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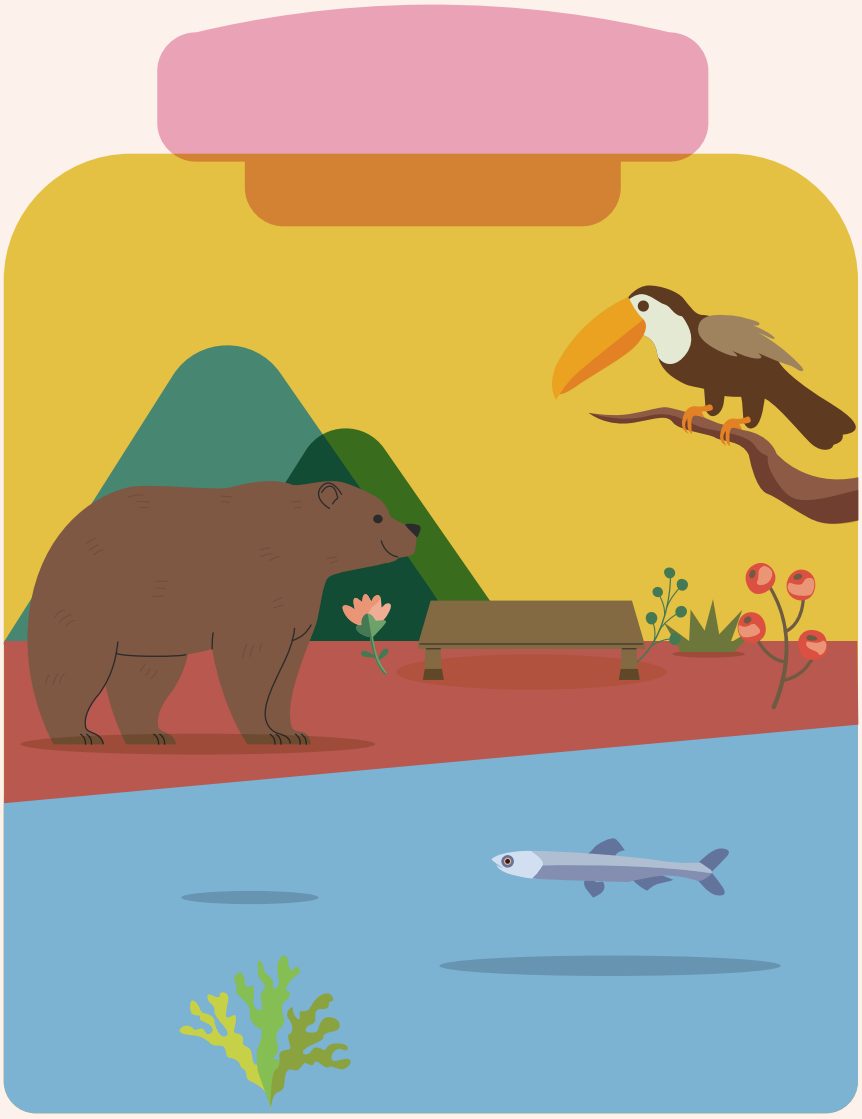
高中自然領域

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(IV)〕



國立彰化師範大學雙語教學研究中心 發行

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★ 主題一 演化 ★
Evolution

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■ 前言 Introduction

本章節中，希望學生能透過在高一生物所學習的演化及天擇概念，進而認識本學期第一章「演化」。老師在課程中可以使用探究教學方式，引導學生根據問題進行科學探究，藉由案例討論學習遺傳變異，舉例說明生物種定義之差異，並提供學生進一步的生物分類概念。

語言作為學生問與答的使用，希望學生透過思考及分析來理解演化的理論，並透過案例補充加深概念理解，因此課堂中老師需要以簡單的方式定義、舉例和歸納專有名詞，來強化學生知識的連結性及其運用。

1-1 現代生物演化理論
Modern Biological Evolutionary Theory

■ 前言 Introduction

在此小節，教師透過高一生物所教的達爾文天擇理論，帶領學生以科學思維探究天擇理論遭受質疑的原因，並了解現代演化理論的發展歷程及挑戰。在授課中，教師需要以理論及相關研究結合供學生討論，也可以利用流程圖介紹現代演化理論的發展順序及相關概念，間接搭配英語句型，讓學生能在圖表中更加了解理論的發展歷程。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
epigenetics	表觀遺傳學	sexual selection	性擇
molecular clock	分子鐘	neutral mutation	中性突變
natural selection	天擇	neutral mutation-random drift hypothesis	中性突變漂變假說
mutation	突變	neutral theory of molecular evolution	中性演化理論
punctuated equilibrium	間斷平衡理論	genetic mutation	遺傳變異
modern evolutionary synthesis	現代綜合論	genetic drift	遺傳漂變

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

❶ _____ proposed _____ in _____.

例句(1)：Sutton and 包法利(英文名)**proposed** chromosome theory of inheritance **in** 1902.
薩登與在 1902 年提出遺傳的染色體學說。

例句(2)：Kimura Motto **proposed** neutral theory of molecular evolution **in** 1968.
木村資生在 1968 年提出中性演化理論。

❷ According to _____, _____ is/can be _____ but not _____.

例句(1)：**According to** neutral theory of molecular evolution, the evolution change **is** caused randomly or accidentally **but not** naturally selected.
根據中性演化理論，演化改變是隨機或偶然所造成，而非天擇。

例句(2)：**According to** the evidence of the experiment, the evolution rate **can be** very fast **but not** as slow as Darwin considered.
根據實驗證據，演化的發生速率可以非常快速，而非如達爾文認為的那般緩慢。

❸ _____ made _____ revision to _____ based on _____.

例句(1)：Genetic scholars **made** the first **revision to** Darwin's theory of natural selection **based on** the research results in the field of genetics.
遺傳學者以遺傳學領域的研究成果對達爾文天擇理論進行第一次修正。

例句(2)：Dobzhansky **made** a second **revision to** Darwin's theory of natural selection **based on** *Genetics and the Origin of Species*.
多布然斯基以《遺傳學與物種起源》對達爾文天擇理論進行第二次修正。

❹ After _____, _____ was accepted as _____.

例句：**After** Darwin proposed the evolutionary natural selection, evolution **was** gradually **accepted as** a fact.
在達爾文提出演化天擇理論後，演化逐漸被人們接受為事實。

❺ After _____ and _____, _____ has/ have been confirmed that _____.

例句：**After** careful experiments by scientists **and** the successive discovery of individuals with genetic variations, it **has been confirmed that** mutations can occur.
在科學家們的縝密實驗和陸續發現具遺傳性變異的個體後，證實突變是可發生的。

■ 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、學生能了解現代生物演化理論的發展歷程。
Students can understand the development process of modern biological evolutionary theories.
二、學生能了解現代綜合論及中性演化理論的內容。
Students can understand the content of modern evolutionary synthesis and the neutral theory of molecular evolution.

❧ 例題講解 ☙

例題一

說明：學生能瞭解天擇說、中性理論及遺傳漂變的概念並加以應用。
Students can understand and apply the concepts of natural selection, neutral theory of molecular evolution, and genetic drift.

Which of the following theories about biological evolution is true?
(A) When Darwin established the theory, he didn't take the amount of biological groups into account.
(B) Without the power of natural selection, biological groups can still evolve.
(C) The founder effect belongs to one of the methods that natural selection operates on.
(D) When Darwin proposed the concept of mutation, he didn't mention genetic variation.

下列有關生物演化理論，何者正確？

(A) 達爾文建立學說時，沒有涉及生物族群的數量。

(B) 沒有天擇的力量，族群仍然可以演化。

(C) 創始者（拓荒者）效應是屬於天擇運作的一種方式。

(D) 達爾文提出生物變異時未提及遺傳差異。

（111 年分科測驗 16）

Teacher: After Darwin proposed evolutionary natural selection, evolution was gradually accepted as a fact. However, why doesn't natural selection— a concept of evolution -- be widely accepted by people?

Student: This is because some species will mutate.

Teacher: Right. According to the neutral theory of molecular evolution, it considers that most of the mutations refer to neutral mutation. ? is mostly affected by genetic drift, which is unrelated to natural selection.

Student: Does genetic drift refer to random selection?

Teacher: Yes. The phenomenon of random variation in gene frequency of biological groups is called genetic drift. Because survival and reproduction are affected by random factors, which means reproduction can be viewed as a kind of sampling process of the parents, the result directly reflects on the variation of genetic frequency of offspring.

Student: Then does the founder effect also belong to genetic drift?

Teacher: That's correct! Because the founder effect is a mechanism that causes the group's genetic constitution to change. When a small portion of individuals leave the mother group to form a new group, the genetic diversity of the new group is usually lower than the mother group, which also means genetic drift occurs.

