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(I)〕

國立彰化師範大學雙語教學研究中心 發行

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國立彰化師範大學生物學系 張閔琦
國立彰化師範大學英語學系 林之曦

■ 前言 Introduction

本章將介紹細胞的基本組成分子及其特性、深入研究細胞中各種構造的構成與功能，以及它們的運作方式。同時，也將探索細胞分裂、生長、凋亡等生命歷程。在語言知識的部分，本章將結合相關的細胞組成分子詞彙和句型，以幫助學生了解細胞內部結構的英文專有名詞，以及描述細胞組成成分的句型表達方式。透過這一章的學習，學生們將能夠更深入地了解細胞的奧秘，並具備探索更高層次生物學知識的基礎。

1-1 細胞的分子組成
The Molecular Composition of Cells

■ 前言 Introduction

細胞由各種分子組成，這些分子具有不同的結構與特性。細胞由無機物及有機物組成。無機物包括水和礦物質，有機物包括醣類、蛋白質、脂質、核酸與維生素等等。本節將介紹這些分子的成分與結構，以及它們在細胞中的功能。在語言方面則藉由細胞分子組成物質英文詞彙介紹及句型運用讓學生了解其英文表達方式。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
purine	嘌呤	cellulose	纖維素
pyrimidine	嘧啶	lipid	脂質
molecule	分子	disaccharide	雙醣
protein	蛋白質	organic matter	有機物
monosaccharide	單醣	inorganic matter	無機物
polypeptide	多肽	vitamin	維生素
polysaccharide	多醣	amino acid	胺基酸
saccharide	醣類	glucose	葡萄糖
phospholipid	磷脂質	sucrose	蔗糖
steroid	類固醇	starch	澱粉

mineral	礦物質	nucleotide	核苷酸
nitrogenous base (base)	含氮鹼基(鹼基)	fatty acid	脂肪酸
Nucleic acids	核酸	triglyceride	三酸甘油脂
hydrogen bond	氫鍵	cellulose	纖維素

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

❶ ____ be composed of ____.

例句：Neutral fat **is** mainly **composed of** one molecule of glycerol and three molecules of fatty acid.

中性脂肪主要由 1 分子甘油與 3 分子脂肪酸所組成。

❷ ____ the most abundant _____ in _____.

例句：Protein is **the most abundant** organic matter **in** cells.

蛋白質是細胞內含量最多的有機物。

❸ ____ have/ has the function of _____.

例句：Minerals **have the function of** maintaining normal cell function.

礦物質有維持細胞正常運作的功能。

❹ ____ be the main component of ____.

例句：Cellulose **is the main component of** plant cell walls.

纖維素是植物細胞壁的主要成分。

❺ ___ be divided into ___ based on ___.

例句：Phospholipids' structures **are divided into** hydrophilic head and hydrophobic head **based on** their polarity.

磷脂質的分子結構依極性分為親水端和疏水端。

■ 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、學生了解何謂聚合物，以及生物體中聚合物的組成單體為那些分子，還有這些單體的組成原子為何。

Students will understand what polymers are, what their molecules in organisms, and what the constituent atoms of these monomers are.

❧ 例題講解 ☙

例題一

說明：學生了解生物體中各種常見的多醣、雙醣是由哪些單醣所組成。

Students will learn which monosaccharides the different polysaccharides and disaccharides in organisms are composed of.

After the starch, sucrose and lactose have completely decomposed into monosaccharide molecules, how many different molecular weights can be measured?

(A) One

(B) Two

(C) Three

(D) Four

將澱粉、蔗糖與乳糖完全分解為單醣分子後，可測得幾種不同之分子量？

(A) 1 種

(B) 2 種

(C) 3 種

(D) 4 種

（110 指考生物 11）

解析 Solution:

根據組成多醣和雙醣的單醣種類去比較分子量。

The molecular weights are compared based on the types of monosaccharides that constitute polysaccharides and disaccharides.

Teacher: What do we get when starch is decomposed into monosaccharides?
Student: Glucose.
Teacher: What about sucrose and lactose?
Student: Sucrose decomposes glucose and fructose and, lactose decomposes into glucose and galactose.
Teacher: That's right! Do you still remember whether these three monosaccharides are pentose or hexose?
Student: They are all hexose.
Teacher: What is the ratio of carbon, hydrogen, and oxygen in carbohydrates?
Student: 1:2:1.
Teacher: So, since glucose, fructose, and galactose are all hexose, what will their molecular weights be?
Student: They will be the same!

老師： 同學們，澱粉分解成單醣會得到甚麼物質？
學生： 葡萄糖。
老師： 那蔗糖與乳醣呢？
學生： 蔗糖分解可以得到葡萄醣與果醣，乳醣分解可以得到葡萄糖與半乳糖。
老師： 沒錯！同學們還記得這三種單醣是五碳醣還是六碳醣嗎？
學生： 都是六碳醣。

老師： 一般來說碳水化合物的碳、氫、氧的比例為何？

學生： 1:2:1。

老師： 也就是說，同樣都是六碳醣的葡萄糖、果醣、半乳糖，他們三者的分子量會如何呢？

學生： 會相同！

例題二

說明：了解組成生物體的重要成分之一蛋白質，其組成為碳、氫、氧、氮、硫，以及聚合物的分子量非常大。

Understand that proteins are important element of organisms, and they are made up of carbon, hydrogen, oxygen, nitrogen and sulfur, and the molecular weight of polymers is very large.

Which of the following chemical formulas is protein?

(A) $C_5H_{10}O_5$　(B) $C_{10}H_{16}O_{13}N_5P_3$　(C) $C_{18}H_{32}O_2$　**(D) $C_{500}H_{1400}O_{120}N_{75}S_2$**

下列化學分子式，何者為蛋白質？

(A) $C_5H_{10}O_5$　(B) $C_{10}H_{16}O_{13}N_5P_3$　(C) $C_{18}H_{32}O_2$　**(D) $C_{500}H_{1400}O_{120}N_{75}S_2$**

（91 指考生物 6）

解析 Solution:

蛋白質由 C、H、O、N、S 組成。

Proteins are composed of C, H, O, N, S.

Teacher: Do you remember that protein is a polymer? And what kind of monomer is protein polymerized from?

Student: Amino acid.

Teacher: That's right, and what kinds of atoms are amino acids made of?

Student: Carbon, hydrogen…

Teacher: Yes, they are composed of carbon, hydrogen, oxygen, nitrogen, sulfur. And option D fits this.

Teacher: Besides the types of atoms combined, what other features can be discussed when describing option D?

Student: Compared to other options, its weight is huge!

Teacher: Yes, polymers are characterized as having very large molecular weights, usually in the hundreds or even thousands. It may be easier to describe them this way? However, if there are two kinds of polymers in question, you'll need to characterize them by their constituent atoms!

老師： 還記得蛋白質是一種有機聚合物嗎？大家記得他是由哪種單體聚合而成的嗎？

學生： 胺基酸。

老師： 沒錯，請問除了碳、氫、氧之外，胺基酸尚有哪些原子組成？

學生： 氮、硫。

老師： 是的，由碳、氫、氧、氮、硫組成，答案D符合。

老師： 除了從組合的原子種類判斷，你們認為D選項還有什麼特性嗎？

學生： 跟其他選項相比，數字非常大！

老師： 沒錯，聚合物有個特點就是分子量非常大，通常都好幾百甚至上千。這樣判斷是不是更容易了？不過題目若有兩種聚合物時，就需要各位判斷組成原子囉！

1-2 細胞的構造與功能
Structure and Function of Cells

■ 前言 Introduction

介紹細胞各項重要的構造與其功能。依據細胞核的有無，可將細胞分成真核細胞和原核細胞。真核細胞構造包含細胞膜、細胞質及細胞核，有些則具有細胞壁，本節在探討真核細胞的構造與功能。語言部份欲使學生理解細胞內重要構造與功能的英語詞彙，並用句型表達物質在細胞的運輸過程及方式，如胞吞作用、胞飲作用、簡單擴散與促進性擴散的描述方法。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
passive transport	被動運輸	nuclear pore	核孔
exocytosis	胞吐	nucleoplasm	核質
endocytosis	胞吞作用	nucleolus	核仁
pinocytosis	胞飲作用	simple diffusion	簡單擴散
membrane protein	膜蛋白	cell wall	細胞壁
hypotonic solution	低張溶液	cell membrane	細胞膜
isotonic solution	等張溶液	cytoskeleton	細胞骨架
phagocytosis	吞噬作用	facilitated diffusion	促進性擴散

endomembrane system	內膜系統	lipid bilayer	脂雙層
endoplasmic reticulum	內質網	active transport	主動運輸
vesicle	囊泡	receptor-mediated endocytosis	受體媒介胞吞
fluid mosaic model	流體鑲嵌模型	osmosis	滲透作用
Golgi apparatus	高基氏體	lysosome	溶體
hypertonic solution	高張溶液	Plasmodesmata	原生質絲
peroxisome	過氧化體	vacuole	液泡(液胞)
nuclear membrane	核膜		

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

❶ ____ can be divided into _____ and _____.

例句：Common transport proteins **can be divided into** channel proteins **and** carrier proteins.
常見的運輸蛋白可分為通道蛋白和載體蛋白。

❷ ____ be transported across _____.

例句：Some small molecules can **be transported across** cell membranes.
有些小分子物質可以透過細胞膜運輸。

❸ _____ bind to _____.

例句：When receptor-mediated endocytosis occurs, specific molecules **bind to** receptors on the cell membrane.
受體媒介胞吞作用發生時，特定分子會和細胞膜上的受體結合。

❹ _____ be composed of ____.

例句：Eukaryote' cells **are composed of** organelles and structures with different components and functions.

真核生物細胞是由不同成分與功能的胞器和構造所組成。

■ 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、了解細胞中與蛋白質製造有關的各項胞器與其功能。

Understand the various organelles and their functions involved in protein production in cells.

二、了解細胞膜的構造與功能。

Understand the structure and function of cell membrane.

❧ 例題講解 ☙

例題一

說明：學生須了解胰島素為蛋白質，並了解製造蛋白質需要用到那些胞器。

Students will understand that insulin is a protein and understand what organelles are used to make the protein.

When pancreatic cells are synthesizing insulin in large quantities, which intracellular structures are significantly more developed?

(A) ribosome

(B) golgi apparatus

(C) mitochondria

(D) smooth endoplasmic reticulum

(E) rough endoplasmic reticulum

當胰臟細胞正在大量合成胰島素時，其胞內哪些構造明顯比不進行合成時發達？

(A) 核糖體

(B) 高基氏體

(C) 粒線體

(D) 平滑內質網

(E) 粗糙內質網

（92 指考生物 48）

Teacher: Students, insulin is actually a protein! The question to ask is which organelles are used to make proteins. The production of proteins first requires transcription and translation to obtain polypeptide chain. Which organelles in the options above have these functions?

Student: Ribosome.

Teacher: That's right. Next, it needs to be modified to become insulin, and the Golgi apparatus and the rough endoplasmic reticulum are all involved in the modification process.

Student: Why is the mitochondrion a correct option, too?

Teacher: These processes can only be completed by consuming ATP. Of course, the energy that mitochondria provides is indispensable!

老師： 同學們，胰島素其實是一種蛋白質唷！這題要問的是製造蛋白質會用到那些胞器。製造蛋白質首先需要轉錄與轉譯得到多肽鏈，選項中那些構造有這些功能呢？

學生： 核醣體。

老師： 沒錯。接下來要經過修飾才會成為胰島素，而高基氏體、粗糙內質網都有參與修飾的過程。

學生： 那粒線體為什麼也是正確選項？

老師： 這些過程都是要消耗 ATP 才能完成的，當然少不了提供能量的粒線體囉！

例題二

說明：學生了解細胞膜的構造與功能。

Students will learn about the structure and function of cell membranes.

Which of the following statements about cell membranes is correct?

(A) Bilayer lipids are composed of triglycerides.

(B) Proteins within cell membranes move through lipid bilayers.

(C) Membrane bilayer lipids of different cells contain different amounts of cholesterol.

(D) A cell contains equal amounts of protein on both sides of the lipid bilayer of the cell membrane.

(E) Bilayer lipids provide cells with a lipid-soluble barrier, so substances inside and outside the membrane cannot move in and out at will.

下列有關細胞膜的敘述，何者正確？

(A) 雙層脂質是由三酸甘油脂組成。

(B) 細胞膜內的蛋白質會在雙層脂質中移動。

(C) 不同細胞的細胞膜雙層脂質含有不同量的膽固醇。

(D) 一個細胞的細胞膜雙層脂質的兩邊含有等量的蛋白質。

(E) 雙層脂質提供細胞一個脂溶性的障礙，使膜內外物質不能隨意進出。

（93 年敏督利颱風受災地區考生補救考試指考生物 22）

Teacher: What is the cell membrane composed of?

Student: Bilayer phospholipids

Teacher: That's right. Let's move on to option B. This is what the fluid mosaic model tells us. That is, membrane proteins can move within the cell membrane.

Student: Why is C right?

