理和生化過程中起著至關重要的作用。

❷ ____ be present in ____.

例句：Auxin **is present in** all parts of a plant, although in very different concentrations.
生長素存在於植物的所有部分，儘管其濃度非常不同。

❸ _____ develop(s) from _____.

例句：A branch **develops from** a bud derived from a group of meristematic cells in the axil of a leaf.
分枝從葉腋中的一組分生組織細胞衍生的芽發育而來。

❹ _____ essential for _____.

例句：Cytokinins comprise a family of signaling molecules **essential for** regulating the growth and development of plants, acting both locally and remotely.
細胞分裂素包含一個信號分子家族，對調節植物的生長和發育至關重要，在局部和遠處發揮作用。

❺ _____ benefit(s) at the expense of another _____.

例句：Antagonism is a type of interaction between organisms where one organism **benefits at the expense of another**.
拮抗作用是生物體之間的相互作用，其中一個生物體以犧牲另一個生物體為代價獲益。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本章節後，學生應習得以下概念：

After completing this section, students should acquire the following concepts:

一、學生熟知植物激素的特性。

Students are familiar with the characteristics of plant hormones.

二、學生熟知植物激素的種類與功能。

Students are familiar with the types and functions of plant hormones.

❧ 例題講解 ☙

例題一

說明：了解植物激素的作用。

Understand the role of plant hormones.

Which of the following statements about plant hormones are correct?

(A) Some plant hormones are similar to animal hormones and contain protein components.

(B) Hormones can have antagonistic or additive effects on each other.

(C) Larger organs require higher concentrations of hormones to elicit physiological effects.

(D) If rice seedlings are infected with fungi that secrete gibberellins, they will grow taller than uninfected plants.

(E) Hormones synthesized in roots can be transported to leaves through phloem.

下列有關植物激素的敘述，哪些正確？

(A) 有些與動物激素相似，具有蛋白質成份。

(B) 激素間具有拮抗或加成的作用。

(C) 比較大的器官需要較高濃度的激素才能引發生理作用。

(D) 若水稻幼苗被分泌吉貝素的真菌所感染，其將會長得比未被感染的植株高。

(E) 在根合成的激素可經由韌皮部運送至葉進行作用。

（106 年指考生物 33）

Teacher: What are animal hormones mostly composed of?

Student: Proteins.

Teacher: Most plant hormones are composed of small organic molecules. There are currently no known plant hormones that contain protein components. Therefore, (A) is incorrect.

Teacher: (B) states that hormones can have antagonistic or additive effects on each other. Can someone give an example of hormones that have an antagonistic effect?

Student: Cytokinins and auxins. Auxins inhibit lateral bud growth while cytokinins promote bud growth.

Teacher: Very good! Can you give me another example of hormones with additive effects?

Student: Cytokinin and auxin can also work together. When they are at a certain concentration ratio, they promote cell division but not differentiation, forming callus tissue. When the ratio of the two hormones increases, callus tissue will form roots, and when the ratio decreases, callus tissue will form shoots.

Teacher: Correct! Therefore, (B) hormones can have antagonistic or additive effects. What about (C)? Do larger organs require higher hormone concentrations to induce physiological effects?

Student: Most plant hormones have an effect at trace concentrations, and the concentration of hormones varies with different plant organs, regardless of organ size.

Teacher: Good! For example, what effect does a high concentration of auxin have on roots?

Student: It inhibits root growth.

Teacher: Right! Instead, low concentrations of auxin promote root growth. What about (D)? What are the functions of gibberellins?

Student: They promote cell elongation and cell division, causing stem elongation and plant growth.

Teacher: Very good. Therefore, if rice seedlings are infected with fungi that secrete gibberellins, how will they grow compared to uninfected plants?

Student: They will grow taller!

Teacher: Yes! And for (E), how can hormones synthesized in the roots be transported to the leaves?

Student: Through diffusion or transport through vascular bundles.

Teacher: Correct! Therefore, hormones can also be transported through the phloem from the roots to the leaves!