老師： 在達爾文提出演化天擇理論後，演化逐漸被人們接受為事實，但其中的天擇理論為何未被廣為接受呢？

學生： 因為有些物種會產生突變。

老師： 沒錯，中性理論認為大多突變屬於中性突變，?留存與否主要受到遺傳漂變的影響，與天擇無關。

學生： 遺傳漂變是指隨機選擇的意思嗎？

老師： 對的，族群中基因頻率發生隨機變動的現象稱為遺傳漂變。因個體存活與繁殖皆受到隨機因素影響，即繁殖可視為一種對親代的抽樣過程，其結果則直接表現在子代的基因頻率變化。

學生： 那這樣創始者效應也是屬於遺傳漂變嗎？

老師： 是喔。因為創始者效應是一種造成族群遺傳結構發生變化的機制：當一小群個體脫離母族群、建立新族群時，新建立的族群的遺傳多樣性通常會遠低於母族群的遺傳多樣性，因此也算是發生了遺傳漂變。

例題二

說明：學生能了解達爾文演化論的主要內容。

Students can understand the main content of Darwin's evolution theory.

Which of the following descriptions of Darwin's evolution theory is true?

(A) Because asexual organisms don't undergo genetic variation, natural selection won't act on them.

(B) The theory of natural selection, proposed by Darwin, was established based on Mendel's Laws of Inheritance.

(C) Darwin was the first scientist to propose species have to mutate to evolve.

(D) The pressure of natural selection can preserve some features of the species, and further enhance species' ability to adapt.

下列有關達爾文演化論的敘述，何者正確？

(A) 無性生殖的生物因不會產生遺傳變異，故天擇不會作用在這類的生物上。

(B) 達爾文提出天擇說是建立在孟德爾遺傳定律的基礎上。

(C) 達爾文是第一位提出物種必須有變異才能演化的科學家。

(D) 天擇壓力可以使物種的某些特性保留下來，進而提高物種的適應能力。

（103 年指考 16）

Teacher: Do asexual organisms mutate?

Student: Yes, asexual organisms may have genetic variation owing to mutations.

Teacher: That's right. It represents natural selection also acts on asexual organisms.

Student: Wow, so both sexual and asexual organisms are affected by natural selection.

Teacher: What are the concerns of natural selection and Mendel's Laws of Inheritance on the aspects of biology?

Student: Natural selection focuses on the expression and adaptation of traits in a population, while Laws of Inheritance emphasizes on how genes are delivered between individuals.

Teacher: That's right! So Darwin's theory of natural selection was not established based on Mendel's Laws of Inheritance.

Teacher: Then which scientists proposed the relation between species variation and evolution before Darwin?

Student: Lamarck!

Teacher: Great! Darwin also used Lamarck's theory of use and disuse as the foundation of the evolution mechanism.

老師： 無性生殖的生物會發生突變嗎？

學生： 會，無性生殖的生物也有可能因為突變而產生遺傳變異。

老師： 沒錯！代表天擇也會作用在無性生殖的生物上。

學生： 原來有性或無性的生物都會受到天擇的影響。

老師： 那天擇說及遺傳定律分別關注的是生物學哪些層面呢?

學生： 天擇說關注性狀在群體中的表現和適應，而遺傳定律關注基因如何在個體間傳遞。

老師： 沒錯! 所以達爾文提出的天擇說並非建立在孟德爾的遺傳定律基礎上。

老師： 那在達爾文之前有哪位科學家已經提出了物種變異與演化的關係呢？

學生： 拉馬克！

老師： 很棒！達爾文還以拉馬克的用進廢退說作為演化機制的依據。

1-2 族群遺傳學 Population Genetics

■ 前言 Introduction

在此小節，教師藉由前一節學生所學的現代綜合論帶入族群的演化，藉由探討活動引導學生分析等位基因頻率的意義與重要性，學習其定義與計算方法。了解哈溫平衡的意義及對族群遺傳結構造成影響之各因素。在授課中，教師需要以範例搭配公式，教導學生基因頻率的算法，並搭配圖表幫助學生了解改變族群遺傳結構的機制。

語言的部分，可以在計算公式及圖表中搭配單字及句型，使專有名詞及語言能清楚對照，讓學生能更容易辨別其定義。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
frequency selection	頻率選擇	genotype	基因型
bottleneck effect	瓶頸效應	genotype frequency	基因型頻率
non-random mating	非隨機交配	gene pool	基因池
allele	等位基因	macroevolution	巨演化
allele frequency	等位基因頻率	founder effect	創始者效應
natural selection	天擇	population genetics	族群遺傳學
mutation	突變	random mating	隨機交配

單字	中譯	單字	中譯
Hardy-Weinburg equilibrium	哈溫平衡	heterozygosity superiority	異型合子優勢
gene frequency	基因頻率	genetic drift	遺傳漂變
gene flow	基因流動	microevolution	微演化

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

❶ _____ time _____ equals _____.

例句(1)：The numbers of A in genotype **time** the numbers of individuals **equals** the numbers of allele A.

等位基因 A 的數量**等於**基因型中 A 的數量**乘以**個體的數量。

例句(2)：The numbers of a in genotype **time** the numbers of individuals **equals** the numbers of allele a.

等位基因 a 的數量等於基因型中 a 的數量乘以個體的數量。

❷ _____ divide _____ equals _____.

例句(1)：The numbers of allele A **divide** the total numbers of alleles **equals** the frequency of allele A.

等位基因 A 的頻率等於等位基因 A 的數量除以等位基因總數。

例句(2)：The numbers of allele a **divide** the total numbers of allele **equals** the frequency of allele a.

等位基因 a 的頻率等於等位基因 a 的數量除以等位基因總數。

❸ The condition of maintaining Hardy-Weinburg equilibrium should include _____.

例句(1)：**The condition of maintaining Hardy-Weinburg equilibrium should include** an extremely large number of group individuals.

要維持哈溫平衡的族群條件應包括極大的族群個體數。

例句(2)：**The condition of maintaining Hardy-Weinburg equilibrium should include** the random mating between individuals.
要維持哈溫平衡的族群條件應包括個體間隨機交配。

❹ _____ will cause the group not to be able to maintain the ideal state of Hardy-Weinburg equilibrium and further alter the genetic structure of the group.

例句(1)：Mutation **will cause the group not to be able to maintain the ideal state of Hardy-Weinburg equilibrium and further alter the genetic structure of the group.**
突變會造成族群無法維持哈溫平衡的理想狀態，進而改變族群遺傳結構。

例句(2)：Natural selection **will cause the group not to be able to maintain the ideal state of Hardy-Weinburg equilibrium and further alter the genetic structure of the group.**
天擇會造成族群無法維持哈溫平衡的理想狀態，進而改變族群遺傳結構。

❺ _____ may _____ and further _____.

例句(1)：Mutation **may** produce new alleles **and further** increase genetic variation in the group.
突變可能會產生新的等位基因，進而增加族群遺傳變異。

例句(2)：The immigration or emigration of individuals in a group **may** cause genetic flow in the group **and further** alter its genetic frequency and the overall genetic structure.
族群中個體的遷入或遷出可能會造成族群的基因流動，進而改變其基因頻率與整體遺傳結構。

■ 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、學生能熟悉等位基因頻率的計算。

Students can familiarize the calculation of allele frequency.

二、學生能了解哈溫定律及改變哈溫平衡的力量。

Students can understand Hardy-Weinburg principle and the power of changing Hardy-Weinburg equilibrium.

三、學生能藉由族群遺傳學的觀點理解天擇與適應。

Students can understand natural selection and adaptation through the perspective of population genetics.

❧ 例題講解 ☙

例題一

說明：學生能瞭解哈溫定律及計算等位基因頻率。

Students can understand Hardy-Weinburg principle and the calculation of allele frequency.

There is a group under Hardy-Weinburg equilibrium, its different genotypes that control a certain trait, and the numbers of individuals are AA=77, Aa=94, and aa=99 separately. Which of the following statements are correct? (multiple choices)

(A) The frequency of allele A is 0.62.

(B) The allele frequency of A in the next generation is 0.31.

(C) The frequency of allele a is 0.26.

(D) If the next generation contains 1000 individuals, the number of genotype Aa individuals is roughly 470.

(E) When the size of the group decreases sharply, the probability of losing allele A in the next generation is smaller than allele a.

一個處於哈溫平衡的族群，其控制某性狀的不同基因型及個體數目分別是 AA=77，Aa=94，aa=29。以下哪些敘述正確？(複選題)

(A) A 等位基因的頻率是 0.62。

(B) 下一代的 A 等位基因頻率是 0.31。

(C) a 等位基因的頻率是 0.26。

(D) 若下一代有 1000 個體，則 Aa 基因型的個體約有 470 個。

(E) 當族群大小驟減時，A 等位基因在下一代遺失的機率小於 a 等位基因。

（102 年指考 24）

Teacher: How to calculate the frequency of allele A and allele a?

Student: We have to get the total number of individuals first, which is 77+94+29=200, then calculate the total number of alleles, which is 200×2=400.
Therefore, the frequency of allele A, f(A)=(77×2÷400＋94÷400）＝0.62, and the frequency of allele a, f(a)=(29×2÷400＋ 94÷400）＝0.38.