Teacher: Different cell membranes have different structures, so it is very difficult to get the same amount of cholesterol. Option D is the same, the protein inside and outside the cell membrane will have different contents depending upon the function of the cell. Finally, look at option E. What substances can pass through the phospholipid membrane?

Student: Water, gas, and fat-soluble substances.

Teacher: Yes, other substances need to go through protein channels to get in and out.

老師： 各位同學們，細胞膜的成分是什麼？

學生： 雙層磷脂質～

老師： 沒錯。再來看 B 選項，這就是流體鑲嵌模型要告訴我們的，膜蛋白可以在細胞膜中移動。

學生： 那 C 為甚麼是對的？

老師： 不同的細胞膜上的構造也不一樣喔，膽固醇要一樣多是非常困難的。D 選項也是一樣的道理，細胞膜內外的蛋白質會依據細胞的功能有不同含量唷。最後，看看 E 選項，是正確的。有哪些物質可以穿過磷脂質膜呢？

學生： 水、氣體、脂溶性物質。

老師： 是的，其他物質都需要經過蛋白質通道才能進出唷。

1-3 細胞的生命歷程
Life Cycle of a Cell

■ 前言 Introduction

就像人類會經歷出生、成長、老化和死亡的過程一樣，細胞也有自己的生命週期。本章將深入介紹細胞分化、增殖、衰老和死亡等相關過程。在語言方面，將討論與細胞分化、增殖、衰老和死亡相關的英文詞彙和句型，包括不同類型的幹細胞的差異，細胞如何進行分裂，以及癌細胞如何在身體中轉移等現象。本章將透過詳細的描述和解釋，使同學對這些生物學中重要的過程有更深入的了解。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
embryonic stem cell	胚胎幹細胞	cell cycle	細胞週期
pluripotent stem cell	富潛能幹細胞	mitotic phase	細胞分裂期
telomere	端粒	apoptosis	細胞凋亡
interphase	間期	somatic stem cell	成體幹細胞
stem cells	幹細胞	free radical	自由基
totipotent stem cell	全潛能幹細胞	carcinogenesis	癌變
cell differentiation	細胞分化	cell cycle	細胞週期
metastasize	轉移		

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

❶ _____ divide to produce _____.

例句：Stem cells **divide to produce** daughter cells.
幹細胞分裂產生子細胞。

❷ ____ generate new cells by _____.

例句：Multicellular organisms **generate new cells by** cell proliferation.
多細胞生物以細胞增殖的方式產生新細胞。

❸ _____ be adjusted according to _____.

例句：The way stem cells divide can **be adjusted according to** the actual needs of the organism.
幹細胞的分裂方式會視生物體的實際需求而調整。

❹ _____ metastasize to ____ through ____.

例句：Cancer cells **metastasize to** other parts of the body **through** blood vessels or lymph.
癌細胞經由血管或淋巴轉移至身體其他部位。

■ 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、學生了解幹細胞的功能，以及各種不同幹細胞分化潛能性的高低。

Understand the function of stem cells, and differentiation potential of various stem cells.

❧ 例題講解 ☙

例題一

說明：學生了解各種幹細胞的分化潛能性高低。

Students learn to the differentiation potential of various stem cells.

A cell that has the potential to develop into a complete individual is called a totipotent stem cell. Which of the following mammalian cells is most likely to be a totipotent stem cell?

(A) neural stem cell

(B) embryonic stem cell

(C) umbilical cord blood cell

(D) hematopoietic stem cells

一個細胞具有發展成完整個體的潛能稱之為全潛能性細胞。下列哪一種哺乳類的細胞最可能具全潛能性？

(A) 神經幹細胞

(B) 胚胎幹細胞

(C) 臍帶血幹細胞

(D) 血球幹細胞

（108 指考生物 3）

解析 Solution:

(A) 神經幹細胞可分化爲神經元、星狀細胞、寡突膠質細胞。

(B) 胚胎幹細胞具有全潛能性，可形成生物體的各種結構。

(C) 臍帶血內含有豐富的造血幹細胞，是胎兒製造血液的主要來源。

(D) 血球幹細胞（造血幹細胞）可以分化出所有的血球細胞。

(A) Neural stem cells can differentiate into neurons, astrocytes, oligodendrocytes.

(B) Embryonic stem cells are totipotent and can give rise to various structures of an organism.

(C) Umbilical cord blood is rich in hematopoietic stem cells, which are the main source of fetal blood production.

(D) Hematopoietic stem cells can differentiate into all blood cells.

Teacher: Students, look at option A. Since it is called a neural stem cell, what do you think it can differentiate into?

Student: Different nerves?

Teacher: That's right! So it only has the differentiation potential of neural. In the same way, option D, hematopoietic stem cell, what cells do you think it can differentiate into?

Student: All kinds of blood cells!

Teacher: Yes, and option C cord blood stem cells are actually a type of hematopoietic stem cell. Finally, let's look at embryonic stem cells, which can develop into different cells in our body. So which one has the greatest potential?

Student: Embryonic stem cells.

Teacher: That’s right!

老師： 同學們看看 A 選項，既然叫做神經幹細胞，你覺得它可以分化出什麼？

學生： 各種神經？

老師： 沒錯！所以它的潛能只有神經唷。同理，D 選項血球幹細胞，又叫做造血幹細胞，大家覺得它能夠分化為那些細胞呢？

學生： 各種血球！

老師： 是的，而 C 選項臍帶血幹細胞，其實是造血幹細胞的一種唷，他也能夠分化成紅血球、白血球等等不同細胞。最後來看看胚胎幹細胞，它是要發育為我們全身的各種細胞的。同學們覺得誰的潛能性最高呢？

學生： 胚胎幹細胞。

老師： 沒錯唷！

例題二

說明：學生了解幹細胞的功能與特性。

Students will learn about the functions and properties of stem cells.

Which of the following statements about stem cells are correct?

(A) Stem cells can be used to treat Down syndrome.

(B) Stem cells can differentiate into a variety of cells.

(C) Stem cells are present in both embryos and adults.

(D) Stem cells can continuously proliferate more stem cells.

(E) Bone marrow stem cells can differentiate into individuals.

下列有關幹細胞的敘述，哪些正確？

(A) 幹細胞可以用來治療唐氏症。

(B) 幹細胞可以分化成多種細胞。

(C) 胚胎和成體中都有幹細胞的存在。

(D) 幹細胞可以不斷地增生更多幹細胞。

(E) 骨髓幹細胞可以分化成個體。

（100 年指考生物 23）

Teacher: Does everyone still remember what cause Down's syndrome?

Student: The 21st pair of chromosomes has an extra chromosome.

Teacher: That's right, so it cannot be treated with stem cells. The function of stem cells is described in option B, and they can differentiate into many different types of cells. On the other hand, cells that have the ability to differentiate can be called stem cells. Option C is correct. Embryonic cells have the potential to differentiate into all the cells of the human body, because of it has the differentiation potential that is why we call them stem cells. Can anyone give me an example of stem cells in the adult body?

Student: Bone marrow cells.

Teacher: Very good, the bone marrow cells of option E are indeed stem cells, but they only have hematopoietic functions and cannot differentiate into individuals. Finally, look at option D. As long as the stem cell is not differentiated, the cells it divides are always stem cells, so it is correct.

老師： 大家還記得唐氏症的病因嗎？

學生： 第 21 對體染色體多了一條。

老師： 沒錯唷，所以這是無法用幹細胞來治療的，幹細胞的功能是 B 選項敘述的，可以分化成多種細胞，換句話說，有分化能力的細胞就可以稱為幹細胞。而 C 選項是正確的唷，胚胎細胞會分化為人體所有細胞，因為有分化潛能，所以是幹細胞。至於成體有的幹細胞，有同學可以舉例嗎？

學生： 骨髓細胞

老師： 很好，E 選項的骨髓細胞的確是幹細胞，但它只有造血功能，不能分化成個體。最後看看 D 選項，只要幹細胞沒有分化，它分裂出的細胞就一直是幹細胞，所以是正確的。

★ 主題二 細胞的代謝與能量 ★
Cellular Metabolism and Energy

國立彰化師範大學生物學系 張閔琦
國立彰化師範大學英語學系 林之曦

■ 前言 Introduction

細胞需要經由代謝作用，使生物得以表現各種生命現象。自營生物利用代謝作用，將光能轉換為化學能，以養分的形式儲存於體內，而細胞也需要經由代謝作用才能利用這些養分產生能量。本章將介紹細胞進行代謝作用的過程以及如何將自然界中的能量轉移細胞利用。並希望透過細胞代謝與能量的英文字彙和其句型片語讓學生理解本章英文之學習重點。

2-1 細胞的代謝作用
The Metabolic Processes of Cells

■ 前言 Introduction

代謝作用是細胞內化學反應的總稱，在代謝過程中會產生能量的流轉和物質轉換以維持生命。而酶對於代謝非常重要，本小節將介紹酶的功能與影響酶活性的因素並透過細胞代謝相關英文詞彙及句型使學生運用以理解對酶的特性及作用之描述。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
enzyme	酶	activation energy	活化能
coenzyme	輔酶	activity	活性
cofactor	輔因子	substrate	受質
metabolism	代謝	catabolism	異化代謝
anabolism	同化代謝		

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

❶ ____ synthesize ____ into _____.

例句：Anabolism is the process by which cells **synthesize** smaller molecules **into** larger molecules under the catalysis of a series of enzymes.
同化代謝是指細胞將較小的分子在系列酶的催化下，合成較大分子的過程。

❷ ____ decompose _____ into _____

例句：Catabolism is the process by which cells **decompose** (break down) larger molecules **into** smaller ones, catalyzed by of a series of enzymes.
異化代謝是指細胞將較大分子在系列酶的催化下，分解較小分子的過程。

❸ ____ be transferred to _____.

例句：Only through ATP molecules can the energy released by catabolism **be** smoothly **transferred to** anabolism.
異化代謝所釋出的能量必須透過 ATP 分子才能順利進行能量轉移給同化代謝用。

❹ The higher ____ the faster_____.

例句：When the enzyme concentration is fixed, **the higher** the substrate concentration, **the faster** the reaction rate.
在酶的濃度固定時，受質濃度越高，反應速率越快。

■ 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、學生了解酶的特性與影響酶活性的因素。

Students will understand how enzymes work and what causes them to work.

❧ 例題講解 ☙

例題一

說明：學生了解酶的特性。

Students will learn about the properties of enzymes.

Which of the following statements about the properties of enzymes is false?

(A) Some RNA molecules have enzymatic activity.

(B) The substrate binds to the active site of the enzyme.

(C) The structure of the substrate changes during catalysis.

(D) The optimal conditions for protease activity are the same in the small intestine and the stomach.

下列有關酶特性的敘述，何者「不」正確？

(A) 某些 RNA 分子具有酶活性。

(B) 受質會與酶的活化位結合。

(C) 催化過程中受質的結構會發生改變。

(D) **小腸與胃的蛋白酶活性最適條件相同。**

（98 指考生物 20）

Teacher: Students, look at option D, what is the biggest difference in of the small intestine and the stomach?

Student: The stomach is acidic and the small intestine is alkaline.

Teacher: Yes, acidity and alkalinity will affect enzymes work, so the enzymes in the stomach work best in acidic, and those in the small intestine work best in alkaline. The other options are correct.

老師： 同學們，看看錯誤選項D，小腸與胃中環境最不一樣的地方是什麼？
學生： 胃中是酸性環境、小腸中是鹼性環境。
老師： 沒錯，酸鹼性會影響酶的活性，所以在胃中的酶在酸性環境中活性較佳，小腸中的酶在鹼性環境中活性較佳。其餘選項都是正確的。

例題二

說明：學生了解有哪些因素會影響酶活性。

Students learn to identify factors that affect how enzymes work.

Enzymes work by lowering the activation energy of a reaction. Which of the following statements are correct?

(A) Substrate concentration may affect enzyme activity.

(B) Heavy metal ions may affect enzyme activity.

(C) Coenzymes are small proteins that can affect enzyme activity.

(D) Changes in acid and base may affect the activity of enzymes.

(E) As the temperature increases, the enzyme functions at a higher rate.

酶的活性可以反應速率來代表。在一定生理範圍內，下列有關影響酶活性之敘述，哪些正確？

(A) 受質濃度會影響酶活性。

(B) 重金屬離子會影響酶活性。

(C) 輔酶是一種小蛋白質，可影響酶活性。

(D) 酸鹼變化會影響酶的活性。

(E) 溫度愈高酶活性愈強。

（99 指考生物 29）

Teacher: Concentration, heavy metal ions, pH, temperature, etc. are all factors that can affect enzyme activity, so options A, B, and D are all correct. Coenzymes are small organic molecules, not proteins. Some enzymes need to be combined with coenzymes in order to be active.

Student: OK!

Teacher: The high temperature will affect the structure of protein, that make the enzyme lost its function, therefore, the statement "As the temperature increases, the enzyme functions at a higher rate" is wrong.