老師： 請問同學們動物激素大部分都由什麼物質構成？

學生： 蛋白質。

老師： 而植物激素大部分都是由小分子有機物組成，目前已經確知的植物激素尚無蛋白質成分者。因此(A)是錯誤的。

老師： 那麼(B)激素間具有拮抗或加成的作用，同學可以舉例有拮抗作用的激素嗎？

學生： 細胞分裂素跟生長素，生長素會抑制側芽的生長，而細胞分裂素會促進側芽的生長。

老師： 非常好！那麼同學們可以再舉一個有加成作用的激素嗎？

學生： 細胞分裂素跟生長素也可以混合作用，兩者在一定濃度比率時，會使細胞分裂但不會分化，形成癒傷組織；當兩者濃度比率升高時，癒傷組織會形成根；濃度比率下降時，則會使癒傷組織形成芽。

老師： 沒錯！因此(B)激素間具有拮抗或加成的作用！那麼(C)比較大的器官需要較高濃度的激素才能引發生理作用嗎？

學生： 大部分植物激素在微量濃度下便有作用，作用的植物器官種類的不同，激素濃度高低才有所不同，與器官大小無關。

老師： 沒錯！像是生長素對於根部的作用，當生長素濃度高時會對根有什麼作用？

學生： 抑制根的生長。

老師： 沒錯，反而是當生長素濃度低時，才能促進根的生長。(D)吉貝素具有怎麼樣的功能？

學生： 促進細胞伸長和細胞分裂，使莖的節間增長、植株長高。

老師： 正確！因此若水稻幼苗被分泌吉貝素的真菌所感染，那麼他將會長得比未被感染的植株還要怎麼樣？

學生： 高！

老師： 沒錯！(E)在根合成的激素可經由什麼運送至葉進行作用？

學生： 擴散作用或是透過維管束運送。

老師： 沒錯！因此激素也可以透過韌皮部從根部運送至葉進行作用！

例題二

說明：了解有關植物荷爾蒙的作用。

Understand the role of plant hormones.

Which of the following statements about the effects of plant hormones are correct?

(A) Gibberellins can promote stem elongation and seed germination in plants.

(B) Abscisic acid (ABA) promotes abscission layer formation.

(C) Cytokinins stimulate plant cell division and delay leaf aging.

(D) The effects of auxin are related to apical dominance, phototropism, and gravitropism.

(E) The gaseous plant hormone ethylene can promote stomatal closure.

下列有關植物荷爾蒙（激素）作用的敘述，哪幾項正確？

(A) 吉貝素能促進植物莖部延長、種子萌發。

(B) 離酸(離素、離層素、離層酸)會促進離層形成。

(C) 細胞分裂素能刺激植物細胞分裂、延遲葉片老化。

(D) 生長素的作用與頂芽優勢、向光性和向地性等反應有關。

(E) 氣態植物激素乙烯能促進氣孔關閉。

（94 年指考生物 24）

Teacher: What are the functions of gibberellins?

Student: Gibberellins can promote cell elongation and cell division, leading to stem elongation. They also promote the differentiation of shoot apical meristem into flower buds. Additionally, they can be used for artificial parthenocarpy, breaking seed dormancy, and promoting seed germination.

Teacher: Excellent! So answer (A) it is correct. Gibberellins can promote stem elongation and seed germination in plants. Now, let's look at (B), does abscisic acid promote abscission layer formation?

Student: No, it doesn't.

Teacher: What is the primary physiological function of abscisic acid?

Student: It inhibits plant growth, induces seed and bud dormancy, and is associated with plant resistance to water stress.

Teacher: And which kind of hormone would promote abscission?

Student: Ethylene promotes abscission.

Teacher: Correct! Therefore, (B) is incorrect. What is the function of cytokinins?

Student: They promote cell division and differentiation, stimulate the synthesis of proteins and nucleic acids within cells, and delay the aging of plant organs.

Teacher: Yes! Therefore, (C) is correct that cytokinins can stimulate plant cell division and delay leaf aging. Now, what is apical dominance?

Student: When the apical bud is present, the synthesized auxins move downwards and inhibit the growth of lateral buds, which is known as apical dominance.

Teacher: What are phototropism and gravitropism?

Student: Plants respond to environmental stimuli and cause uneven distribution of auxins on both sides, leading to phototropism and gravitropism.

Teacher: Therefore, apical dominance, phototropism, and gravitropism are related to which hormone?