Teacher: Very good! From the result, we can figure out that f(A)+f(a)=1.

Student: I see, I can calculate one of the frequencies of the allele and subtract it from 1, then I can get the other frequency of the allele.

Teacher: That's right. It is because the group is under Hardy-Weinburg equilibrium, which means the allele doesn't increase or decrease. Here comes a question: How much is the frequency of allele A in the next generation?

Student: Because the frequency of allele doesn't change, so the frequency of allele A will still be 0.62.

Teacher: If there are a thousand individuals in the next generation, how to calculate the number of individuals of genotype Aa?

Student: The frequency of Aa is 2f(A)×f(a) ＝2×0.62×0.38＝0.4712, so there will be roughly 471 individual numbers of Aa.

Teacher: Great! I think all of you have understood Hardy-Weinburg principle and the calculation of gene frequency.

老師： A 等位基因與 a 等位基因的頻率要如何計算呢？

學生： 先算出總個體數為 77+94+29=200，再算出總等位基因數為 200×2=400。
A 等位基因頻率 f(A)=(77×2÷400＋94÷400）＝0.62，
a 等位基因頻率 f(a)=(29×2÷400＋ 94÷400）＝0.38 。

老師： 非常好！從這個結果便可以發現 f(A)+f(a)=1

學生： 原來如此，那我也可以算出其中一個等位基因頻率，再用 1 去減，便可以得到另一個等位基因頻率。

老師： 沒錯!那因為此族群是處於哈溫平衡，表示等位基因沒有增減，所以下一代的 A 等位基因頻率會是多少呢？

學生： 因為基因頻率沒有改變，所以下一代的 A 等位基因頻率一樣會是 0.62。

老師： 那如果下一代有 1000 個體，要如何算出 Aa 基因型的個體數呢？

學生： Aa 個體的頻率為 2f(A)×f(a) ＝2×0.62×0.38＝0.4712，故子代 1000 個中，約有 471 個 Aa 個體。

老師： 很棒！我想大家都了解哈溫定律及基因頻率的計算方式了。

例題二

說明：學生能了解演化原理與哈溫定律。

Students can understand evolution and Hardy-Weinburg principle.

Which description of evolution below is correct?

(A) Mutation is harmful to organisms, so it is not good for the evolution of creatures.

(B) The frequencies of a certain allele are incompatible to Hardy-Weinburg principle for an evolving group.

(C) People who take in lots of antibiotics will increase the number of drug-resistant bacteria, which is the result of artificial solutions.

(D) The theory of use and disuse from Lamke is the basis of Darwin's evolutionary theory.

有關演化的敘述，下列何者正確？

(A) 突變常對生物體有害，故不利於生物演化。

(B) 一個正在演化的族群，其某一等位基因出現的頻率不符合哈溫定律。

(C) 人類大量使用抗生素，使得抗藥性的細菌增加，為人擇作用的結果。

(D) 拉馬克用進廢退理論，是達爾文演化論的基礎。

（106 年指考 14）

Teacher: Mutation is harmful to organisms, but why does it still benefit the evolution of organisms?

Student: Because mutation can make organisms produce genetic variation for natural selection, so it is still beneficial for the evolution of organisms.

Teacher: That's true. Sometimes we take antibiotics when we get sick. If we use it improperly, it will lead to an increase in the number of drug-resistant bacteria. Is it a result of natural selection or artificial selection?

Student: Natural selection!

Teacher: Great! It is the environment with antibiotics selecting drug-resistant bacteria instead of humans selecting it on purpose, so the result is natural selection but not artificial selection.

Student: I see. Then why the theory of use and disuse from Lamke in option D cannot be the basis of Darwin's evolutionary theory?

Teacher: Darwin used natural selection to interpret evolutionary theory, which is different from the viewpoint of considering creatures can obtain sex genetics in nurture in Lamke's theory of use and disuse.

老師： 突變對生物體有害，但為什麼仍然有利於生物的演化呢？

學生： 因為突變可以讓生物體產生遺傳變異以供天擇，所以仍然是有利於生物演化的。

老師： 沒錯。那我們有時候生病吃的抗生素，如果使用不當會導致抗藥性的細菌增加，這是天擇還是人擇的結果呢？

學生： 天擇！

老師： 很棒！因為是具有抗生素的環境選擇了抗藥性的細菌，不是人為刻意去選擇的，因此是天擇而非人擇的結果喔。

學生： 原來如此。那(D)選項的拉馬克用進廢退理論為什麼不是達爾文演化論的基礎呢？

老師： 因為達爾文是以天擇來解釋演化論，跟拉馬克用進廢退理論認為生物可以後天獲得性遺傳不同喔！

1-3 物種形成 Speciation

■ 前言 Introduction

在此小節，教師透過生物內在生殖隔離與地理外在環境條件，使學生了解物種形成機制。搭配課本圖及實際物種形成例子，介紹生物生殖隔離的合子形成前屏障與形成後屏障，理解物種形成地理條件的異域種化與同域種化，並舉生活實例說明染色體多倍體是植物種化的重要途徑。

語言的部分，可以在圖表及實例中搭配單字及句型，使專有名詞及語言能清楚對照，加深學生記憶並融會運用。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
gametic isolation	配子隔離	mating	交配
ecological isolation	地理隔離	habitat isolation	棲地隔離
sympatric speciation	同域種化	behavioral isolation	行為隔離
autopolyploid	同源多倍體	speciation	種化
mechanical isolation	構造/機械隔離	temporal isolation	時間隔離
zygote	合子	reproductive isolation	生殖隔離
postzygotic barrier	合子形成後的屏障	hybridization	雜交

單字	中譯	單字	中譯
prezygotic barrier	合子形成前的屏障	allopatric speciation	異域種化
gene flow	基因交流	allopolyploid	異源多倍體

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

❶ _____ is to _____. For example, _____.

例句(1)：The mechanism of the prezygotic barrier **is to** interfere with the chance of mating and fertilizing. **For example,** using the differences of habitats among the population to prevent mating.

合子形成前屏障的作用機制在於阻礙交配與受精的機會，例如以族群間的生存棲地差異阻止交配。

例句(2)：The mechanism of the postzygotic barrier **is to** reduce the fertility of offsprings. **For example,** the infertility of hybridized offsprings.

合子形成後屏障的作用機制在於降低後代生育能力，例如雜交後代不孕。

❷ If _____ cannot have gene flow due to _____, it is called _____.

例句(1)：**If** the individuals in the population **cannot have gene flow due to** the preference of habitat, **it is called** habitat isolation.

族群間的個體若因棲地偏好差異導致無法發生基因交流，稱為棲地隔離。

例句(2)：**If** the individuals in the population **cannot have gene flow due to** the structure, position or size of the reproductive organs, **it is called** mechanical isolation.

族群間的個體若因生殖器官的結構、位置或尺寸差異導致無法發生基因交流，稱為構造隔離。

❸ Due to _____, _____ is formed and gradually _____.

例句：**Due to** the long-term lack of gene flow of same creatures in different populations, reproductive isolation **is formed and gradually** specialized.

同種生物的不同族群間因長期缺乏基因交流，形成生殖隔離而逐漸種化。

❹ _____ owing to _____ is called _____.

例句(1)：The biological population living in different areas have speciation of reproductive isolation **owing to** habitat isolation **is called** allopatric speciation.

生活在不同地區的生物族群，因地理隔離而產生生殖隔離的種化，稱為異域種化。

例句(2)：The biological population living in the same areas have speciation of reproductive isolation **owing to** different ecological conditions **is called** sympatric speciation.

生活在同一地區的生物族群，因不同的生態條件而產生生殖隔離的種化，稱為同域種化。

❺ _____ refers to _____.

例句(1)：Autopolyploid **refers to** the increasing chromosomes coming from the same type of plants.

同源多倍體是指增加的染色體來自同種植物。

例句(2)：Allopolyploid **refers to** the hybridized offspring of different species, which mixes the chromosomes of two different species.

異源多倍體是指不同物種間雜交產生的後代，混合了兩個不同物種的染色體。

■ 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、學生能了解物種生殖隔離的形成機制。

Students can understand the formation mechanism of reproductive isolation of species.

二、學生能了解形成物種的地理環境條件。

Students can understand the geographical or environmental conditions of species formation.

❧ 例題講解 ☙

例題一

說明：學生能了解新物種的產生涉及隔離的機制。

Students can understand the formation of new species involves the mechanism of isolation.

How to form a new species is one of the vital issues in the process of researching the evolution of species. There are many possible reasons for species formation, but which one below is not included?

(A) the formation of polyploid

(B) reproductive isolation in population

(C) ecological isolation in population

(D) increased gene flow in population

新物種如何形成是研究物種演化過程的重要議題之一。物種形成的可能原因有很多種，但卻不包括下列哪一項？

(A) 多倍體生成

(B) 族群間產生生殖隔離

(C) 族群間產生地理隔離

(D) 族群間遺傳交流增加

（93 年指考 2）

Teacher: Do you know the formation of polyploids? Is it sympatric speciation or allopatric speciation of plants?