老師： 濃度、重金屬離子、酸鹼度、溫度等等，都是會影響酶活性的因素，所以 A、B、D、E 選項都是正確的。而輔酶是小分子有機物，並不是蛋白質喔。有些酶需要與輔酶結合，才有活性。

學生： 了解！

老師： 溫度過高影響蛋白質結構，會使酵素失去活性，所以溫度愈高酶活性愈強是錯誤敘述。

2-2 細胞的能量來源—呼吸作用
The Source of Energy for The Cells – The Respiratory Process

■ 前言 Introduction

本節介紹 ATP 形成的方式，並探討有氧呼吸、無氧呼吸及發酵作用的過程。細胞的能量來自有機養分，而有機養分所儲存的能量，必須透過呼吸作用釋放，並轉移至 ATP，細胞才能利用。呼吸作用又分為有氧參與的有氧呼吸，以及不需要氧參與的無氧呼吸和發酵作用。語言部分則著重於與呼吸作用相關單字及名詞，並運用句型學習呼吸作用進行的過程。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
pyruvic acid	丙酮酸	alcoholic fermentation	酒精發酵
fermentation	發酵作用	substrate-level phosphorylation	受質層次磷酸化
electron transport chain	電子傳遞鏈	lactic acid fermentation	乳酸發酵
glycolysis	糖解作用	acetyl coenzyme A {=acetyl CoA}	乙醯輔酶 A
TCA cycle	檸檬酸循環	aerobic respiration	有氧呼吸
chemiosmosis	化學滲透作用	anaerobic respiration	無氧呼吸

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

❶ ____ be catalyzed by _____ to produce _____.

例句：葡萄糖經過一系列酶的催化下，產生丙酮酸。

Glucose is catalyzed by a series of enzymes **to produce** pyruvic acid.

❷ ____ reacts with _____ to form _____.

例句：乙醯輔酶 A 和基質中的四碳化合物反應，形成六碳的檸檬酸。

Acetyl-CoA **reacts with** four-carbon compounds in the substrate **to form** six-carbon citric acid.

❸ _____ be composed of _____.

例句：電子傳遞鏈是由粒線體內膜上的一系列電子載體所組成。

The electron transport chain **is composed of** a series of electron carriers on the inner membrane of mitochondria.

❹ _____ occur during ____.

例句：受質層次磷酸化發生在糖解作用及檸檬酸循環的過程。

Substrate-level phosphorylation **occurs during** glycolysis and the TCA cycle.

■ 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、了解細胞呼吸作用的過程及產物。

Understand how cellular respiration works.

❧ 例題講解 ☙

例題一

說明：學生熟悉細胞呼吸作用中的各項反應與其產物。

Students will learn to understand the reactions and products of cellular respiration.

Which of the following reactions produces the high-energy electron carrier NADH in cellular respiration?

(A) glycolysis

(B) fermentation

(C) Calvin cycle

(D) electron transport chain

(E) Krebs cycle

細胞呼吸作用中，高能電子攜帶者 NADH 是在下列哪些反應中產生？

(A) 糖解作用

(B) 醱酵作用

(C) 卡爾文循環

(D) 電子傳遞鏈

(E) 克氏循環

（98 指考生物 34）

Teacher: Students, where can NADH be produced?
Student: Glycolysis and the citric acid cycle.
Teacher: Yes, the electron transport chain produces ATP, not NADH! Next, look at option C. Do you still remember what the Calvin cycle is? It's not respiration!
Student: Photosynthesis.
Teacher: You are all geniuses!
Student: Can't fermentation make NADH?
Teacher: Fermentation is not a process of respiration.

老師： 同學們，呼吸作用時有哪些地方有產生 NADH？
學生： 糖解作用、檸檬酸循環。
老師： 沒錯，電子傳遞鏈產生 ATP，不是產生 NADH 唷！接下來看 C 選項，大家還記得卡爾文循環是什麼作用的循環嗎？
學生： 光合作用。
老師： 大家是小天才吧！
學生： 老師發酵作用不是會產生 NADH 嗎？
老師： 發酵作用不是呼吸作用的過程。

例題二

說明：學生了解細胞呼吸作用的過程、發生地點、產物...等等。
Students will learn how cellular respiration works, where it happens, what its products are, etc.

Which of the following statements about cellular respiration is correct?
(A) All processes take place in the mitochondria.
(B) Aerobic respiration releases more energy than fermentation.
(C) Plant cells can ferment in the absence of oxygen.
(D) Animal cells normally produce carbon dioxide.
(E) Glycolysis does not take place in hypoxia.

下列有關細胞呼吸作用的敘述，哪些正確？

(A) 所有過程皆在粒線體中進行。

(B) 有氧呼吸比發酵作用釋出更多能量。

(C) 植物細胞在缺氧時可進行發酵作用。

(D) 動物細胞在一般情況下都會產生二氧化碳。

(E) 在缺氧情況下不進行糖解作用。

(103 年指考生物 32)

解析 Solution:

(A)糖解作用於細胞質中進行。

(E)在缺氧情況下，無氧呼吸過程進行糖解作用。

(A) Glycolysis takes place in the cytoplasm.

(E) Glycolysis occurs during anaerobic respiration in the absence of oxygen.

Teacher: Let's see, where does glycolysis take place at Figure 2-2.1 on page 67?

Student: It takes place in the cytoplasm, so we cannot choose option A.

Teacher: Very good. Now look at Figure 2-2.2, fermentation only produces energy in the first half procedure of glycolysis! Aerobic respiration can provide more energy through the electron transport chain.

Student: Teacher, can plants ferment if they are starved of oxygen?

Teacher: Yes, plants can also suffer from hypoxia, too. So option C is correct! In option D, what type of respiration do animal cells generally carry out?

Student: Aerobic respiration and fermentation will take place unless there is a lack of oxygen.

Teacher: That's right. Final fermentation is also by glycolysis! If you look at 2-2.2, only glycolysis can produce energy, so less energy is produced.

老師： 大家看課本 p.67 圖 2-11 糖解作用在哪裡進行呢？

學生： 在細胞質中進行，不能選 A 選項。

老師： 很好。那大家看看 p.73 圖 2-16，發酵作用只有在前半段的糖解作用有產生能量唷！而有氧呼吸經過電子傳遞鏈，可以提供更多能量。

學生： 老師，植物缺氧時也可以進行發酵作用嗎？

老師： 可以，植物也是有缺氧的可能，所以 C 選項是正確的唷！D 選項中，動物細胞一般會進行哪種呼吸？

學生： 有氧呼吸，除非缺氧情況才會進行發酵作用。

老師： 沒錯。發酵作用也會經過糖解作用唷！看看 p.73 圖 2-16，只有糖解作用產生能量，所以產生較少的能量。

2-3 能量的來源、流轉與使用
Source, Circulation, and Use of Energy

■ 前言 Introduction

細胞的能量(ATP)主要來自葡萄糖，而葡萄糖中的所儲存的化學能從何而來？本章將介紹生物體獲取能量的方式，以及 ATP 合成後將可以作用於那些生理反應。透過 ATP 的來源、流轉和運用的英文相關詞彙及句型，學生能夠理解日常生活或題目中英文敘述方式及其含意。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
phosphorylation	蛋白質磷酸化	active transport	主動運輸
Na^+-K^+ pump	鈉鉀幫浦	autotroph	自營生物
photoautotroph	光自營生物	heterotroph	異營生物
chemoautotroph	化學自營生物		

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

❶ _____ synthesize _____ from _____.

例句：Autotrophs are able to **synthesize** organic nutrients **from** inorganic environmental substances on their own.
自營生物可自行將環境中的無機物合成有機養分。

❷ ____ take _____ from _____.

例句：Heterotrophs have to **take** organic nutrients **from** the outside world.
異營生物需要由外界攝取有機養分。

❸ _____ converted into _____ through _____.

例句：Light energy from the sun is **converted** into the chemical energy of organic nutrients **through** photosynthesis.
太陽的光能經光合作用轉換為有機養分的化學能。

❹ ___metastasize to____ through____.

例句：Potassium ions **metastasize to** the inside of the cell **through** the sodium-potassium pump.
鉀離子藉由鈉鉀幫浦轉移到細胞內。

■ 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、學生了解自營生物的意義。

Students will understand what is the autotrophs.

二、學生了解 ATP 轉換為 ADP 的意義，並了解那些現象為耗能反應。

Students will understand the significance of the converting of ATP (ATP convert to ADP) and which phenomena are energy-consuming reactions.

❧ 例題講解 ☙

例題一

說明：學生了解自營生物為能自行合成有機養分的生物。

Students will understand that autotrophs are organisms that are able to synthesize their own organic nutrients.

Which of the following statements about autotrophs is correct?

(A) All autotrophs can carry out photosynthesis.

(B) The Venus flytrap, which catches insects, is a heterotroph.

(C) Autotrophs can convert inorganic substances into organic nutrients.

(D) Autotrophs are organisms that can feed themselves.

下列關於自營生物的敘述，何者正確？

(A) 自營生物皆可行光合作用。

(B) 捕蠅草捕食昆蟲，屬於異營生物。

(C) 自營生物能夠將無機物轉換為有機養分。

(D) 自營生物是指能自行進食的生物。

Teacher: Students, what does the term "autotroph" mean?

Student: It refers to organisms that can synthesize their own organic nutrients.

Teacher: Correct! Let's look at the options together! Starting with option (A), can all autotrophs perform photosynthesis?

Student: Not necessarily!

Teacher: That's right, some bacteria are chemosynthetic autotrophs, which use chemical methods to produce organic nutrients.

Next, let's look at option (B). Venus flytraps capture catch insects to supplement their nitrogen source, but they still perform photosynthesis and synthesize their own organic nutrients, so they are still autotrophs!

Student: I see!

Teacher: Finally, let's look at option (D). Does the description "feed themselves" fit the definition of an autotroph?

Student: No, it doesn't. Autotrophs are organisms that can synthesize their own organic nutrients.

Teacher: Exactly!

老師： 同學們，請問自營生物是什麼意思？

學生： 是指能夠自行合成有機養分的生物。

老師： 沒錯！讓我們一起來看選項吧！首先看到選項(A)，請問自營生物皆可行光合作用嗎？

學生： 不一定！

老師： 是的，有些細菌屬於化學自營生物，會用化學方法和成有機養分喔。

接下來看到選項(B)，捕蠅草捕捉昆蟲是為了補充氮源，但捕蠅草仍然會行光合作用，自行合成有機養分，所以它還是屬於自營生物喔！

學生： 原來如此！

老師： 最後讓我們看到選項(D)，請問「自行進食」這個敘述符合自營生物的定義嗎？

學生： 不符合，自營生物是能夠自行合成有機養分的生物。

老師： 沒錯！

例題二

說明：學生能識別出在哪些生物學過程需要消耗能量，亦即 ATP 被分解釋放能量，進而轉化為 ADP 和 Pi。

Students will learn to identify the biological processes that require energy consumption, i.e. where ATP is broken down to release energy and converted to ADP and Pi.

Which of the following statements describes the process where ATP is converted to ADP + Pi?

(A) Oxygen diffuses into the cell.

(B) The light reactions of photosynthesis.

(C) Plant roots take up minerals from the soil.

(D) Plant roots take up water from the soil.

下列敘述何者會發生 ATP → ADP＋Pi 的過程？

(A) 氧氣擴散進入細胞。

(B) 光合作用的光反應。

(C) 植物根吸收土壤中的礦物質。

(D) 植物根吸收土壤中的水分。

Teacher: Students, what is the process of ATP → ADP + Pi represent?

Student: The hydrolysis of ATP into ADP + Pi releases energy.

Teacher: Under what conditions does this reaction take place?

Student: When an organism needs to use energy.

Teacher: Correct! Does option (A) require the consumption of ATP?

Student: No, diffusion doesn't require energy.

Teacher: Does option (B) require the consumption of ATP?

Student: No, the light reactions of photosynthesis use light energy to synthesize ATP.

Teacher: Correct! Plant roots absorb minerals from the soil by active transport. Does this process require ATP?

Student: Yes.

Teacher: Correct, so that's the right answer. Finally, does option (D) – plant roots absorbing water from the soil – require ATP?

Student: No, after absorbing minerals, there is a difference in osmotic pressure, and water is absorbed by osmosis. This process doesn't require energy.