Student: Auxin.

Teacher: Correct! Then, (D) is correct. The function of auxin is related to apical dominance, phototropism, and gravitropism.

Teacher: Lastly, when plants face water shortage stress, what hormone does the root produce and send to the leaves to increase abscisic acid, leading to the closure of stomata and reduction of water loss?

Student: Abscisic acid.

Teacher: Correct! Therefore, (E) is incorrect. The gaseous plant hormone ethylene does not promote stomatal closure. Rather, it is abscisic acid that leads to the closure of stomata.

老師： 請問同學，吉貝素有哪些功能？

學生： 吉貝素可以促進細胞伸長、細胞分裂，使莖部延長；促進莖頂分生組織分化成花芽；還可以應用在人工單性結果，以及打破種子休眠、促進種子萌發。

老師： 很棒！因此(A)吉貝素能夠促進植物莖部延長以及使種子萌發是正確的！那麼(B)離層酸會促使離層的產生嗎？

學生： 不會。

老師： 那麼離層酸主要生理作用為何？

學生： 抑制植物生長、造成種子和芽休眠，以及與植物體對抗水逆境有關。

老師： 什麼激素才能促使離層的產生？

學生： 乙烯才能使離層產生。

老師： 沒錯！因此(B)錯誤。細胞分裂素的功能為何？

學生： 促進細胞的分裂與分化、促進細胞內蛋白質和核酸的合成，使植物器官延遲老化。

老師： 沒錯！因此(C)細胞分裂素能夠刺激植物細胞分裂以及延遲葉片老化是正確的。接下來，請問同學們頂芽優勢是什麼？

學生： 當頂芽存在時，頂芽合成的生長素向下運移，會抑制側芽的生長，即為頂芽優勢。

老師： 那麼向光性以及向地性又是什麼？

學生： 植物受環境因素刺激，造成兩側生長素分布不均，就會產生向光性和向地性。

老師： 因此頂芽優勢、向光性和向地性和什麼激素有關？

學生： 生長素。

老師： 沒錯！因此(D)生長素的作用與頂芽優勢、向光性和向地性等反應有關是正確的。

老師： 當植物遇到缺水逆境時，根部會合成什麼激素，傳送到葉部，使葉部的離層酸大量增加，使氣孔關閉，減少水的蒸散。

學生： 離層酸。

老師： 正確！因此(E)不是氣態植物激素乙烯促進氣孔關閉，而是離層酸促使植物的氣孔關閉。

4-4 植物體對環境刺激的反應
Plant response to environmental stimuli

■ 前言 Introduction

本節介紹植物的運動和對環境因子的反應，植物在逆境下的反應與防禦，以及植物如何與其他個體進行交互作用。英文則介紹各類影響植物的環境因子名稱和其交互作用如何進行的句型及文法描述。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
tropism	向性	critical day length	臨界日照
phototropism	向光性	critical dark length; critical night length	臨界夜長
positive geotropism /gravitropism	正向地性	florigen	開花素
nastic	傾性	vernalization	春化作用
phytochrome	光敏素	stress	逆境
photoperiod	光週期	long-day plant, LDP	長日照植物
short-night plant	短夜植物	short-day plant, SDP	短日照植物
long-night plant	長夜植物		

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ in response to _____.

例句：When a plant exhibits growth movement **in response to** a stimulus, it is referred to as tropism.

當植物因應刺激而表現出某種生長運動時，它被稱為向性。

❷ ____ either ____ or _____

例句：Plants can **either** display a negative **or** positive movement in response to a stimulus.

植物可以因應刺激而表現出正向或負向的運動。

❸ _____ initiate(s)_____ in _____.

例句：Critical day length is the specific length of daylight that is required to **initiate** the flowering response **in** long day plants.

臨界日照是促進長日照植物開花反應所需的特定日照長度。

❹ make _____ do something.

例句：Scientists use vernalization to **make** winter wheat **bloom** in spring.

科學家通過春化技術讓冬小麥在春天快速開花。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本章節後，學生應習得以下概念：

After completing this section, students should acquire the following concepts:

一、學生熟知植物體對於環境刺激的反應。

Students are familiar with the responses of plants to environmental stimuli.