Student: I know! It belongs to sympatric speciation.

Teacher: That's right. Because polyploid individuals are reproductively isolated from their original diploid parents, they can generate new species without ecological isolation.

Student: If the gene flow increases in population, it will be harmful to form the isolation mechanism.

Teacher: Yes, it is also harmful to the formation of new species.

Student: So the formation of new species should involve the isolation mechanism?

Teacher: Sure! Because the chance of reducing gene flow in the population for a long time will form reproductive isolation, then the species will gradually evolve to different species.

老師： 你們知道多倍體的形成是植物的同域種化還是異域種化嗎？

學生： 知道！是屬於同域種化。

老師： 沒錯，因為多倍體的個體會與原來的二倍體親代產生生殖隔離，所以不需要地理隔離便能夠產生新種喔！

學生： 那族群間的遺傳交流增加，應該會不利於隔離機制形成。

老師： 對的，因此也不利於新種產生。

學生： 所以新種的產生必須涉及隔離機制？

老師： 沒錯！因長時間減少族群間基因交流的機會形成生殖隔離，便能逐漸演化成為不同物種。

例題二

說明：學生能了解染色體的改變與演化的關係。

Students can understand the relation between chromosomal changes and evolution.

Which of the following descriptions of chromosomes and evolution is true?

(A) Inverted chromosomes make pairing difficult and are not retained by natural selection.

(B) Haploid organisms do not exist in the animalia as a result of natural selection.

(C) Chromosomal deletion is not genetic variation.

(D) Chromosomal polyploidy can lead to sympatric speciation.

(E) Chromosomal changes can be artificially produced.

下列有關染色體與演化的敘述，哪些正確？

(A) 發生倒位的染色體導致配對困難，天擇不會加以保留。

(B) 天擇的結果使動物界中不存在單倍體的生物體。

(C) 染色體缺失一段不是遺傳變異。

(D) 染色體多倍體化可造成同域種化。

(E) 染色體數目的改變可由人為的方式產生。

（105 年指考 23）

Teacher: Inverted chromosomes make pairing difficult, then they cannot be retained by natural selection.

Student: No, they may be retained by natural selection.

Teacher: Then what haploid organisms exist in animalia?

Student: Drones are haploid organisms.

Teacher: Awesome! So do male ants! So natural selection will not make haploids non-existent in the animalia.

Student: Does the loss of a part of a chromosome refer to genetic variation?

Teacher: Yes, many reasons are causing genetic variation, examples like mutation, genetic recombination, etc. all contribute to genetic variation.

Student: I see!

Teacher: Then the sympatric speciation caused by chromosomal polyploidy an important way of animal or plant speciation?

Student: It is a vital mechanism of plant sympatric speciation.

Teacher: That's correct. The change of chromosome numbers can be generated by artificial ways like processing by Colchicine.

Student: I got it! How amazing artificial technology is!

老師： 發生倒位的染色體導致配對困難，天擇便不能加以保留嗎？

學生： 不對，天擇仍可能保留下來。

老師： 那動物界中有存在哪些單倍體的生物體呢？

學生： 雄蜂便是單倍體的生物體。

老師： 非常棒！雄蟻也是喔！因此天擇並不會使動物界中不存在單倍體喔。

學生： 那染色體缺失一段是屬於遺傳變異嗎？

老師： 沒錯！造成遺傳變異有很多種因素，像是突變、遺傳重組等都有助於遺傳變異。

學生： 原來如此！

老師： 那染色體多倍體化造成同域種化，是動物還植物種化的重要途徑呢？

學生： 是植物同域種化的重要機制。

老師： 沒錯，且染色體數目的改變可由人為的方式產生，例如以秋水仙素處理。

學生： 了解了！人工技術真的好厲害啊！

1-4 物種與分類
Species and Classification

■ 前言 Introduction

在此小節，教師藉由上節物種形成機制的了解，建立生物的「種」概念的歷史發展過程，透過形態種與生物種的物種定義解釋，搭配實際例子，讓學生理解「物種定義」的適用問題，及對於生物分類的重要性。

語言的部分，可以在學名及物種定義上搭配單字及句型，使專有名詞及語言能清楚對照，加深學生記憶並融會運用。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
mutation	變種	scientific name	學名
phylogenetic species	譜系種	species	種
type specimen	模式標本	specific name	種小名
typological species	模式種	biological species	生物種
taxonomy	分類學	generic name	屬名
taxonomic species	分類學種	common name	俗名
morphological species	形態種	subspecies	亞種

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

❶ _____ is made up of _____ and _____.

例句：The scientific name of each species **is made up of** a generic name and a specific name.
每個物種的學名是由屬名和種小名組成。

❷ The definition of _____ is _____.

例句(1)：**The definition of** morphological species **is** viewing a group of morphologically similar individuals in appearance as the same species.
形態種的定義是將一群在外觀上具有類似形態的個體視為同種。

例句(2)：**The definition of** biological species **is** a group of organisms that can reproduce with one another in nature and produce fertile offspring.
生物種的定義是指在自然界中能夠相互交配並產生具生殖能力後代的一群生物體。

❸ Even _____ may _____ due to _____.

例句(1)：**Even** the same kind of organisms **may** have population changes **due to** differences in food choices.
即使是同種生物，也可能因食物選擇差異產生族群變化。

例句(2)：**Even** the same kind of organisms **may** have population changes **due to** geographic isolation.
即使是同種生物，也可能因地理隔離產生族群變化。

❹ _____ is the subspecies of _____. There are _____ but not _____

例句(1)：Formosan blue magpie **is the subspecies of** blue magpie**. There are** certain differences between subspecies **but not** reproductive isolation.
台灣藍鵲是中國藍鵲的亞種。亞種間具有一定的差異性，但不具有生殖隔離。

例句(2)：Formosan black bear **is the subspecies of** Asian black bear. **There are** certain differences between subspecies **but not** reproductive isolation.
台灣黑熊是亞洲黑熊的亞種。亞種間具有一定的差異性，但不具有生殖隔離。

❺ _____ is the basic unit of _____.

例句(1)：Species **is the basic unit of** biological classification.

「種」是生物分類的基本單位。

例句(2)：Species **is the basic unit of** biological reproduction.

「種」是生物繁殖的基本單位。

■ 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、學生能了解生物「物種」概念的歷史發展過程。

Students can understand the historical development of the concept of biological species.

二、學生能了解形態種和生物種的物種定義。

Students can understand the definition of morphological species and biological species.

三、學生能了解物種定義對生物分類之影響。

Students can understand the influence of defining species on the classification of organisms.

❧ 例題講解 ☙

例題一

說明：學生能了解育種與物種定義。

Students can understand the definition of breeding and species.

In the process of breeding, crops with different characteristics are often repeatedly hybridized to produce a large number of mutated offspring, then the offspring with specific characteristics are selected to breed new strains. According to the description above, which of the following statements are correct?

(A) The process of crop hybridization may involve genetic recombination.

(B) The hybridized crops represent that there is no reproductive isolation, so the crops are definitely the same species.

(C) The new strains bred after hybridization have the opportunity to undergo polyploidization.

(D) The process of breeding new strains of crops belongs to allopatric speciation.

(E) The traditional process of breeding is similar to natural selection, but it is called artificial selection because it is humans that choose the characteristics.

育種過程中，常將帶有不同特徵的作物反覆雜交後，產生大量變異的子代，再選擇具特定特徵的子代，培育成新的品系。根據以上描述，下列敘述哪些正確？

(A) 作物雜交的過程可能牽涉到基因重組。

(B) 作物可以雜交，表示沒有生殖隔離，必定為相同物種。

(C) 雜交後培育出的新品系有機會發生多倍體化的現象。

(D) 育種產生新品系作物的過程屬於異域種化。

(E) 育種的傳統過程類似天擇，但由人為選定特徵，故稱為人擇。

（109 年指考 30）

Teacher: Why does the process of crop hybridization involve genetic recombination?

Student: Because there are the phenomena of gene exchange and chromosome recombination in the process of sexual reproduction.

Teacher: That's right! That is because of the meiosis in sexual reproduction to produce the phenomenon.

Student: But why do the crops which can hybridize not necessarily belong to the same species?

Teacher: This is because the definition of biological species can not apply to many plants. Different plant species having a closer kinship can also naturally hybridize.

Student: I see, so are polyploids also the product of hybridization?

Teacher: Yes, you're right. If chromosomes do not separate in the process of meiosis, the multiplied gametic chromosome number gives the chance of producing polyploids.

Student: I understand. The sexual reproduction of plants is really interesting!

Teacher: Let me ask you the last question. If there is no geographical isolation in the process of breeding new species of crop, which kind of speciation does it refer to?
Student: Because there is no geographical isolation, it is sympatric speciation.
Teacher: Awesome! It seems you understand breeding and the definition of species.