老師： 同學們請問 ATP → ADP＋Pi 的過程代表什麼？

學生： ATP 水解成 ADP＋Pi ，這個過程會釋放能量。

老師： 請問什麼情況下會發生這個反應呢？

學生： 當生物體需要消耗能量的時候。

老師： 沒錯！請問(A)選項需要消耗 ATP 嗎？

學生： 不需要，擴散作用是不需要消耗能量的。

老師： 請問(B)選項需要消耗 ATP 嗎？

學生： 不需要，光合作用的光反應是吸收光能作為能量，來合成 ATP。

老師： 嗯！植物根藉由主動運輸，吸收土壤中的礦物質，請問這個過程需要消耗 ATP 嗎？

學生： 需要。

老師： 對，所以這是正確選項。最後選項(D)植物根吸收土壤中的水分，需要消耗 ATP 嗎？

學生： 不需要，植物根吸收土壤中的礦物質後，形成滲透壓差，再藉由滲透作用吸收水分，這個過程不需要消耗能量。

★ 主題三 從染色體到 DNA ★
From Chromosomes to DNA

國立彰化師範大學生物學系 張閔琦
國立彰化師範大學英語學系 林之曦

■ 前言 Introduction

過去人們觀察到親代的表徵會遺傳給子代，卻無法詳細解釋。孟德爾觀察豌豆而提出性狀由遺傳因子控制一說，並提出分離率與分配律等遺傳法則，本章將介紹遺傳因子和遺傳的染色體學說之間的關聯之處，還有此學說如何被驗證。英文介紹了染色體學說如何驗證，基因如何遺傳與分配、訊息遺傳分子以及 DNA 結構的英文單字還有相關文法之運用。

3-1 遺傳的染色體學說之驗證
Verification of the Chromosomal Theory of Inheritance

■ 前言 Introduction

本節介紹遺傳因子是如何由抽象概念成為具體的構造。孟德爾藉由觀察豌豆，提出了分離律與獨立分配律等學說，也提出了遺傳因子的說法。科學家們發現了染色體，且基因位在染色體上，嘗試利用染色體來驗證分離律與獨立分配律，並且發現了例外的案例如性聯遺傳，使學說更加完整。語言部分介紹染色體學說、性聯遺傳、連鎖與互換的英文字詞以及基因分配的相關句型使學生更了解染色體學說的英文知識。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
trait	表徵	gene recombination	活化能基因重組
law of segregation	分離律	parent generation (P generation)	親代
law of independent assortment	獨立分配律	sex-linked inheritance	性聯遺傳
linkage	連鎖	testcross	試交
linkage group	連鎖群	chromosome	染色體
Crossing over	互換	allele	等位基因
dorminance	顯性	recessive	隱性

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

❶ ____ separate into _____.

例句：During meiosis, homologous chromosomes **separate into** different gametes.
減數分裂時，同源染色體會分離至不同配子。

❷ ____ be located on _____

例句：In Mendel's dihybrid cross experiment, the alleles that control the two traits **are located on** non-homologous chromosomes.
在孟德爾雙性雜交實驗中，控制兩種性狀的等位基因分別位於非同源染色體上。

❸ ____ be distributed to _____.

例句：During meiosis, the alleles that are located on the same chromosome **are distributed to** the same gamete.
減數分裂時，位在同一條染色體的等位基因會分配至同一配子內。

❹ ____ to form _____.

例句：In the prophase of meiosis, synapsis occurs **to form** tetrads of homologous chromosomes.
在減數分裂前期，聯會作用發生使同源染色體形成四分體。

■ 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、學生了解顯性與隱性的意義。

Students will learn about the difference between dominance and recessive meanings.

二、學生了解連鎖與互換和計算表現型比例的方式。

Students learn about linkage and crossing over and understand how to calculate the ratio of offspring's phenotype.

❧ 例題講解 ☙

例題一

說明：學生了解連鎖與互換的計算方式。

Students understand will learn how to calculate linkage and crossing over.

The genes that control wing length and body color in Drosophila are located on the same chromosome, 20 units apart. If an isogenic long-winged black body (VVbb) female Drosophila mates with a short-winged gray body (vvBB) male Drosophila, and the resulting offspring (VvBb) female Drosophila mates again with a short-winged black body (vvbb) male Drosophila, what is the correct ratio of offspring phenotypes?

(A) Long-winged gray body accounts for 10%

(B) Short-winged black body accounts for 20%

(C) Long-winged black body accounts for 10%

(D) Short-winged gray body accounts for 20%

控制果蠅翅膀長度與體色性狀的基因聯鎖在同一條染色體上，相距 20 個互換單位。若同基因型的長翅黑身（VVbb）雌果蠅與短翅灰身（vvBB）雄果蠅交配，所得子代（VvBb）雌果蠅再與一短翅黑身（vvbb）雄果蠅交配。下列後代表現型的比例，何者正確？

(A) 長翅灰身佔 10%

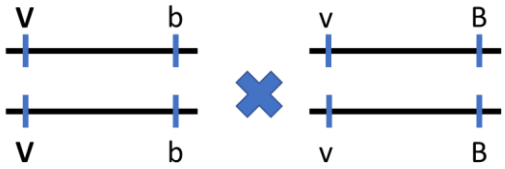
(B) 短翅黑身佔 20%

(C) 長翅黑身佔 10%

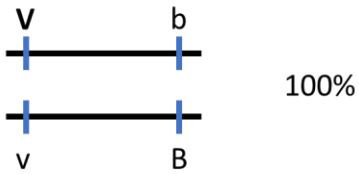
(D) 短翅灰身佔 20%

（99 年指考生物 5）

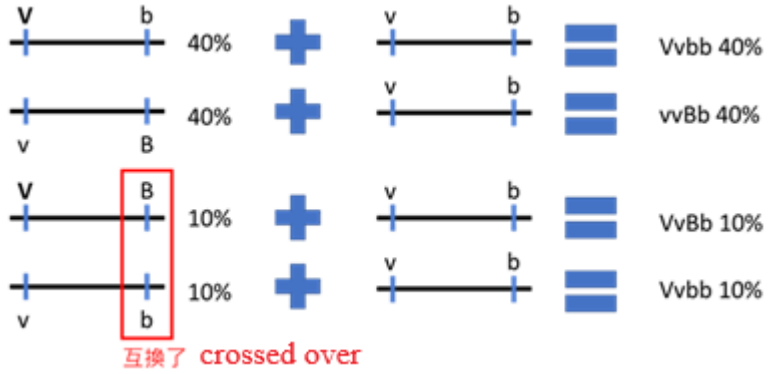
解析 Solution:



▲圖 3-1.1



▲圖 3-1.2



▲圖 3-1.3

Teacher: Look at Figure 3-1.1. The horizontal lines represent the chromosomes. You can see that v(V) and b(B) are drawn on the same chromosome. The figure is the parent generation mentioned in the title: VVbb × vvBB, think about, how to draw the chromosomes of the offspring?

Student: (Draw Figure 3-1.2, or it doesn't matter if they couldn't draw it.)

Teacher: Yes, it should be drawn that V and b are on the same chromosome, and vB is on the same chromosome, so, that Vb is linked and vB is linked, as shown in Figure 3-1.2. Next, which two gametes should there be if there is no exchange of gametes produced by this offspring?

Student: Vb, vB.

Teacher: Yes, the question mentioned that the cross over rate is 20%, so how many percent will there be no cross over?

Student: 80%.

Teacher: What percentage of Vb and vB will be?

Student: 40%.

Teacher: So what will happen to the combination of genes after the cross over?

Student: VB、vb.

Teacher: Yes, just like the red boxed part in Figure 3-1.3, then they will each be 10%. We can see that the gene ratio in the resulting gametes it produces is: vb:VB:Vb:vB=1:1:4: 4. Next, try mating with vvbb. We can know the proportion of phenotype in the offspring.

Student: Long gray: Long black: Short gray: Short black = 1:4:4:1.

老師： 同學們，請看圖 3-1.1，橫線代表染色體，可以看到ｖ(V)和ｂ(B)被畫在相同染色體上。圖中是題目所說的親代：VVbb × vvBB，大家想一想，子代的染色體應該怎麼畫呢？

學生： （畫出圖 3-1.2，或沒畫出來也無妨。）

老師： 沒錯，應該畫出 V、b 在相同染色體上，vB 在相同染色體上 ，也就是說 Vb 連鎖、vB 連鎖。就像圖 3-1.2。接下來，這個子代產生的配子中，沒有發生互換的話，應該會有哪兩種呢？

學生： Vb、vB。

老師： 對，題目中說互換率 20%，那請問沒有互換的會有多少%？

學生： 80%。

老師： 那 Vb、vB 會各有幾%？
學生： 40%。
老師： 那如果發生了互換之後基因的組合會如何呢？
學生： VB、vb。
老師： 對，就像圖 3-1.3 中紅色框起來的部分，那他們會各佔 10%，我們可以看到他產生的配子中基因比：vb:VB:Vb:vB=1:1:4:4。接下來再進行試交，與 vvbb 交配。我們就可以得知子代表現型的比例如何了。
學生： 長灰：長黑：短灰：短黑=1:4:4:1。

例題二

說明：學生能判斷究竟基因是否有連鎖。

Students will learn how to determine whether genes are linked to each other.

A group of high school students conducted a study on the genetic traits of two purebred plant strains. The first strain produces purple flowers and leaves with smooth edges, while the second strain produces white flowers and leaves with serrated edges. When the two strains were crossed, the F1 generation plants all had smooth-edged leaves and purple flowers. The students then crossed the F1 plants with the second strain and observed the following traits in the F2 generation: 100 plants with smooth-edged leaves and purple flowers, 92 plants with serrated-edged leaves and white flowers, 24 plants with serrated-edged leaves and purple flowers, 20 plants with smooth-edged leaves and white flowers.

Are the genetic factors for these two traits located on the same chromosome?

(A) Yes, because the F2 traits include plants with the same traits as the parent strains.

(B) No, because the F2 traits are observed in four different combinations.

(C) Yes, because the individual ratios of the four trait combinations in F2 do not match 1:1:1:1.

(D) No, because the individual ratios of the four trait combinations in F2 do not match 9:3:3:1.

某群高中生參與研究兩個純品系植株的遺傳性質。第一個品系開紫色花，葉緣完整；第二個品系開白色花，葉緣缺裂。當他們將兩個品系雜交並分析這兩個性狀的遺傳方式，得到 F1 植株，全部長出葉緣完整的葉子，開出紫色花的結果。學生們繼續將 F1 植株與第二個品系雜交，結果 F2 植株具有四種不同性狀組合：100 棵葉緣完整紫花，92 棵葉緣缺裂白花，24 棵葉緣缺裂紫花，20 棵葉緣完整白花。

這兩個性狀的遺傳因子是否在同一個染色體上？

(A) 是的，因為 F2 的性狀包含與親代相同性狀的植株。

(B) 不是，因為 F2 的性狀組合有四種。

(C) 是的，F2 的四種性狀組合的植株個體比率不符合 1:1:1:1。

(D) 不是，F2 的四種性狀組合的植株個體比率不符合 9:3:3:1。

（110 指考生物 9）

Teacher: According to the phenotype of F1, which one is dominant, purple flower or white flower? Leaf margin complete or deficient?

Student: Purple flowers and complete leaf margins are dominant.

Teacher: That's right, because all F1s are all purple flowers with complete leaf margins. Now, let's assume that the gene controlling flower color is dominant A and recessive a, and the gene controlling leaf margin is dominant B and recessive b. What should the genotype of the F1 be?

Student: AaBb.

Teacher: That's right. The second line has white flowers and deficient leaf margins. What should its genotype be?

Student: aabb .

Teacher: That's right. The question says to cross F1 with a second strain, if the two genes are on different chromosomes, they are not linked, the genotype ratio of the second offspring (F2) will be AaBb:Aabb:aaBb:aabb=1:1:1:1, what should the phenotype ratio be?

Student: The ratio of the four characteristics is 1:1:1:1.

Teacher: That's right, but the ratio in the question seems to be very different from 1:1:1:1, so we can be sure that there is a linkage.

老師： 根據 F1 的表現型，紫花與白花哪一個是顯性呢？葉緣完整與缺裂，哪個是顯性呢？

學生： 紫花、葉緣完整是顯性。

老師： 沒錯唷，因為 F1 全都是紫花、葉緣完整。現在，我們假設控制花朵顏色基因顯性為 A、隱性為 a，控制葉緣基因顯性為 B、隱性為 b。F1 的基因型應該是甚麼呢？

學生： AaBb。

老師： 沒錯唷。第二個品系開白色花、葉緣缺裂，他的基因型應該是甚麼呢？

學生： aabb 。

老師： 沒錯唷。

題目說將 F1 與第二個品系雜交，如果這兩個基因在不同染色體上，也就是說，沒有連鎖，第二子代(F2)的基因型比會是 AaBb:Aabb:aaBb:aabb=1:1:1:1，那表現型的比率應該會怎麼樣呢？

	AB	**Ab**	**aB**	**ab**
ab	AaBb	Aabb	aaBb	aabb
ab	AaBb	Aabb	aaBb	aabb
ab	AaBb	Aabb	aaBb	aabb
ab	AaBb	Aabb	aaBb	aabb

學生： 四種性狀比率為 1:1:1:1。

老師： 沒錯呀，可是題目中的比例看來並不符合 1:1:1:1，所以我們可以確定，此為連鎖。

3-2 攜帶遺傳訊息的分子
Molecules Carrying Genetic Information

■ 前言 Introduction

本節介紹科學家們如何透過實驗來得知遺傳物質是 DNA 的過程。藉由摩根的果蠅實驗確認了基因應位於染色體，然而人們並不知道負責攜帶遺傳訊息的分子是什麼，只能確定染色體的主要成分是 DNA 與蛋白質，本章將介紹科學家們如何透過實驗確定遺傳物質是 DNA。英文則介紹了不同遺傳分子及細菌種類以及以噬菌體實驗證明遺傳物質為 DNA 的相關單字和句型。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
petri dish (plate)	培養皿	transformation	轉形
E.coli (*Escherichia coli*)	大腸桿菌	hydrolase	水解酶
bacterial colony	菌落	phage	噬菌體
capsule	莢膜		

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

❶ ____ consists of_____.