❧ 例題講解 ☙

例題一

說明：能知道光週期對於植物開花的影響。

Students can understand the effect of photoperiod on flowering of plants.

A student conducted an experiment on the effect of photoperiod environments on the flowering of a certain plant. The plant was grown in different photoperiod environments, and it flowered when given 8 or 11 hours of daylight, but did not flower when given 13 or 16 hours of daylight. Assume that this plant is an annual and germinates in the spring. The length of daylight during the summer solstice (June 21st) at its growing location is 14 hours, and the length of daylight during the winter solstice is 10 hours. The length of daylight during the spring and fall equinoxes is 12 hours. What is the most likely month for this plant to start flowering?

(A) March

(B) June

(C) August

(D) November

(E) December

學生試驗光週期對某種植物開花的影響，將試驗植物種植於不同光週期環境中，給予 8 與 11 小時的日照長度時，植物開花；而給予 13 與 16 小時的日照長度時，植物不開花。若此植物為一年生，且在春天發芽，其生長地的夏至（6 月 21 日）日照長度 14 小時，冬至日照長度 10 小時，及春分、秋分日照長度 12 小時。請問此種植物最有可能開始開花的月份為何？

(A) 3 月　(B) 6 月　(C) 8 月　**(D) 11 月**　(E) 12 月

（104 年學測自然 60）

Teacher: Many plants require specific photoperiod stimuli to form flower buds and then bloom. What is the key condition that affects plant flowering?
Student: The uninterrupted dark period during the photoperiod.
Teacher: Correct! According to the question, for a certain plant to bloom, how long does it need to be in the dark?
Student: It needs to be in the dark for 13-16 hours continuously.
Teacher: For what duration of continual darkness will the plant not bloom?
Student: It will not bloom if it's in the dark for 8 to 11 hours continuously.
Teacher: Correct! And after the equinox, summer solstice, and autumnal equinox, which is from March to September, how many hours of darkness are there?
Student: The hours of darkness are less than 12 hours for all of these.
Teacher: And from the autumnal equinox to the winter solstice, which is from September to December, how many hours of darkness are there?
Student: More than 12 hours, and up to 14 hours during the winter solstice.
Teacher: Therefore, we can infer that this plant is most likely to bloom in which month?
Student: From September to December.
Teacher: So the answer is (D) November.

老師： 許多植物需要有適宜的光週期刺激，才會形成花芽進而開花。請問同學們影響植物開花的關鍵條件為何？
學生： 光週期中的連續暗期。
老師： 沒錯！由題目所述，請問同學們某種植物需要處於多長的黑暗才會開花？
學生： 當連續黑暗長 13~16 小時才會開花。
老師： 而處於多長的黑暗仍不會開花？
學生： 當連續黑暗長 8~11 小時仍不會開花。
老師： 正確！而經過春分、夏至與秋分，也就是 3~9 月時夜長為幾個小時？
學生： 皆短於 12 小時。
老師： 而秋分以後至冬至，也就是 9~12 月葉長為幾個小時？
學生： 長於 12 小時，至冬至時長於 14 小時。
老師： 由此推測，此種植物最有可能在幾月開始開花？
學生： 9~12 月。
老師： 因此選擇(D)11。

例題二

說明：了解植物的防禦作用。

Students can understand plant defense mechanisms.

Which of the following statements related to plant defense is correct?

(A) When insects feed on plant leaves, the plant promotes the production of jasmonic acid which disrupts their digestive process.

(B) Salicylic acid can cause the cell wall of pathogens to thicken, causing them to lose their pathogenicity.

(C) The apoptosis (spontaneous death) of plant cells induced by pathogen infection can prevent the spread of pathogens.

(D) After being bitten by caterpillars, corn leaves release specific volatile substances that attract parasitic wasps, causing the death of the caterpillars. This is a type of chemical defense mechanism.

下列與植物防禦相關的敘述，何者正確？

(A) 昆蟲攝食植物葉片時，植物會促使昆蟲產生茉莉酸以干擾其消化作用。

(B) 水楊酸可導致病原菌細胞壁增厚，而使病原菌失去致病作用。

(C) 植物受病原體感染時所引發的細胞凋亡（自發性死亡），可避免病原體的擴散。

(D) 玉米葉片被毛蟲咬傷後會釋出特定揮發物質，吸引寄生蜂前來寄生，造成毛蟲死亡，屬化學防禦機制。

（106 年指考生物 15）

Teacher: (A) When a plant's leaves are bitten by insects, which cells of the plant produce jasmonic acid?