老師： 在作物雜交的過程為何會牽涉到基因重組呢？
學生： 因為在有性生殖的過程中，會有基因互換、染色體排列重組的現象。
老師： 沒錯！因為有性生殖會進行減數分裂，產生這些現象。
學生： 那為什麼作物可以雜交，卻不一定是相同物種呢？
老師： 因為生物種的定義在很多植物上並不適用，親緣關係較近的不同植物物種，也是能夠自然雜交的。
學生： 原來如此，所以染色體多倍體也是雜交後的結果嗎？
老師： 沒錯，如果在減數分裂時染色體無分離現象，配子染色體倍增，就有機會產生多倍體喔！
學生： 了解了，植物的有性生殖真有趣啊！
老師： 那再問你最後一個問題，育種產生新品系作物的過程沒有地理隔離，因此屬於什麼種化呢？
學生： 因為沒有地理隔離，所以是同域種化。
老師： 非常棒！看來你對育種及物種定義非常了解。

例題二

說明：學生能了解生物分類的基本階層，及生物種、形態種之概念。

Students can understand the basic hierarchy of bio taxonomy as well as the concept of biological species and morphological species.

Which of the following concepts related to species and phylogenetic trees is correct?

(A) Testing two groups of samples, if they can mate and produce offspring, they belong to the same species.

(B) Mayr took the similarity of morphology as the standard to propose the concept of biological species.

(C) The concept of biological species is also quite suitable to be applied to the bacteria kingdom.

(D) Species is the basic hierarchy located below the genus in the system of bio taxonomy.

下列有關物種與生命樹的概念，何者正確？

(A) 測試兩族群樣本，若可交配產生子代即屬於同物種。

(B) 梅爾（Mayr）以形態上之相似性為準，提出生物種的概念。

(C) 生物種的概念應用於細菌界亦相當適合。

(D) 物種是分類系統中位於屬之下的一個基本階層。

（105 年指考 5）

Teacher: When testing whether the two groups of samples belong to the same species, in addition to being able to mate and produce offspring, what kind of ability should the offspring possess?

Student: The offspring of two groups should possess the ability of reproduction to prove they are the same species.

Teacher: That's right. Then using the similarity of morphology as the reference of the same species belongs to morphological species. What is the definition of biological species?

Student: The definition of biological species should be that the organisms in the same species can mutually mate and produce offspring that possess the ability to reproduce.

Teacher: Awesome! So the definition of biological species cannot be applied to the bacteria kingdom, which lacks the ability for sexual reproduction.

Student: I see, so species are at the bottom of the classification of bio taxonomy, which lies under the hierarchy of genus?

Teacher: Correct! The basic hierarchy of bio taxonomy following the order from high to low is kingdom, phylum, class, order, family, genus, and species.

Student: Got it. I've written down the hierarchy of bio taxonomy.

老師： 在測試兩族群樣本是否屬於同物種時，除了可交配產生子代外，其子代需具有什麼能力呢？

學生： 兩族群所產生的子代需具有生殖能力，才屬於同物種。

老師： 沒錯，那以形態相似性作為同種生物的依據是屬於形態種，而生物種的定義為何？

學生： 生物種的定義應該是同種生物可相互交配並產生具有生殖能力的子代。

老師： 非常棒！因此生物種的定義並不適用於不具有有性生殖的細菌界喔。

學生： 原來如此，那物種應該就是在分類階層的最下面，也就是屬的下面一個階層嗎？

老師： 沒錯！生物分類系統的基本階層，由高到低依序排列為:界、門、綱、目、科、屬、種。

學生： 了解，我已經把分類階層記下來了！

★ 主題二 生物與環境 ★
Organisms and the Environment

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■ 前言 Introduction

生物依賴著環境生存，生態學研究生物之間及其與環境的互動。生態學包括個體、族群、群集、生態系、生物圈等不同層級，這些層即由小而大，構成了生命世界。本章節將探討生態學各層級，介紹了族群的特徵及其如何受環境影響，與生物的生態區位如何影響群集互動。以及生態系中的食物網與食物鏈形成營養階層，以及非生物因素對能量流動和物質循環的影響。

2-1 生態學的研究層級
Levels of Research in Ecology

■ 前言 Introduction

生態學關注生物之間，以及生物與環境之間的互動。這門科學覆蓋了從單一生物個體到更為複雜的生物群體，包括個體、族群、群集、生態系、生物圈...等等，各個層面。這些層面之間相互聯繫，共同組成了我們自然世界的生命網絡。

在本小節中，我們將一起探索這些不同的生態學層級。藉由生態學相關單字及句型的學習，我們將了解每個層級的特點、英文描述方式，以及它們如何相互影響，形成一個大的生態系統。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
ecology	生態學	biosphere	生物圈
individual	個體	autoecology	個體生態學
population	族群	population ecology	族群生態學
coenosium / community	群集	coenology	群集生態學
ecosystem	生態系		

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

❶ ____ adapt to the environment through _____.

例句：The study of ecology primarily investigates how organisms **adapt to the environment through** physiological processes and behaviors.
生態學主要探討生物如何透過生理作用及行為以適應環境。

❷ ____ can be categorized into _____

例句：In the field of ecology, research **can be categorized into** the following levels: individual, population, community, ecosystem, and biosphere.
在生態學的研究領域當中，可分為以下研究層級，分別為個體、族群、群集、生態系及生物圈。

❸ ____ develop the behavior of _____ to adapt to _____.

例句：Some birds have **developed the behavior of** seasonal migration **to adapt to** the seasonal changes in their environment and the food resources necessary for survival.
部分鳥類發展出季節遷移的行為，以適應生存環境及食物資源的季節變動。

❹ ____ be closely related to_____.

例句：Ecological research **is closely related to** the theory of evolution.
生態學的研究與演化理論息息相關。

❺ Without _____. _____ could not _____.

例句：Without the Earth's environment or support from other organisms, living things **could not** survive on Earth.
地球上所有的生物若沒有地球的生存環境或是其他生物的支持，都無法存活。

❻ _____ not only _____ but also _____.

例句：The concept of the biosphere is **not only** the broadest research level in ecology **but also** the largest scope of life known to humanity.

生物圈的概念不只是生態學最寬廣的研究層級，也是目前人類已知生命現象的最大範圍。

■ 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、學生了解生態學的研究層級。

Students understand the levels of research in ecology.

❧ 例題講解 ☙

例題一

說明：學生能了解生態學的研究層級。

Students can understand the levels of research in ecology.

A researcher studied a specific type of fiddler crab in an estuary wetland, and recorded the annual population changes of this crab in a particular area. Which level of ecology was studied?

(A) Individual　(B) **Population**

(C) Community　(D) Ecosystem.

某一學者研究河口溼地中某種招潮蟹，記錄特定區域中該招潮蟹每一年的數量變化。請問他所研究的是生態學中的哪一種層級？

(A) 個體　(B) **族群**

(C) 群集　(D) 生態系

Teacher: What is the researcher studying in the estuary wetland in this question?
Student: The population changes of a certain type of fiddler crab.
Teacher: Right, the research is recording the annual population of that fiddler crab in a specific area. Which level of ecology does this belong to?
Student: Is it the individual level?
Teacher: No, the individual level involves studying a single organism. The researcher in this question is studying the population of the entire species in the same area. What level should that be?
Student: Is it the population level?
Teacher: Exactly. Next, let's look at communities and ecosystems. What does a community mean?
Student: It means the collection of two or more species in the same area.
Teacher: Correct! And an ecosystem includes the community and the environment.

老師： 同學們，請問題目中的學者在河口溼地中研究什麼？
學生： 某種招潮蟹的數量變化。
老師： 對，他記錄的是特定地區中，該招潮蟹每年的數量。這屬於生態學中的哪個層級呢？
學生： 是個體層級嗎？
老師： 不是喔，個體層級是研究單一個體，題目中的學者是研究同個區域內整個物種群的數量，這應該是什麼層級呢？
學生： 是族群層級嗎？
老師： 沒錯。
接下來我們來看看群集和生態系，請問群集是什麼意思呢？
學生： 是指同一區域中兩種以上的物種群的集合。
老師： 沒錯！
而生態系的意思則是群集加上環境唷。

例題二

說明：學生能了解生態學的研究層級之間的關係。

Students can understand the relationships between the different research levels in ecology.

Please arrange the following ecological research levels from smallest to largest:

(a) population (b) individual (c) ecosystem (d) community

(A) cdab (B) cadb

(C) badc (D) adbc

請將下列生態學的研究層級由小排到大：

(a)族群 (b)個體 (c)生態系 (d)群集

(A) cdab (B) cadb

(C) badc (D) adbc

Teacher: This question discusses the levels of research in ecology. What is an individual?

Student: An individual refers to a single organism.

Teacher: Correct, and is the individual the smallest level that can be researched?

Student: Yes.

Teacher: What's the next level?

Student: It should be population!

Teacher: Right, and what is a population?

Student: A population includes all individuals of a specific species within a certain time and area.