例句：DNA **consists of** 4 nucleotides.

DNA 由 4 種核甘酸構成。

❷ ____ be higher than _____.

例句：The proportion of protein in chromosomes **is higher than** that of DNA.

染色體中蛋白質所占比率高於 DNA。

❸ _____ are pathogenic _____.

例句：S-type bacteria **are pathogenic**, R-type bacteria are not pathogenic.

S 型菌具有致病力，R 菌不具致病力。

❹ _____ high temperatures can kill ____.

例句：**High temperatures can kill** S-type bacteria, but not mixed S and R-type bacteria.

高溫可以殺死 S 型菌，但不能殺死 S 型菌和 R 型菌的混合。

❺ _____ be pelleted with ____.

例句：E. coli **was pelleted with** a centrifuge.

用離心機使大腸桿菌沉澱。

❻ _____ be the genetic material of ____.

例句：DNA **is the genetic material of** bacteriophages.

DNA 是噬菌體的遺傳物質。

■ 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、學生了解生物學家探討遺傳物質成分的方法與各個實驗的結論。

Students will learn about the methods biologists use to study genetic make-up and the conclusions they draw from each experiment.

二、學生能了解其他重要發現、經典實驗的原理與結論。

Students will understand how other important discoveries and classic experiments work and why.

❧ 例題講解 ☙

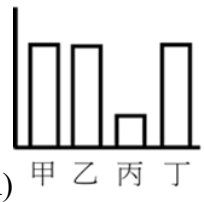
例題一

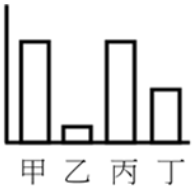
說明：學生須了解遺傳物質為 DNA，也了解加入分解酶的功能。

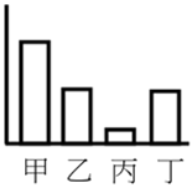
Students will understand the genetic material as DNA and the function of the degrading enzyme.

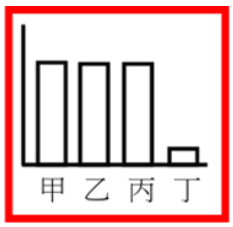
The horizontal axis in the option diagram represents four different treatments with heat-killed S-type pneumococcal extract through 甲~丁(A~D). The vertical axis represents the number of S-type pneumococcus after mixing the treated extract with live R-type pneumococcus.
The four treatments are as follows: A is untreated, B is treated with an RNA degrading enzyme, C with a protein degrading enzyme, and D with a DNA decomposing enzyme. Which of the following options is closest to the results of Avery's transformation study in 1944?

選項圖中的橫軸代表用熱殺死 S 型肺炎雙球菌萃取液經甲~丁四種不同處理；縱軸則表示處理後之萃取液與活的 R 型肺炎雙球菌混合後，所測得的 S 型肺炎雙球菌數量。四種處理如下，甲為未處理，乙為加入 RNA 分解酶，丙為加入蛋白質分解酶，丁為加入 DNA 分解酶。下列選項何者接近 1944 年艾佛瑞（Avery）的轉形研究結果？

(A) 

(B) 

(C) 

(D) 

（107 指考生物 14）

Teacher: Do you remember the transformation effect of bacteria? Bacteria incorporate genetic material from the environment into their bodies to acquire new characteristics. So the question is, what is the composition of the genetic material of bacteria?

Student: DNA.

Teacher: Yes, I want to know which of the treatments in questions 1 to 4 will cause the DNA to be decomposed?

Student: DNA degrading enzymes.

Teacher: That's right, so there will be very few S bacteria in IV, because the DNA is broken down in the extract with S bacteria is decomposed. The answer is D.

老師：各位同學，還記得細菌的轉形作用嗎？細菌會將環境中的遺傳物質納入體內，以獲得新的性狀。那麼問題來了，細菌的遺傳物質的成分是甚麼？

學生：DNA。

老師：對，題目中甲、乙、丙、丁分別做了 4 種處理，哪一種會讓 DNA 被分解呢？

學生：DNA 分解酶。

老師：沒錯唷，因為萃取液中 S 菌的 DNA 被分解了，使得丁的 S 菌會特別少，答案選 D。

例題二

說明：學生了解經典實驗原理與結論。

Students will understand the principles and conclusions of classical experiments.

According to the above question, which of the following classical experimental conclusions is similar to the above experimental results?

(A) Meselson and Stahl used the isotope ^{15}N to identify the semi-conservative replication of genetic material.

(B) Hershey and Chase used ^{32}P and ^{35}S to discover the characteristics of bacteriophage genetic material.

(C) Fleming found penicillin produced by Penicillium during the cultivation of Staphylococcus.

(D) Morgan suggested genetic model of eye color from Drosophila hybridization experiments.

呈上題，下列哪個經典實驗結論與上述實驗所得相似？

(A) 麥舍生（Meselson）與史塔爾（Stahl）利用同位素 ^{15}N ，鑑定出遺傳物質的半保留複製方式。

(B) 賀雪（Hershey）與蔡斯（Chase）利用 ^{32}P 及 ^{35}S，發現噬菌體遺傳物質的特性。

(C) 弗萊明（Fleming）從葡萄球菌培養過程中，發現青黴菌所產生的青黴素。

(D) 摩根（Morgan）從果蠅雜交實驗中，提出眼色的遺傳模型。

（107 年指考生物 15）

Teacher: In the experiment of the first question, the conclusion is that the genetic material is DNA. So we're looking for options that have to do with genetic material.

Student: Both A and B are about genetic material.

Teacher: That's right, but A's experiment is about how the genetic material is replicated, so option B can confirm that the genetic material of the phage is DNA.

老師： 大家看課本 p.67 圖 2-11 糖解作用在哪裡進行呢？

學生： 第一題的實驗中，結論得知遺傳物質是 DNA。那我們要找題目中與遺傳物質有關的。

老師： A、B 都與遺傳物質有關。

學生： 沒錯，但是 A 的實驗是在探討遺傳物質的複製方式，而 B 選項可以證實噬菌體的遺傳物質為 DNA。

3-3 DNA 的結構
The Structure of DNA

■ 前言 Introduction

本節介紹遺傳物質的物理與化學特性。融入 DNA 與 RNA 基本結構的英文單字和形容 DNA 組成的相關句型，讓學生更理解 DNA 組成成分及規則的英文用法。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
purine	嘌呤	nitrogenous base	含氮鹼基
pyrimidine	嘧啶	double-stranded	雙股的
deoxyribonucleotide	去氧核糖核苷酸	double helix	雙股螺旋
nucleotide	核苷酸	pentose	五碳糖

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

❶ _____ exist within _____.

例句：Two different nucleic acids **exist within** cells.

細胞內存在兩種不同的核酸。(原核細胞一樣存在兩種不同的核酸)

❷ ____ basic structural unit of ____ are ____.

例句：The results of biochemical reactions, suggest that the **basic structural units of** DNA and RNA **are** both nucleotide.

依據生化反應結果推論 DNA 與 RNA 的基本構造單元皆為核甘酸。

❸ _____ consist of _____.

例句：Nucleic acid **consists of** nitrogenous bases, pentose and phosphate group.

核甘酸由含氮鹼基、五碳醣與磷酸基所組成。

❹ _____ have a similar ratio .

例句：Of the nitrogenous bases that make up double-stranded DNA, A and T **have a similar ratio**, while G and C have a similar ratio.

組成雙股 DNA 的含氮鹼基中，A 和 T 所佔比率相近，而 G 和 C 所占比率相近。

❺ _____ and ____ are paired .

例句：Of the nitrogenous bases that make up double-stranded DNA, A **and** T **are paired**, and G and C are paired.

組成雙股 DNA 的含氮鹼基中，A 和 T 配對，而 G 和 C 配對。

❻ _____ be formed between _____.

例句：Two hydrogen bonds can **be formed between** the nitrogenous bases A and T, and three hydrogen bonds can be formed between G and C.

含氮鹼基 A 和 T 之間可形成兩個氫鍵，G 和 C 之間可形成三個氫鍵。

❼ _____ be determined by _____.

例句：The directionality of the polynucleotide chain **is determined by** the pentose.

聚核苷酸鏈的方向性由五碳醣決定。

❽ _____ be parallel to each other_____.

例句：The two polynucleotides that make up DNA **are parallel to each other** and run in opposite directions.

構成 DNA 的兩股聚核苷酸鏈互相平行且方向相反。

■ 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、學生熟悉 DNA 構造，並了解雙股之間鍵結的方式。

Students will understand the structure of DNA and how double strands bond together.

二、學生了解 DNA 和 RNA 的成分及構造。

Students will learn about the composition and structure of DNA and RNA.

❧ 例題講解 ☙

例題一

說明：學生熟悉 DNA 構造，並了解雙股之間鍵結的方式。

Students will understand the structure of DNA and how double strands bond together.

The number of hydrogen bonds determines the ease with which double-stranded DNA can be denatured and separated into single-stranded DNA. Which of the following four double-stranded DNA sequences is the easiest to denature and separate into single-stranded DNA?

氫鍵多寡決定雙股 DNA 變性分離成單股的難易程度，下列 4 個雙股 DNA 序列，何者最容易變性分離成單股？

(A) GGATTACCAATTCAT
CCTAATGGTTAAGTA

(B) GGCGTACCATTTAAT
CCGCATGGTAAATTA

(C) GGCGTACCAGCGCAT
CCGCATGGTCGCGTA

(D) ATAGTACCAGCGCAT
TATCATGGTCGCGTA

（96 年指考生物 12）

Teacher: The double strands of DNA are linked by hydrogen bonds. How do you connect A, T, C, and G?

Student: A is paired with T, C with G.

Teacher: Yes, the number of hydrogen bonds between A and T is different from the number of hydrogen bonds between C and G. How many are there?

Student: There are three between C and G, and two between A and T.

Teacher: That's right, then let's look at the question, we have to choose the option with the most bonds between A and T. Which option A and T have the most connections?

Student: A.

老師： DNA 的雙股之間以氫鍵連結，請問大家 A、T、C、G 是如何配對的呢？

學生： A 跟 T 配對，C 跟 G 配對。

老師： 是的～A、T 之間的氫鍵數目，與 C、G 之間的氫鍵數目，是不一樣的。請問分別是多少個呢？

學生： A、T 之間有 2 個，CG 之間有 3 個。

老師： 沒錯唷，那麼我們看看題目，我們要選 A、T 連結最多的選項。請問哪個選項 A、T 連結最多？

學生： A。

例題二

說明：學生了解 DNA 和 RNA 的成分及構造。

Students will learn about the composition and structure of DNA and RNA.

Which of the following statements are true when comparing of DNA and RNA?

(A) There are deoxyribose and phosphate in DNA and RNA.

(B) DNA is usually a double-stranded structure, whereas RNA is a single-stranded structure.

(C) DNA contains pentose, RNA contains hexose.

(D) DNA is a polymer of nucleotides, RNA is a polymer of nucleic acids.

(E) DNA contains thymine, RNA contains uracil.

有關 DNA 與 RNA 的比較，下列敘述哪些正確？

(A) 二者均含去氧核糖和磷酸根。

(B) 通常 DNA 為雙股結構，RNA 為單股結構。

(C) DNA 含五碳糖，RNA 含六碳糖。

(D) DNA 是核苷酸的聚合物，RNA 是核酸的聚合物。

(E) DNA 含胸腺嘧啶，RNA 含脲嘧啶。

（96 年指考生物 27）

Teacher: This question mainly compares the similarities and differences in the composition and structure of DNA and RNA. First, look at option A, DNA is the abbreviation of deoxyribonucleic acid in English, “de” at the beginning means "removal", and oxy stands for oxygen, so DNA is composed of deoxyribonucleic acid. And RNA is the abbreviation for ribonucleic acid in English. It does not have a deoxy at the beginning. So is RNA deoxyribonucleic acid?

Student: No.

Teacher: Correct. If you look at this picture in the textbook, you can see that DNA has deoxyribose in the nucleotides, and RNA has ribose.

Teacher: Now, look at option B. It is correct, usually DNA is a double-stranded structure, and RNA is a single-stranded structure.

Teacher: Now, look at option C. You will see the same picture in the textbook. Is RNA a pentose or a hexose?

Student: Pentose.

Teacher: That's right, everyone should remember that. Now, look at option D. This is crucial. Nucleotides are linked together to form a long chain, creating a nucleic acid. This means that both DNA and RNA are both polymers of nucleotides.

Teacher: Finally, look at option E. Do you remember what the code name for thymines is?

Student: It's T.

Teacher: Right. The first letter of Thymine is T. Do you remember the code name for uracil?

Student: It's U.

Teacher: That's right. The first letter of uracil. The textbook shows that the nitrogenous bases of DNA are ATCG, while those of RNA are AUCG. This means that DNA contains thymine and RNA contains uracil.