Student: The leaf cells produce a large amount of jasmonic acid, rather than the insects.

Teacher: Correct! The jasmonic acid produced by the neighboring cells of the wounded area induces the plant to produce defense proteins to combat insect damage, thereby inhibiting insect growth. What is (B) the role of salicylic acid?

Student: Salicylic acid triggers plants to develop resistance against pathogens, preventing the plant from being infected again.

Teacher: Yes! When plants are infected by pathogens, the infected sites produce methyl salicylate, which is transported through the phloem to other parts of the plant. In distant non-infected areas, methyl salicylate is converted to salicylic acid, triggering resistance in other parts of the plant. Therefore, the description in (B) is incorrect.

Teacher: When a pathogen invades a plant, the plant has an allergic reaction. What is the allergic reaction?

Student: After being infected by the pathogen, the cells in the surrounding area of the infected site of the plant die rapidly, causing the pathogen to lose nutrients and die.

Teacher: Correct, therefore (C) is correct. Finally, let's take a look at (E). When a corn leaf is bitten by a caterpillar, it releases specific volatile substances to attracting parasitic wasps, the natural enemy of caterpillars, to parasitize the caterpillar, laying eggs on its body and causing the caterpillar to die. Which plant defense mechanism is this?

Student: Since parasitic wasps cause the death of the caterpillar, this type of defense mechanism is biological.

Teacher: Correct!

老師： (A)當植物遭受昆蟲咬傷葉片時，植物會促使誰產生茉莉酸？

學生： 植物會促使葉部細胞產生大量茉莉酸，而不是由昆蟲產生。

老師： 對！受傷處鄰近組織的細胞所產的茉莉酸，會誘導植物體產生與防禦有關的蛋白質來對抗蟲咬的侵害，進而抑制昆蟲生長。請問(B)水楊酸的作用為何？

學生： 水楊酸則會引發植物產生對病原菌的抗性，避免植物再度被感染。

老師： 正確！病原體感染植物時，受感染部位會產生水楊酸甲酯，經由韌皮部運輸到其他部位，在遠離感染的部位轉變成水楊酸，使植株其他部位產生抗性。因此(B)所描述為錯誤。

老師： 當病原體入侵時，植物會啟動過敏反應，何謂過敏反應？

學生： 受到病原體染以後，植物會使感染部位周圍區域的細胞迅速死亡，使得病原菌失去營養而死亡。

老師： 沒錯，因此(C)所述為正確的。最後(E)玉米葉片被毛蟲咬傷後會釋出特定揮發物質，吸引毛蟲的天敵寄生蜂前來寄生，將卵產在毛蟲身上，造成毛蟲死亡，這是屬於植物體的哪一種防禦？

學生： 因為是寄生蜂前來寄生而造成毛蟲死亡，所以應屬於生物防禦機制。

老師： 沒錯！

國內外參考資源 More to Explore

HHMI Biointeractive 教學資源網站，可以根據學生教育階段(高中或大學)及主題選擇教學資源(含影片)。 https://www.biointeractive.org/	
Rediscovering Biology: Molecular to Global Perspectives 是一個進階的課程。提供給高中老師最新的生物知識，網站有影片，課程指引，師生互動網頁。 https://www.learner.org/classroom-resources/	
Khan Academy 可汗學院，有分年級的生物教學影片及問題的討論。 https://www.khanacademy.org/	
Interactive Simulations, University of Colorado Boulder 互動式電腦模擬，除了生物，還有其他自然科。 https://phet.colorado.edu/	

自然領域雙語教學資源手冊：生物科英語授課用語
[選修生物(II)]
A Reference Handbook for Senior High School Bilingual Teachers in the Domain of Natural Sciences (Biology): Instructional Language in English
[Elective Biology (II)]

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- 撰稿：張閔琦、林之曦
- 學科諮詢：駱奕帆
- 綜合規劃：曾松德
- 排版：吳依靜
- 封面封底：JUPE Design

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