Teacher: Exactly. What's the next level after population?

Student: It's community.

Teacher: Yes. A community includes the populations of different species within an area. And finally, what does an ecosystem include?

Student: An ecosystem refers to the environment and all the organisms within it.

Teacher: Correct. So, how should we arrange these levels from smallest to largest?

Student: Individual, population, community, ecosystem.

Teacher: Exactly! So, which option is correct?

Student: Option (C) badc.

老師： 同學們，這一題討論的是生態學的研究層級。首先，請問什麼是個體？
學生： 個體指的是單一的生物體。
老師： 沒錯，那個體是不是最小的層級？
學生： 是的。
老師： 接下來，下一個層級應該是哪個呢？
學生： 應該是族群！
老師： 沒錯，請問族群是什麼意思呢？
學生： 是指特定物種在特定時間、特定區域內所有個體的集合。
老師： 沒錯。
族群的下一個層級是什麼呢？
學生： 是群集。
老師： 是的。群集包括了一個地區內，所有不同物種的族群。最後，最大的層級是生態系，請問生態系是什麼意思呢？
學生： 生態系是指環境與其中的所有生物。
老師： 沒錯。那麼由小到大排列這些層級的話，應該怎麼排呢？
學生： 個體、族群、群集、生態系。
老師： 沒錯！所以正確的選項應該是哪個呢？
學生： 選項 (C) badc。

2-2 族群
Population

■ 前言 Introduction

族群是生態學研究中的一個研究層級，指的是一個利用相同環境資源且能進行繁殖的同種群體。在本小節中，我們將介紹族群的多種特徵，包括族群密度、成長曲線、存活曲線以及年齡結構等，並探討這些特徵如何受到環境等因素的影響。其中也將針對本節的重要英文句型及單字進行應用。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
population	族群	birth	出生
habitat	棲地	death	死亡
area	面積	immigration	遷入
volume	體積	emigration	遷出
population density	族群密度	clumped distribution	聚集分布
population growth	族群成長	random distribution	隨機分布
carrying capacity	負荷量	uniform distribution	均勻分布
survival curve	存活曲線	pre-reproductive	生殖前期
age structure	年齡結構	reproductive period	生殖期

exponential population curve/ J-shaped growth form	J 型群成長	post-reproductive	生殖後期
logistic population curve/ S-shaped growth form	S 型群成長		

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

❶ the larger the_____, the larger the _____

例句：The size of a population is usually related to the size of its habitat; **the larger the** habitat, **the larger the** population.

族群大小通常與其棲地大小有關，棲地越大、族群一般也會越大。

❷ _____is/are influenced by _____.

例句：Changes in population size **are influenced by** the birth, death, immigration, and emigration of individuals, as well as environmental variations.

族群大小變化受到出生、死亡、遷入與遷出的影響，環境的變動等都會影響族群大小。

❸ _____ is/are helpful for _____.

例句：Understanding changes in population size **is helpful for** predicting and managing the quantity of organisms.

了解族群大小的變化，有助於預測與管理生物的數量。

❹ the fewer_____, the lower_____.

例句：If the habitat size remains constant, **the fewer** individuals there are in the population, **the lower** the population density.

若棲地大小不變，族群中的個體數越少、族群密度也越低。

❺ _____ change(s) over time _____.

例句：Population size **changes over time**, and the graph representing this change is called a population growth curve.

族群大小會隨著時間而變化，將此變化所繪製的圖形，稱為族群成長曲線。

■ 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、學生了解並解釋族群的特徵，包括族群密度的定義、族群存活曲線的意涵、族群年齡結構的意義。

Students understand and explain the characteristics of a population, including the definition of population density, the implications of population survival curves, and the significance of population age structure.

二、學生了解族群生存曲線三種基本模式，族群如何在不同階段適應當前狀況。

Students understand the three basic patterns of population survival curves and how populations adapt to current conditions at different stages.

∞ 例題講解 ∞

例題一

說明：學生能了解族群密度、年齡結構及存活曲線的意義。
Students can understand the significance of population density, age structure, and survival curves.

Which of the following statements about populations and their age structures is correct?

(A) Population density refers to the number of individuals per unit area, per unit time.

(B) The age structure of a population cannot be used to infer overall trends in the population.

(C) If the human age structure is pyramid-shaped, it indicates that the birth rate of the population is higher than the death rate.

(D) According to the survival curve, humans have a high mortality rate from infancy through youth to middle age, with the mortality rate gradually decreasing after middle age.

下列有關族群及其年齡結構的敘述，何者正確？

(A) 族群密度是指單位面積、單位時間內的個體數目。

(B) 由族群年齡的結構不能夠推測整個族群的變化趨勢。

(C) 人類年齡結構若呈金字塔型，即表示族群出生率高於死亡率。

(D) 依據生存曲線，人類從幼年、青年、到中年期間的死亡率很高，而到中年期以後死亡率則逐漸降低。

（94 年學測自然 13）

Teacher: Let's look at this question about population characteristics. To start, what features come to mind when we think about population characteristics?

Student: The size, age structure, survival curves, and growth curves of the population!

Teacher: Wow! You answered quickly and accurately! First the size of the population was mentioned. What concept can represent this?

Student: Population density.

Teacher: Good. So, what's the definition of population density?

Student: It's the number of individuals in a unit of space.

Teacher: Right! So, option (A)'s definition of population density is incorrect. It should be changed from "per unit area, per unit time" to "within a unit of space." Next, we see options (B) and (C) both mention age structure. What does age structure refer to?

Student: Age structure refers to the distribution of individuals in a population across different age groups.

Teacher: Very good! More precisely, it's the "proportion" of individuals in each age group within the population. We can then plot the "number of individuals" and "gender" by their proportion. Can the age structure of a population be used to infer overall trends in the population, as mentioned in (B)?

Student: Yes, because we can know the proportion of individuals in pre-reproductive, reproductive, and post-reproductive stages, and thus predict the future development of the population. For example, if a population has fewer individuals in the pre-reproductive stage than in the post-reproductive stage, the future birth rate will be lower than the death rate. Therefore, we can predict that the overall population size will decrease.

Teacher: You've explained it very well. So, to which of the age structure types does this example belong?

Student: The declining type!

Teacher: Very good! Moving on to option (C), if the human age structure is pyramid-shaped, it indicates that the birth rate of the population is higher than the death rate, right?

Student: That's correct!

Teacher: Right, then let's test you further, which of the three types does the pyramid-shaped age structure belong to?

Student: The expanding type!

Teacher: Good job! Finally, we come to option (D), which mentions the survival curve. What are the three basic patterns in survival curves?

Student: The Type I survival curve (convex), the Type II survival curve (diagonal), and the Type III survival curve (concave).

Teacher: Well done! What's the significance of the survival curve?

Student: The horizontal axis is the percentage by age, and the vertical axis is the number of survivors per thousand individuals. The survival curve represents the survival and adaptation conditions of the population at each stage.

Teacher: So, which type of survival curve do humans belong to, according to (D)?

Student: It should be the Type I survival curve (convex) because humans protect their young, and both juveniles and middle-aged individuals have relatively high survival rates, while the elderly have higher mortality rates.

Teacher: Exactly, so option (D) “Humans have a high mortality rate from infancy through youth to middle age” should be changed to “low,” and “the mortality rate gradually decreases after middle age” should be “gradually increases after middle age.”

老師： 同學們，我們一起來看到這題有關族群特徵的題目敘述。
先來幫同學們回憶一下，說到族群的特徵，同學們想到了哪些性質呢？

學生： 有族群的大小、族群年齡的結構組成、族群的存活曲線，還有族群成長曲線！

老師： 哇！同學們答得又快又準確喔！
首先提到的族群的大小，可以利用什麼來代表呢？

學生： 族群密度。

老師： 很好，那麼請問同學們族群密度的定義為何？

學生： 單位空間中族群的個體數量有多少。

老師： 沒錯！因此看到選項(A)中的族群密度的定義是錯的，應該把「單位面積、單位時間內」改成「單位空間內」唷!
接著我們看到選項(B)(C)都提到了年齡結構，請問同學們年齡結構是指什麼?