老師： 這題主要是比較 DNA 跟 RNA 的成分與構造的異同。首先我們看選項 A，DNA 是英文 deoxyribonucleic acid 的縮寫，開頭的 de 就是「去」的意思，oxy 代表氧，所以 DNA 是去氧核醣核酸構成的。而 RNA 是英文 ribonucleic acid 的縮寫，他的開頭沒有 deoxy，那請問 RNA 是去氧核醣核酸嗎？

學生： 不是。

老師： 對，大家看到課本中的圖片 ，可以看到 DNA 的核甘酸中為去氧核糖，RNA 的是核糖。

老師： 接下來看 B 選項，是正確的，通常 DNA 為雙股結構，RNA 為單股結構。

老師： 接下來看 C 選項，可以看課本中 DNA 與 RNA 的構造圖，RNA 中是幾碳糖呢？

學生： 5 碳糖。

老師： 沒錯唷，大家要記得。 接下來看選項 D，這很重要喔，一個一個的核苷酸，連接起來變成長長的鏈條之後，就是核酸，所以 DNA 和 RNA 都是核苷酸的聚合物。

老師： 最後看看選項 E，大家還記得胸腺嘧啶的代號是什麼嗎?

學生： 是 T。

老師： 沒錯，因為胸腺嘧啶 thymine 開頭第一個字母是 T。尿嘧啶的代號是什麼大家還記得嗎？

學生： 是 U。

老師： 沒錯，是 uracil 開頭的第一個字母。從課本的這張圖就可以看到，DNA 的含氮鹼基有 ATCG，RNA 的則是 AUCG 。所以 DNA 含胸腺嘧啶，RNA 含脲嘧啶。

★ 主題四 DNA 與生物科技 ★
DNA and Biotechnology

國立彰化師範大學生物學系 張閔琦
國立彰化師範大學英語學系 林之曦

■ 前言 Introduction

本章介紹 DNA 如何進行複製，基因要如何表現其功能還有當 DNA 發生改變時會對生物體造成甚麼影響，而遺傳工程又是如何製造基改生物。透過 DNA 與生物科技相關英文詞彙與句型學習本章知識和認識科學家們如何運用實驗設計來驗證假說，一步步解開謎團。

4-1 DNA 複製
DNA Replication

■ 前言 Introduction

過去人們並不知道 DNA 是如何複製的，本節介紹科學家如何用實驗證明 DNA 的半保留複製，接著介紹真核生物的 DNA 複製過程，由巨觀到微觀，介紹複製叉與複製泡，讓學生了解 DNA 複製的方向，並介紹參與複製過程的酵素等等細節，讓學生更加了解 DNA 複製。語言部分則包含了 DNA 複製相關單字和 DNA 複製程序的句型運用。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
semiconservative replication	半保留複製	centrifugation	離心
nutrient fluid	培養液	leading strand	領先股
template strand	模板股	Okazaki fragment	岡崎片段
origin of replication	複製起點	lagging strand	延遲股
replication fork	複製叉	DNA polymerase	DNA 聚合酶
replication bubbles	複製泡	DNA ligase	DNA 連接酶
extraction	萃取	RNA primer	RNA 引子

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

❶ ____ be preserved by____.

例句：Genetic information can **be preserved by** DNA replication.
遺傳訊息可以透過 DNA 複製保存。

❷ ____ contained in ____

例句：The amount of ^{15}N and ^{14}N **contained in** bacterial DNA is different, and the specific weight of the molecule will be different.
細菌 DNA 中所含的 ^{15}N 和 ^{14}N 量不同，分子的比重就會不同。

❸ ___ be separated as ____.

例句：Under the action of DNA helicases and proteins, the double strands of DNA **are separated as** template strands.
在 DNA 解旋酶與蛋白質的作用下，DNA 雙股會分開作為模板股。

❹ _____ extend from ____ to _____.

例句：The polymerizing direction of the nucleotide chain can only **extend from** the 5' end **to** the 3' end.
核苷酸鏈的聚合方向僅能由 5'端往 3'端延伸。

❺ ___ be ligated into ____.

例句：Catalyzed of DNA ligase, the Okazaki fragments **are ligated into** new polynucleotide chains.
在 DNA 連接酶的催化下，將岡崎片段連接成新股聚核苷酸鏈。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應習得以下觀念：

At the end of learning the chapter, students are able to acquire the following concept:

一、學生了解 DNA 複製的過程及原理，以及科學家探究複製原理的過程。

To understand the process and principles of DNA replication and the process by which scientists study the principles of replication.

❧ 例題講解 ☙

例題一

說明：學生了解半保留複製實驗的意義。

To understand the importance of semiconservative replication experiments.

When bacterial DNA molecules replicate, if the medium contains ^{15}N bases, ^{15}N is synthesized into DNA. A scientist has grown bacteria in ^{15}N medium for many generations, and then inoculated them into a new medium containing ^{14}N. Which of the following statements is correct about bacteria that divide in a new medium?

(A) After one division, 1/4 of the bacteria have ^{15}N DNA.

(B) After one division, half of the bacteria have ^{15}N DNA.

(C) After secondary division, 1/4 of the bacteria have ^{15}N DNA.

(D) After secondary division, half of the bacteria have ^{15}N DNA.

細菌 DNA 分子複製時，培養基中若含有 ^{15}N 的鹼基，則 ^{15}N 會被合成入 DNA 中。一科學家將細菌在 ^{15}N 的培養基中繁殖很多代後，再接種於含 ^{14}N 的新培養基中培養。下列有關細菌在新培養基中進行細胞分裂的敘述，何者正確？

(A) 經過一次分裂後，1/4 的細菌具有 ^{15}N 的 DNA。

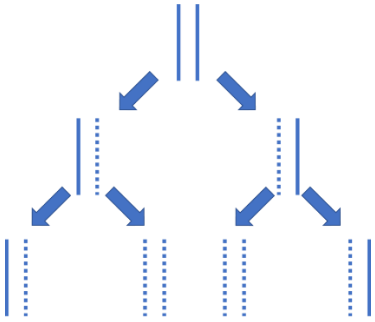
(B) 經過一次分裂後，半數的細菌具有 ^{15}N 的 DNA。

(C) 經過二次分裂後，1/4 的細菌具有 ^{15}N 的 DNA。

(D) 經過二次分裂後，半數的細菌具有 ^{15}N 的 DNA。

（98 年指考生物 2）

Teacher:



If you look at the picture, the way DNA replicates is called semiconservative replication. After the original double-stranded DNA is split, each strand synthesizes the other strand to make two double-stranded DNA. If the orange color represents DNA with ^{15}N, what percentage of the progeny will have ^{15}N after the first division?

Student: 100%.

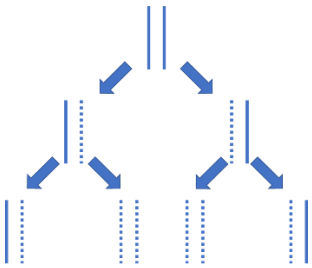
Teacher: Yes, it can be seen that after the first split, two offspring were produced, and they both had one strand of orange DNA and one strand of newly synthesized blue DNA. So options A and B are wrong.

Teacher: What about after the second division?

Student: 50%.

Teacher: That's right! So the correct answer is D.

老師：



大家看圖，DNA 複製的方式是半保留複製，原本的 DNA 雙股分開後，各自合成另一股，變成 2 個雙股 DNA。請問大家，如果橘色代表帶有 ^{15}N 的 DNA，第一次分裂之後有多少%的子代帶有 ^{15}N 呢？

學生：100%。

老師：是的，可以看到第一次分裂後，產生兩個子代，他們都擁有一股橘色 DNA，與一股新合成的藍色 DNA。所以 A、B 選項都不正確。

老師：接下來請問大家，分裂兩次之後呢？

學生：50%。

老師：沒錯唷！所以正確答案是 D。

例題二

說明：學生了解轉錄和 DNA 複製所需物質以及過程。

To understand the substances and processes required for transcription and DNA replication.

Which of the following statements are correct about transcription and DNA replication in human cells?

(A) Both require DNA polymerase.

(B) Both require DNA ligase.

(C) The initial product of transcription is re-spliced.

(D) The resulting polynucleotide chain is synthesized from 5'→3'.

(E) The resulting polynucleotide strand is complementary to the DNA template (strand).

下列有關人體細胞中的轉錄與 DNA 複製之敘述，哪些正確？

(A) 皆需 DNA 聚合酶。

(B) 皆需 DNA 接合酶。

(C) 轉錄初始產物會再經剪接。

(D) 所產生的多核苷酸鏈由 5'→3'合成。

(E) 所產生的多核苷酸鏈與 DNA 模板（股）互補。

（101 指考生物 25 取其中符合此單元部分）

Teacher: What is the function of DNA polymerase?

Student: Synthetic DNA.

Teacher: That's right. So what is transcription?

Student: RNA is synthesized using DNA as a template.

Teacher: Yes,is this DNA polymerase used to synthesize RNA?

Student: No.

Teacher: Is DNA ligase used to synthesize RNA?

Student: No.

Teacher: Correct. Because the transcription process is not used, you can't choose options A and B.

Teacher: Now, look at option C. The RNA produced after transcription will also be sheared before translation begins!

Teacher: Next, is the newly synthesized DNA 3′→5′ or 5′→3′?

Student: 5′→3′.

Teacher: That's right! Remember that for DNA template strands, the direction of synthesis is 3'→5'; for synthetic RNA strands or new DNA strands, the direction of production is 5'→3'.

Teacher: Finally, option E, RNA and DNA are polynucleotide chains, because they are all synthesized from nucleotides. Transcription and DNA replication both use DNA as a template to synthesize new strands. Are the new strands complementary to the template?

Student: Yes.

Teacher: Right.

老師： DNA 聚合酶的功能是什麼？

學生： 合成 DNA。

老師： 沒錯。那麼請問同學們，什麼是轉錄？

學生： 用 DNA 為模板合成 RNA。

老師： 是啊，那合成 RNA 會用到 DNA 聚合酶嗎？

學生： 不會。

老師： 那請問合成 RNA 會用到 DNA 接合酶嗎？

學生： 不會。

老師： 是的，因為轉錄的過程不會用到，所以 A、B 不能選喔。

老師： 接下來看 C 選項，轉錄後產生的 RNA 還會經過剪切，才會開始轉譯唷！

老師： 然後，新合成的 DNA 是 3′→5′還是 5′→3′呢？

學生： 5′→3′。

老師： 沒錯唷！大家要記得，對於 DNA 模板股，合成方向沿著 3′→5′；對於合成的 RNA 鏈或 DNA 新股，產生方向是 5′→3′。

老師： 最後，E 選項，RNA、DNA 都是多核苷酸鏈喔，因為他們都是由一個個的核苷酸合成的。轉錄與 DNA 複製都是以 DNA 為模板來合成新股，那新股會跟模板互補嗎？

學生： 會。

老師： 是啊。

4-2 基因的表現
Gene Expression

■ 前言 Introduction

本節介紹 RNA 在基因轉譯和轉錄的功用以及如何協助 DNA 表現出蛋白質，英文知識包含了 RNA 轉錄轉譯的重要單字和其機制如何進行的相關句型學習。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
codon	密碼子	translation	轉譯
anticodon	反密碼子	stop codon	終止密碼子
Poly-A Tail	多腺苷酸尾	release factor	釋放因子
intron	內含子	exon	外顯子
polyribosome	聚核醣體	five-prime cap	5’端帽
start codon	起始密碼子	initiation	起始
precursor mRNA	前驅 mRNA	elongation	延伸
modify	修飾	termination	終止

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

❶ ____ contain(s) _____.

例句：RNA **contains** four nucleoside monophosphates, AMP, UMP, CMP and GMP.
RNA 包含 4 種核苷單磷酸，AMP、UMP、CMP 和 GMP。

❷ _____ be located in _____.

例句：The DNA of eukaryotic cells **is** mainly **located in** the nucleus, while the ribosomes, which synthesize proteins, are located in the cytoplasm.
真核細胞的 DNA 主要位於細胞核，而合成蛋白的核醣體位於細胞質。

❸ ____ carry ____.

例句：RNA can **carry** DNA information.
RNA 能攜帶 DNA 訊息。

❹ _____ loosen _____.

例句：RNA polymerase **loosens** the double strands of DNA.
RNA 聚合酶將 DNA 的雙股鬆開。

❺ _____ move along ____.

例句：RNA polymerase **moves along** DNA molecule.
RNA 聚合酶沿著 DNA 分子移動。

❻ _____ correspond to _____.

例句：A set of codons can **correspond to** only one amino acid, but an amino acid can correspond to several sets of codons.
一組密碼子僅能對應一種胺基酸，而一種胺基酸可以對應多組密碼子。

❼ **_____ pair with _____.**

例句：tRNA **pairs with** mRNA codons in anticodons.

tRNA 以反密碼子與 mRNA 的密碼子配對。

❽ **_____ be shifted from ____.**

例句：The tRNA **is shifted from** the P to the E position.

tRNA 由 P 位移至 E 位。

■ 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、學生了解查加夫法則。

To understand Chargaff's rules.

二、學生了解轉錄的原理。

To understand the principles of transcription.

❧ 例題講解 ☙

例題一

說明：學生了解查加夫法則，DNA 與 RNA 含氮鹼基的異同。

To understand Chargaff's rule and the similarities and differences between DNA and RNA nitrogenous bases.