學生： 年齡結構指的是族群中各年齡層的個體數分布。

老師： 很好唷！更準確地來說，是族群中各年齡層的個體數在「族群內所占的比例」，再將各年齡層的「個體數」與「性別」依比例繪圖。
請問同學(B)由族群年齡的結構能不能夠推測整個族群的變化趨勢呢？

學生： 可以，因為我們可以知道生殖前期、生殖期和生殖後期的個體數比例，進而預測族群未來的發展，例如如果有個族群的生殖前期的個體數小於生殖後期的個體數，產生的影響可能是未來的出生率會小於死亡率，因此可以預測族群整體數量將減少。

老師： 同學們說明的很好，那麼老師再額外考大家，你們所舉出的例子會是年齡結構三種類型的哪一型呢？

學生： 衰退型！

老師： 非常好！再來看到選項(C)人類年齡結構若呈金字塔型，即表示族群出生率高於死亡率，正確嗎？

學生： 是對的！

老師： 沒錯，那麼再考考大家，金字塔型的年齡結構是屬於三種類型的哪一型呢？

學生： 增長型！

老師： 很好！最後我們看到(D)提到的存活曲線，請問同學存活曲線分為三種基本模式，是哪三種？

學生： 第 I 型存活曲線(凸型)、第 II 型存活曲線(對角線型)、第 III 型存活曲線(凹型)。

老師： 很好！那麼存活曲線所代表的意義為何？

學生： 橫坐標是相對年齡百分比，縱座標是每千個個體存活數，存活曲線代表的是族群在各個階段的生存、適應的狀況。

老師： 那麼請同學想一想(D)人類是屬於哪一型存活曲線？

學生： 應該是第 I 型存活曲線(凸型)，因為人類有護幼行為，幼體和中年個體的存活率相對較高，而老年個體則是死亡率相對較高。

老師： 沒錯，因此選項(D)「人類從幼年、青年、到中年期間的死亡率很高」應該改成「很低」,「而到中年期以後死亡率則逐漸降低」,中年以後的死亡率是逐漸升高才對。

例題二

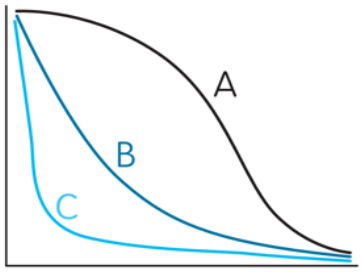
說明：學生能了解族群生存曲線的意義與類型。

Students can understand the significance and types of population survival curves.

Table 1 shows averages from the results of multiple surveys conducted by an ecologist over three years on the population numbers of four species within an ecosystem. Based on the data from Table 1, answer the following questions.

Table 1. The number of members in an ecosystem.

quantity / Individual / species	juvenile	sub-adult	adult	senior adult
a	700	680	600	95
b	350	280	220	190
c	30	14	13	12
d	0	70	30	0

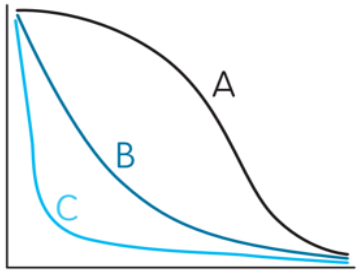


1. Which of the survival curves A, B, or C does the population survival curve of elephants most closely approximate? (2 points) **Answer: A**
2. What do the X-axis and Y-axis represent in the population survival curves shown above? Among the curves A, B, and C, which one represents the population survival curve for species "a" from Table 1? (3 points) **Answer: The X-axis represents the percentage of the population by age, and the Y-axis represents the number of survivors per thousand individuals; A.**

表 1 是某生態學者在三年內對一生態系內四個物種數量進行多次調查所得平均結果，根據表 1 資料回答下列問題。

表 1　一個生態系的成員數量

個體 / 數量 / 物種	幼　體	亞成體	成　體	老成體
甲	700	680	600	95
乙	350	280	220	190
丙	30	14	13	12
丁	0	70	30	0



1. 大象之族群生存曲線近似於 A、B、C 曲線中何者？（2 分）**答案：A**
2. 上圖族群生存曲線之 X 軸及 Y 軸各為何？A、B、C 曲線中，何者為表 1 甲物種的族群生存曲線？（3 分）**答案：X 軸表示年齡百分比，Y 軸表示每千個個體存活數；A。**

（100 年指考生物非選擇題二）

Teacher: What can we learn about population characteristics by plotting the survival status of different age stages within a population?

Student: The population's survival curve.

Teacher: Excellent. We know that survival curves can generally be divided into three patterns. What are these three types, and how do they correspond to the population survival curves A, B, and C in the figure above?

Student: The Type I survival curve corresponds to curve A, Type II to curve B, and Type III to curve C.

Teacher: Correct. So, which of the curves A, B, or C does the elephant population's survival curve most closely resemble? Why?

Student: Curve A, because the Type I survival curve indicates that juveniles and middle-aged individuals have relatively high survival rates, while the elderly have decreasing survival rates and increasing mortality. Elephants, as mammals, provide comprehensive care and protection for their young, fitting the Type I survival curve.

Teacher: Very good! Now, what do the X and Y axes represent in the population survival curve chart?

Student: The X-axis represents the percentage of the population by age, and the Y-axis represents the number of survivors per thousand individuals in the population.

Teacher: Very good! This allows us to compare the survival status of different life stages among populations, which is the significance of the survival curve chart. Next, which of the curves A, B, or C is most likely the population survival curve for species "a" from Table 1? Why?

Student: Curve A, because based on Table 1, we can deduce that this species has a higher survival rate from the juvenile and sub-adults stages to the adult stage. There is a significant decline in survival rate only in old age, which matches population survival curve A.

老師： 請問同學們根據一族群中不同年齡階段的生存狀況繪圖，可以得到什麼樣的族群特徵？

學生： 族群的存活曲線。

老師： 很好，首先我們知道存活曲線大致可以分為三種模式，請問同學是哪三種？又如何對應到上圖中的族群生存曲線 A、B、C ？

學生： 第 I 型存活曲線對應到曲線 A，第 II 型存活曲線對應到曲線 B ，而第 III 型存活曲線對應曲線 C。

老師： 沒錯，那麼題目一大象之族群生存曲線近似於 A、B、C 曲線中何者？為什麼？

學生： A 曲線，因為第 I 型存活曲線代表幼體和中年個體的存活率相對高，而老年個體的存活率下降、死亡率上升，大象這種族群為哺乳類動物，對於幼體的照顧與保護較周全，因此屬於第一型存活曲線。

老師： 非常好！那麼請問題目二族群生存曲線圖之 X 軸及 Y 軸各代表為何？

學生： X 軸代表族群的相對年齡百分比， Y 軸代表族群每千個個體的存活數量。

老師： 非常好！如此我們就可以比較各個族群間在不同生命階段的生存狀況了，此即為存活曲線圖的意義。接著請問表 1 甲物種的族群生存曲線最可能是 A、B、C 曲線中何者？為什麼？

學生： A 曲線，因為從表一可以判斷出甲物種幼體、亞幼體長至成體的存活率較高，直到老年時期，存活率才大幅下降，符合族群存活曲線 A。

2-3 群體
Community

■ 前言 Introduction

本章節探討生態研究中的群集結構，群集由在同一地理區域內共享資源並進行相互作用的物種組成，每個物種都在生態系中扮演著特定的角色，形成獨特的生態區位。本節也將介紹生態區位寬度和生態區位重疊，如何影響群集的互動。結合本節與群集相關英文單字及文法句型，使學生更了解本節的重要英文知識。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
community	群集	ecological niche	生態區位
ecological niche breadth	生態區位寬度	ecological niche overlap	生態區位重疊
community structure	物種結構	spatial structure	空間結構
interspecific competition	種間競爭	predation	掠食
symbiosis	共生	climax community	極相(巔峰)群集
succession	演替	primary succession	初級演替
secondary succession	次級演替	pioneer species	先驅種

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

❶ _____ change with _____.

例句：The composition of species and the spatial structure of a community will **change with** the external environment.

群集的物種組成和空間結構會隨著外在環境變化。

❷ ____ conditions _____ require _____.

例句：A species' ecological niche includes both the physical and environmental **conditions** it **requires** and the interactions it has with other species

一個物種的生態區位包括其所需的物理和環境條件，以及與其他物種之間的相互作用。

❸ _____ compete for _____.

例句：Woodpeckers and squirrels frequently **compete for** nesting sites in the same holes in trees.

啄木鳥和松鼠經常在同一樹洞中爭奪築巢地點。

❹ _____ share _____ with _____.

例句：Ecological niche overlap describes the situation in which co-occurring species **share** parts of their niche **with** each other.

生態區位重疊描述了共生物種彼此共享部分生態區位的情況。

❺ _____ be distinguished from _____.

例句：Primary succession **is distinguished from** secondary succession, which is the succession after a disturbance.

初級演替與次級演替不同，次級演替是現有生物群落在受到干擾後的演替。

❻ _____ establish oneself _____.

例句：Pioneer species are the first plants or organisms to **establish themselves** in an area during the early stages of ecological succession.

先驅種是在生態演替的早期階段在一個地區定居的第一個植物或生物。

■ 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、學生了解群集中物種的生態區位的意義。

Students understand the significance of ecological niches of species within a community.

二、學生了解群集結構隨時間和環境變化演變的過程，以及演替的定義與形式。

Students comprehend the process of how community structures evolve over time and with environmental changes, as well as the definition and forms of succession.

❧ 例題講解 ☙

例題一

說明：學生能了解演替的過程。

Students can understand the process of succession.