There is a virus whose nucleic acid nitrogen base content is A: 26%, G: 26%, C: 24%, U: 24%. Which of the following is the most likely characteristic of this virus?

(A) Has double-stranded RNA, like tobacco mosaic virus (TMV).

(B) Has double-stranded DNA genetic material, like hepatitis B virus.

(C) Has single-stranded RNA genetic material, such as the novel coronavirus (2019-nCoV)

(D) Double-stranded RNA is embedded in the host chromosome, as in bacteriophages.

有一病毒的核酸含氮鹼基含量為 A：26%、G：26%、C：24%、U：24%。試推測下列何者最可能是此病毒的特性？

(A)　具雙股 RNA，如菸草鑲嵌病毒。

(B)　具雙股 DNA 遺傳物質，如 B 型肝炎病毒。

(C)　具單股 RNA 遺傳物質，如新型冠狀病毒（SARS-CoV-2）。

(D)　雙股 RNA 會嵌入宿主染色體中，如噬菌體。

（109 指考補考生物 1）

Teacher: Can anyone tell me what the four types of nitrogenous bases in DNA are?

Student: A、T、C、G.

Teacher: That's right, but the description in the question is A, U, C, G, so, which is more likely to be the nitrogenous base of DNA or RNA?

Student: RNA's.

Teacher: Yes, so we cannot choose option B. Do you still remember Chargaff's rule? In double-stranded DNA, because of the pairing relationship, the ratio of A and T will be the same, and the ratio of C and G will be the same. Are the ratios similar in the question?

Student: No.

Teacher: Yes, the ratios of A and U are not the same. So, is it double-stranded or single-stranded RNA?

Student: Single-stranded.

老師：各位同學請問 DNA 的含氮鹼基有哪四種？

學生：A、T、C、G。

老師：沒錯，但是題目中的敘述是 A、U、C、G，這比較可能是 DNA 還是 RNA 的含氮鹼基呢？

學生：RNA 的。

老師：是的，所以 B 選項不能選喔。接下來，大家還記的查加夫法則嗎？在雙股 DNA 中，因為配對關係，所以 A、T 的比例會相同，C、G 的比例會相同。同樣的，如果是雙股 RNA，A、U 的比例會相同，C、G 的比例會相同。那題目中有相同嗎？

學生：沒有。

老師：對，題目中 A、U 的比例並不相同，這應該是雙股還是單股的 RNA 呢？

學生：單股的。

例題二

說明：學生了解轉錄的過程細節。

To understand the details of the transcription process.

Which of the following statements is correct about gene transcription?

(A) After the double-stranded DNA is separated, the two single-stranded DNAs are used as templates to synthesize two identical single-stranded RNAs.

(B) The bases A, T, G, C on DNA correspond to the free ribonucleotide bases U, A, C, G, respectively.

(C) Transcription of prokaryotes takes place in the cytoplasm and the transcription of eukaryotes takes place in the nucleus.

(D) Ribosomes bind to DNA and synthesize RNA.

(E) It requires the activities of RNA polymerases.

下列有關基因轉錄的敘述，哪些正確？

(A) 雙股 DNA 分開後，二條單股 DNA 分別作為模板，合成二條相同的單股 RNA。

(B) DNA 上的 A、T、G、C 鹼基分別對應游離的核糖核苷酸鹼基 U、A、C、G。

(C) 原核生物的轉錄在細胞質中進行，真核生物的轉錄在細胞核中進行。

(D) 核糖體會和 DNA 結合，合成 RNA。

(E) 需有 RNA 聚合酶參與。

（110 年指考生物 22）

Teacher: Are the codes of the two strands of double-stranded DNA complementary or the same?

Student: They are complementary.

Teacher: That's right, so they’re different. Can different DNAs transcribe the same RNA?

Student: No.

Teacher: Correct. Then let’s look at option B, there is no T in RNA, so A will pair with U, so option B is correct.

Teacher: Next, option C, prokaryotes have no nucleus and no other membranous organelles as well. All reactions take place in the cytoplasm, and transcription is no exception. Then let's look at option D, E, RNA is synthesized by RNA polymerase, and the ribosome has other functions, does anyone know what that is?

Student: Translate to make protein.

Teacher: That's right.

老師： 請問雙股 DNA 的兩股的密碼子是互補還是相同？

學生： 互補。

老師： 是阿～所以他們並不相同喔，不同的 DNA 轉錄出的 RNA 會一樣嗎？

學生： 不會！

老師： 對。再來看 B，RNA 沒有 T，所以 A 會和 U 配對，所以 B 是對的唷。

老師： C 選項，原核生物是沒有細胞核的，也沒有其他膜狀胞器，所有的反應都會在細胞質中進行，所以轉錄也不例外唷。D、E 選項，RNA 由 RNA 聚合酶合成，而核醣體有其他功能唷，請問是什麼呢 ？

學生： 轉譯出蛋白質。

老師： 沒錯。

4-3 基因表現的調控
Operators of Gene Expression

■ 前言 Introduction

同個體中的所有細胞基因都相同，卻能在不同發育階段或不同組織中，有不同的表現，本節介紹基因如何調控以達成不同表現的結果。英文內容包含了基因表現操縱組的組成及特性介紹的相關英文字彙及句型。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
Escherichia Coli	大腸桿菌	lactose	乳糖
regulatory gene	調節基因	lac operon / lactose operon	乳糖操縱組
structural gene	結構基因	operator	操作子
promoter	啟動子	double-stranded	抑制蛋白
double helix	誘導物		

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

❶ _____ includes _____.

例句：The lac operon **includes** promoters, operators and structural genes.
乳糖操縱組具有啟動子、操作子和結構基因。

❷ ____ be located between _____.

例句：The operator of the lac operon **is located between** the promoter and the structural gene.
乳糖操縱組的操作子位於啟動子與結構基因之間。

❸ ____ contain _____.

例句：Structural genes **contain** several genes that synthesize enzymes involved in lactose metabolism.
結構基因含有多個基因，這些基因可合成與乳糖代謝有關的酶。

❹ _____ involved in _____.

例句：Structural genes contain several genes that synthesize enzymes which **involved in** lactose metabolism.
結構基因含有多個基因，這些基因可合成與乳糖代謝有關的酶。

❺ _____ bind to _____.

例句：When a repressor protein **binds to** an operator, the expression of the structural gene is suppressed.
當抑制蛋白與操作子結合，結構基因的表現會被抑制。

❻ _____ be suppressed.

例句：When a repressor protein binds to an operator, the expression of the structural gene **is suppressed**.

當抑制蛋白與操作子結合，結構基因的表現會被抑制。

❼ _____ be the way _____.

例句：Operon **is the way** prokaryotes regulate gene expression.

操縱組為原核細胞調控基因表現的方式。

❽ _____ enable ____ to _____.

例句：The expression of regulatory genes **enable**s single-celled organisms **to** adapt to changes in their environment.

調節基因的表現使單細胞生物體能適應環境的變化。

■ 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、學生了解操縱組為原核生物調控基因表現的方式，並了解其原理。

Students understand how the manipulator regulates gene expression in prokaryotes and how it works.

例題講解

例題一

說明：學生熟悉原核生物轉錄的過程，特別是操作子調控基因的方式。

Students will understand the process of transcription in prokaryotes, particularly the way in which operators regulate genes.

Which of the following statements about gene regulation in prokaryotes is correct?

(A) To improve the accuracy of the protein sequence, the mRNA is not translated until it is completely transcribed.

(B) A fragment of mRNA can express many different proteins through splicing.

(C) Binding of regulatory proteins to operons can inhibit DNA polymerase replication of this gene operator group.

(D) The operator is located between the promoter and the construct genome.

下列對於原核生物基因調控之敘述，何者正確？

(A) 為提高蛋白質序列正確度，mRNA 完整轉錄完後才會進行轉譯。

(B) 一段 mRNA 可以藉由剪接作用而表現出多種不同的蛋白質。

(C) 調節蛋白與操作子結合後可以抑制 DNA 聚合酶複製此基因操縱組。

(D) 操作子位於啟動子和構造基因組之間。

（96 年指考生物 12）

Teacher: Please note the title, this is the prokaryote! So, prokaryotes can transcribe and translate at the same time.

Student: So option A is wrong.

Teacher: Yes. Next, let's look at option B. Be careful, everyone, although eukaryotic mRNA becomes mature mRNA after splicing, the title is about prokaryotes! Do prokaryotes splice mRNA?

Student: No!

Teacher: Yes. Next, let's look at option C. The operator affects the process of transcription. We can look at the picture in the textbook. If the repressor protein binds to the operon, it will block the path of RNA polymerase. Can it still be transcribed?

Student: No, it can't.

Teacher: Correct. Finally, we can see from the same figure that the operator is located between the promoter and the construct genome, so option D is correct.

老師： 同學們要注意，題目中說的是原核生物唷！原核生物轉錄與轉譯可同時進行的。

學生： 所以 A 選項不正確。

老師： 是啊。接下來看 B 選項，注意唷，雖然真核生物的 mRNA 的確會經過剪接才成為成熟的 mRNA，但題目說的是原核生物唷！原核生物會進行 mRNA 剪接嗎？

學生： 不會！

老師： 是啊～接下來看看 C 選項，操作子是影響轉錄的過程唷，可以看課本的圖，抑制蛋白與操作子結合的話，就會擋住 RNA 聚合酶的去路，這樣還能轉錄嗎？

學生： 不能。

老師： 是的。最後，根據同一張圖可以看到，操作子位於啟動子和構造基因組之間，D 選項正確。

例題二

說明：學生了解大腸桿菌的特性，作為原核生物，大腸桿菌具有細胞壁、不具有膜狀胞器，也要了解乳糖操縱組如何調控基因表現。

Students will understand the characteristics of *Escherichia coli*. As a prokaryotic organism, *Escherichia coli* has a cell wall but no membranous organelles. It is also important to understand how the lac operator regulates gene expression.

Which of the following statements are correct about *Escherichia coli*?

(A) It has a cell wall.

(B) It has a membranous structure in the cytoplasm.

(C) ATP is made in the mitochondria via the electron transport chain.

(D) The lactose operator is switched on when there is a lack in lactose.

(E) Lactose operator genes transcribe mRNA in the cytoplasm.

下列有關大腸桿菌的敘述，哪些正確？

(A) 具有細胞壁。

(B) 細胞質內具有膜狀構造。

(C) 在粒線體中經由電子傳遞鏈產生 ATP。

(D) 缺乏乳糖時會開啟乳糖操縱組。

(E) 乳糖操縱組基因在細胞質中轉錄 mRNA。

（102 年指考生物 29 取其中與本單元相關部分）

Teacher: Is *Escherichia coli* a prokaryotic or a eukaryotic?

Student: It's prokaryotic.

Teacher: Yes, so, do prokaryotes have a nucleus?

Student: No.

Teacher: Right. Actually, prokaryotes do not have membranous organelles, so they also do not have a nucleus. Also, all the reactions in cells take place in the cytoplasm.

Student: So we cannot choose option B.

Teacher: Correct. It doesn't have membranous organelles, so does it have mitochondria?

Student: No.

Teacher: Great, and if there is no nucleus, where would the transcription take place?

Student: In the cytoplasm.

Teacher: That's right, all the reactions take place in the cytoplasm. Finally, the structural gene of the lactose manipulation group is used to produce lactase, so should it be expressed when lactose is lacking, or when lactose is present?

Student: When lactose is present.

Teacher: Yes, that's right.

老師： 各位同學，請問大腸桿菌是原核生物或真核生物？

學生： 原核生物。

老師： 是的，原核生物有細胞核嗎？

學生： 沒有。

老師： 對呀，事實上，原核生物不具有膜狀胞器，當然也沒有核。細胞中所有反應都會在細胞質中進行唷。

學生： 所以不能選Ｂ。

老師： 對。沒有膜狀胞器，會有粒線體嗎？

學生： 不會。

老師： 那麼沒有核的話，應該會在哪邊進行轉錄呢？

學生： 細胞質。

老師： 沒錯，所有反應都在細胞質中進行唷。最後，乳糖操作組的結構基因是用來產生乳糖酶的，那他應該是在缺乏乳糖的時候表現，還是有乳糖的時候表現？

學生： 有乳糖的時候表現。

老師： 沒錯。

4-4 遺傳變異
Genetic Variation

■ 前言 Introduction

同一物種個體間存在差異的現象稱為遺傳變異，本小節介紹各種遺傳變異，如基因重組、突變、多倍體、與染色體數目異常等等。也介紹引起突變的因素、遺傳疾病篩檢等等，與生活息息相關的遺傳知識，並學習基因重組及突變的英文詞彙及句型。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
genetic variation	遺傳變異	trisomy	三染色體
gene recombination	基因重組	deletion	缺失
meiosis	減數分裂	inversion	倒位
mutation	突變	translocation	易位
chromosome	染色體	gene mutation	基因突變
haploid	單倍體	frameshift mutation	框移突變
polyploid	多倍體	induced mutation	誘導突變
homologues / homologous chromosome	同源染色體	amniocentesis	羊膜穿刺

automutation	自發突變	chorionic villus sampling / CVS	絨毛膜取樣
monosome	單染色體		

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

❶ _____ cause _____.

例句：Variations in the number of autosomes can **cause** disease.
體染色體數目變異可造成疾病。

❷ ____ be replaced ____.

例句：A point mutation can **be caused by** one base pair being replaced by another base pair.
點突變可能是一種鹼基對被另一種鹼基對取代。

❸ ___ take ____ as a group.

例句：When genetic information is translated, it **takes** three consecutive nucleotides **as a group**.
遺傳訊息在轉譯時，以 3 個連續的核甘酸為一組。

❹ _____ correspond to _____.

例句：When genetic information is translated, specific groups of nucleotides **corresponds to** specific amino acids.
當遺傳資訊被轉譯時，特定的核苷酸組合對應到特定的胺基酸。

❺ ____ result in ____.

例句：Chromosomal deletions **result in** deleterious traits.
染色體缺失會導致表徵受影響。

❼ ___ cause _____.

例句：There are many factors that **cause** mutations, which occur when the DNA structure changes.
引發突變的因素有很多，當 DNA 構造發生改變時會發生突變。

❽ ____ occur when _____.

例句：Some diseases in individuals **occur when** there is an abnormality in the number of chromosomes.
當染色體數目異常時會導致個體疾病。

❾ ___ exist in ____.

例句：If the mutation **exists in** germ cells, the offspring may have the same disease.
若突變存在於生殖細胞，子代可能出現相同的疾病。

■ 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、生活中引起遺傳變異的各種因素。

The factors in daily life that cause genetic variation.

二、遺傳變異的各種形式，如：染色體數目異常...等。

The forms of genetic variation, such as chromosomal number abnormalities, etc.

∞ 例題講解 ∞

例題一

說明：學生了解生活中引起基因突變的因素有那些。

Students understand the factors in daily life that may cause genetic mutations.

Which of the following statements is correct about genetic mutations?

(A) Ultraviolet rays can damage DNA and cause mutations that lead to skin cancer.

(B) Nitric acid added to food may cause genetic mutations.

(C) Sickle-cell anemia is caused by mutations in single amino acid insertions.

(D) Radiation induces mutations in the pentose of DNA, leading to gene mutations.

下列有關基因突變的敘述，何者正確？

(A) 紫外線可破壞 DNA 導致突變，而引起皮膚癌。

(B) 食品若添加硝酸可能引起基因突變。

(C) 鐮形血球貧血症是單一胺基酸插入的突變所致。

(D) 輻射線會誘導 DNA 的五碳糖發生變異導致基因突變。

（97 指考補考生物 5）

Teacher: Ultraviolet light has a lot of energy. The reason why it can kill bacteria is because it destroys the molecular structure of DNA or RNA in cells, so that the bacteria cannot divide normally and die. So, option A is correct.

Teacher: Let's look at option B, nitric acid is not a food additive, everyone should think it is strange to add strong acid to food, right? So what should be changed? There is a clue for everyone: it is the salt that is going to be in a certain type of sausage.

Student: Nitrite.

Teacher: Yes, it's a chemical mutation. Sickle-cell disease, on the other hand, is caused by the substitution of a single base, not by the insertion of amino acids. Also, radiation causes genetic mutations, but not pentose. Nitrogenous bases are the key to determining DNA coding, so what should be changed to the pentose in option D, which is more appropriate?

Student: Nitrogenous base.

老師：紫外線是能量很強的光，之所以能夠殺菌，就是因為破壞了細胞中 DNA 或 RNA 的分子結構，使細菌無法正常分裂死掉。所以 A 是正確的唷。

老師：B 選項的部分，硝酸並不是食品添加物，大家應該也會覺得添加強酸在食物裡很奇怪吧？那麼應該修改成什麼呢？是某一種香腸中會有的鹽類。

學生：亞硝酸鹽。

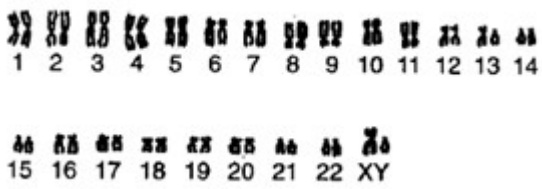
老師：沒錯，這屬於化學因素引起突變。
而鐮型血球貧血症，是單一鹼基被取代導致的，並不是胺基酸插入導致。
最後，輻射線的確會誘導基因突變，但並不是五碳糖。含氮鹼基才是決定 DNA 編碼的關鍵，所以應該把 D 選項中的五碳糖修改為什麼，才是比較合適的呢？

學生：含氮鹼基。

例題二

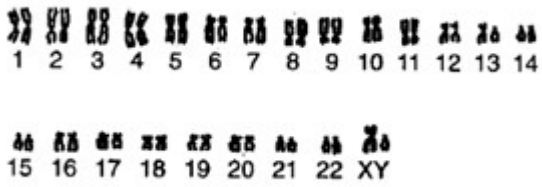
說明：學生能根據染色體核型資料圖判斷性別與是否罹患唐氏症。
Students will learn how to determine gender and whether a person has Down syndrome based on the karyotype image.

Down syndrome is a genetic disorder associated with a chromosomal mutation. The picture below shows someone's karyotype data. According to this information, which of the following descriptions of this person is correct?



(A) A woman with Down syndrome.
(B) A man with Down syndrome.
(C) A woman without Down syndrome.
(D) A man without Down syndrome.

唐氏症是一種與染色體變異有關的遺傳疾病。下圖為某人的染色體核型資料。根據該資料，下列對此人的描述，何者正確？



(A)　患唐氏症的女性。
(B)　患唐氏症的男性。
(C)　未患唐氏症的女性。
(D)　未患唐氏症的男性。

（97 年指考生物 20）

Teacher: Down syndrome is caused by an abnormal number of chromosomes. What will happen to the patient's 21st pair of chromosomes?
Student: It will have one more chromosome than normal.
Teacher: That's right, so is there an extra chromosome in the 21st pair of chromosomes in this picture?
Student: No.
Teacher: Correct, so this person does not have Down syndrome.
Teacher: If we want to judge whether a person is a male or a female, which pair of chromosomes should we look at?
Student: The 23rd chromosome.
Teacher: Yes, so is this person a male or a female?
Student: A male.

老師：同學們，唐氏症是染色體數目異常引起的，請問患者的第 21 對染色體數目會如何？
學生：會多一條。
老師：沒錯唷，那麼這張圖中的第 21 對染色體有多一條嗎？
學生：沒有。
老師：對，所以這並不是唐氏症患者的資料。
老師：各位同學，請問要判斷他是男性或女性，應該觀察哪一對染色體呢？
學生：第 23 對染色體。

老師： 是的，那麼這是男性還是女性呢？
學生： 男性。

4-5 生物科技 Biotechnology

■ 前言 Introduction

本節介紹生活中有哪些利用基因轉殖等生物科技以改善人類生活品質，基因轉殖是相對新穎的技術，瞭解基轉的原理之後，將介紹多基因轉殖技術在生活中的應用，以及這些基因轉殖後的動植物為生活帶來的影響。透過重組 DNA、基因轉殖的相關英文字彙及句型學習，理解生物科技在英文的應用。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
marker genes	標識基因	microinjection	顯微注射
palindromic sequence	迴文序列	restriction enzyme	限制酶
transgenic	基因轉殖	carrier	載體
PCR (polymerase chain reaction)	聚合酶連鎖反應	recombinant DNA	重組 DNA
GMO (genetically modified organism)	基改生物	DNA ligase	DNA 連接酶
cloning	選殖		

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

❶ ____ refer to _____.

例句：Recombinant DNA technology **refers to** the use of artificial methods to recombine different DNA molecules into a new DNA molecule.

重組 DNA 技術是指利用人為的方式，將不同 DNA 分子重新組合成一個新的 DNA 分子。

❷ ____ recombine _____ into _____.

例句：Recombinant DNA technology refers to the use of artificial methods to **recombine** different DNA molecules **into** a new DNA molecule.

重組 DNA 技術是指利用人為的方式，將不同 DNA 分子重新組合成一個新的 DNA 分子。

❸ ____ connect _____ into _____.

例句：DNA ligase **connects** two DNA molecules **into** a complete, continuous chain of polynucleotides.

DNA 連接酶將兩段 DNA 分子連結成完整連續的聚核苷酸鏈。

❹ _____ be used in _____.

例句：Genetically modified bacteria **are** widely **used in** the pharmaceutical, food and chemical industries.

基改細菌廣泛應用在製藥、食品工業與化工業上。

❺ ____ express the characteristic of _____.

例句：Genetically modified plants are plants in which a target genes in introduced into the plant cells so that the plants can **express the characteristics of** the gene.

基改植物為將目標基因送入植物細胞，使植物體可以表現出該基因的特性。

❻ _____ be embedded in _____.

例句：When *Agrobacterium* infects plant cells, the T-DNA in the Ti plasmid **is embedded in** the chromosome of the host cell.

當農桿菌感染植物細胞時，Ti 質體中的 T-DNA 會嵌入宿主細胞的染色體中。

■ 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、學生了解常用的基因轉殖方式的原理。

Students will understand the principles of commonly used gene transfer methods.

二、了解重要生物技術 PCR 的原理。

Students will understand the main principles of biotech PCR.

❧ 例題講解 ☙

例題一

說明：學生了解植物基因轉殖常用的農桿菌的原理。

Students will understand the principles of *Agrobacterium*, which is commonly used in plant gene transfer.

Which of the following statements is correct about *Agrobacterium*?

(A) T-DNA is located on the chromosome of *Agrobacterium*.

(B) It can insert foreign genes into T-DNA, and then use *Agrobacterium* for transfection.

(C) Ti plasmids are also commonly used for gene transfer in animals.

(D) T-DNA does not replicate during plant cell division after insertion into plant chromosomes.

下列有關農桿菌的敘述何者正確？

(A)　T-DNA 位於農桿菌的染色體上。

(B)　可將外源基因插入 T-DNA 中，再利用農桿菌進行轉殖。

(C)　Ti 質體也常用來做動物基因轉殖。

(D)　T-DNA 嵌入植物染色體後不會隨著植物細胞分裂而複製。

（110 年指考生物 13）

Teacher: The Ti plastid is separated from the circular DNA of Agrobacterium. So when the circular DNA is condensed into a chromosome, will the T-DNA of the Ti plasmid be on the chromosome?

Student: No.

Teacher: That's right. After Agrobacterium infects plants, it delivers Ti plasmids into plant cells and inserts T-DNA into the host cell's DNA. If we insert a piece of target DNA into the Ti plasmid, can it also be inserted into the plant along with the T-DNA?

Student: Yes.

Teacher: However, Agrobacterium is used to genetically transform plants, and it cannot infect animals. A common method of gene transfer in animals is microinjection.
Once the target gene is inserted, it becomes part of the chromosome of the genetically modified plant and is replicated when the genetically modified plant divides.

老師：各位同學們，Ti 質體跟農桿菌的環形 DNA 是分開的。那麼環形 DNA 濃縮成染色體的時候，Ti 質體上的 T-DNA 會在染色體上嗎？

學生：不會。

老師：沒錯。農桿菌感染植物後，會將 Ti 質體送入植物細胞中，並將 T-DNA 嵌入宿主細胞的 DNA。同學們，如果我們將一段目標 DNA 嵌入 Ti 質體中，是不是就可以跟著 T-DNA 一起嵌入植物體中了呢？

學生：是！

老師：不過農桿菌是用來基轉植物的，不能感染動物。常見的動物基因轉殖為顯微注射。
而目標基因嵌入之後，就會變成基改植物染色體的一部分，會隨著基改植物的細胞分裂而複製　。

例題二

說明：了解 PCR 的原理與影響酵素活性的因素。

To understand the principle of PCR and the factors that affect enzyme activity.

Which of the following factors directly affects the rate of action of the DNA polymerase during polymerase chain reaction (PCR)?

(A) The ratio of the four types of deoxyadenosine triphosphate.

(B) The number of times the DNA segment is replicated.

(C) The DNA fragment used as the template.

(D) The reaction temperature.

在進行聚合酶連鎖反應（PCR）時，下列哪一個因子會直接影響 DNA 聚合酶作用的速率？

(A) 四種去氧核苷三磷酸的比例。

(B) 重複複製 DNA 片段的次數。

(C) 作為模版的 DNA 片段。

(D) 反應溫度。

（102 年指考生物 7）

Teacher: DNA polymerase is an enzyme. So, what are the factors that affect the activity of enzymes?

Student: pH value, temperature....

Teacher: Yes, temperature affects the enzyme activity, and of course it directly affects the reaction rate.

老師： DNA 聚合酶就是一種酵素。各位，請告訴我影響酵素活性的因素有哪些？

學生： pH 值、溫度....

老師： 對呀，溫度會影響酵素活性，當然就會最直接的影響反應速率囉。

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

- 研編單位：國立彰化師範大學雙語教學研究中心
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發行單位　國立彰化師範大學雙語教學研究中心
NCUE BILINGUAL EDUCATION RESEARCH CENTER

指導單位　教育部師資培育及藝術教育司
MOE DEPARTMENT OF TEACHER AND ART EDUCATION