Figure 14 shows the development of ground vegetation over time after a forest fire in an isolated area. Which of the following statements about the succession of this area are correct? (Choose 3)

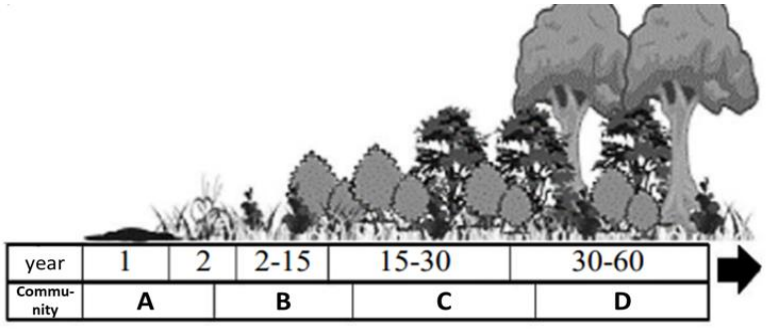


Figure 14

(A) The species richness of community A is lower than community C.

(B) The degree of competition between species is smaller for community B is compared to community D.

(C) The community transition process is faster after a forest fire than after a volcanic eruption.

(D) If community D reaches a climax state, its species composition will no longer change.

(E) The appearance of vegetation formed by the community's succession process is discontinuous.

圖 14 為某隔絕地遭森林大火後，地上植被隨時間發展的情形。下列有關此地消長的敘述哪些正確？（應選 3 項）

(A) 以物種的豐富度而言，甲群集低於丙群集。

(B) 以物種之間的競爭程度而言，乙群集較丁群集為小。

(C) 以群集轉變過程而言，大火後較火山爆發後來得快。

(D) 丁群集若達到巔峰的狀態，其物種組成將不再變化。

(E) 群集消長過程所形成的植被外貌是不連續的。

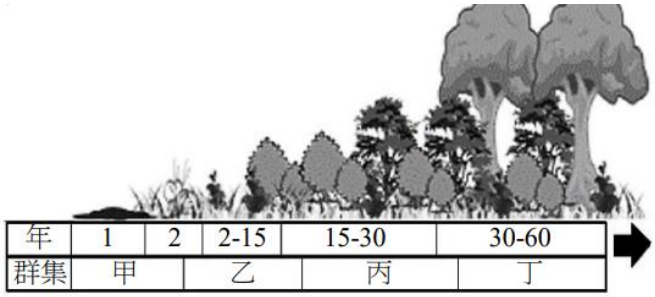


圖 14

（109 年學測 54）

Teacher: Based on the description, can we determine if the rise and fall process of this area is a primary or secondary succession?

Student: It's secondary succession, because the area is undergoing re-succession after being destroyed by a forest fire, while still retaining soil, humus, and plant propagules.

Teacher: Great! Now, looking at option (A), which community, A or B, has greater species richness?

Student: Community B, because the initial pioneer community is in an unstable environment. Pioneer species are usually small, have short life histories, and are fewer in number. As time passes and the environment stabilizes, more dominant species replace the original ones. Therefore, the species richness of community B would be greater than that of community A.

Teacher: Correct. Then for option (B), in terms of the degree of competition, which is greater, community B or community D?

Student: Perhaps community D?

Teacher: Why is that?

Student: Because community D has higher biodiversity! So, there is a greater degree of competition in terms of the number and types of species.

Teacher: Right! The B community is still in a transitional phase of succession with fewer types of species and less competition. Next, in terms of the process of community transition, is it faster or slower after a fire than after a volcanic eruption?

Student: It's faster after a fire! Because after a forest fire, soil, a large amount of humus, and plant propagules in the soil are still preserved. On the other hand, a volcanic eruption leaves behind lava, and bare rocks, and covers the land with volcanic ash, lacking soil nutrients.

Teacher: Exactly, it's because secondary succession occurs after a forest fire, so the rate is faster. Primary succession occurs after a volcanic eruption, so the rate of succession is slower. Looking at option (D), if community D reaches a climax state, will its species composition remain the same?

Student: No, the species composition might still change. It is just that the degree of change tends to be less noticeable.

Teacher: Correct! Lastly, for option (E), is the appearance of vegetation formed by the community's succession process discontinuous?

Student: No, succession is a continuous evolutionary process.

老師： 同學們請問根據題幹敘述我們可以知道，此地的消長過程是屬於初級演替還是次級演替？

學生： 次級演替，因為此地受到森林大火的破壞後重新演替，仍然保留土壤、腐植質和植物的繁殖體。

老師： 非常棒！那麼接著看到選項(A)，請問甲群集與乙群集何者物種豐富度較大？

學生： 乙群集，因為剛長出的先驅群集所處的環境不穩定，所以先驅種通常又小、生活史短、種類也少，而經過時間推移，環境穩定後會有更具優勢的物種取代原先的物種。因此乙群集的物種豐富度會較甲群集大。

老師： 沒錯，那麼選項(B)就競爭程度而言，群集乙和群集丁誰大？

學生： 可能是丁嗎？

老師： 為什麼呢？

學生： 因為丁的生物多樣性高！所以在物種數量和種類上面競爭程度大。

老師： 沒錯！乙群集仍在演替的過渡時期，物種種類較少，競爭程度也小。再來看到選項(C)以群集轉變過程而言，大火後較火山爆發後來得快還是慢？

學生： 大火後群集轉變得比較快！因為森林大火後仍然保留土壤、大量腐植質跟土壤中的植物繁殖體，而火山爆發後會留下岩漿、裸露的岩石、火山灰覆蓋大地，沒有土壤的營養。

老師： 沒錯，也就是因為森林大火後屬於次級演替，因此速率較快。火山爆發後屬於初級演替，演替速率較慢。接著看到選項(D)丁群集若達到巔峰的狀態，其物種組成將不再變化嗎？

學生： 錯誤，物種組成還是可能會改變，只是改變的程度趨於不明顯。

老師： 答對了！最後看到選項(E)群集消長過程所形成的植被外貌是不連續的嗎？

學生： 錯誤，演替為連續性的演變過程。

例題二

說明：學生能了解生態區位相近的物種之間的交互作用。

Students can understand the interactions between species with similar ecological niches.

In the same pond, two species of freshwater snails from the same genus have coexisted for a long time, with similar but not identical ecological niches. Which of the following inferences are correct?

(A) Closely related species utilize similar resources.

(B) The resources in the pond are available indefinitely for their use over the long term.

(C) There is competition between the two species of freshwater snails.

(D) Ecological niches are unrelated to the utilization of living resources.

(E) There is a symbiotic relationship between the two species of freshwater snails.

在同一個池塘中長期存有同屬不同物種的 2 種淡水螺，其生態區位相似但不相同，下列推論哪些正確？

(A) 親緣接近的物種使用類似的資源。

(B) 池塘的資源長期無限地供應它們使用。

(C) 2 種淡水螺之間存有競爭關係。

(D) 生態棲位無關於生活資源的應用。

(E) 2 種淡水螺之間存有共生關係。

（104 年指考 23）

Teacher: What is the main point of this question?

Student: The two species of freshwater snails are closely related and have similar ecological niches.

Teacher: Right, let's first review the definition of an ecological niche.

Student: An ecological niche is the position a species occupies in an ecosystem, the role it plays, and its function.

Teacher: In the same ecosystem, if two organisms have similar demands for resources or ecological adaptation ranges, what is it called?

Student: Ecological location overlap!

Teacher: Very good! Now, let's look at statement (A) which states that closely related species use similar resources. Is this inference correct?

Student: Yes, it's correct because these two species of freshwater snails are closely related and have similar ecological niches. So, it can be inferred that closely related species will use similar resources.

Teacher: Right. Next, (B) the pond's resources are supplied indefinitely for their use. Is this inference correct?

Student: Incorrect! The natural resources of the pond are finite.

Teacher: Right. Do the two species of freshwater snails have a competitive or symbiotic relationship as mentioned in (C) and (E)?

Student: (C) There is a competitive relationship between the two species of freshwater snails because the resources in the pond are limited, and these two species have similar ecological niches, meaning they must compete for limited resources. Hence, they are in competition.

Teacher: Very good! Finally, statement (D) states that ecological niches are unrelated to the utilization of living resources. Is this inference correct?

Student: No, ecological niches also represent how species utilize resources in the ecosystem, so ecological niches and the utilization of living resources are inseparable.

老師： 請問同學們本題的重點是什麼？

學生： 親緣關係相近而且生態區位相似的兩種淡水螺。

老師： 沒錯，我們先來複習一下生態區位的定義為何？

學生： 生態區位是一個物種在生態系中所佔有的位置、扮演特定的角色、具有的功能。

老師： 在同一生態系中，若兩種生物再資源的需求或對生態的適應範圍相近，稱為什麼？

學生： 生態區位重疊！

老師： 非常好！那麼我們來看到題目所敘述(A)親緣接近的物種使用類似的資源，這個推論正確與否？

學生： 正確，因為這兩種淡水螺親緣關係、生態區位都相近，可以推論親緣接近的物種會使用相似的資源。

老師： 沒錯，接著(B)池塘的資源長期無限地供應它們使用，推論是否正確？

學生： 錯誤！池塘中的自然資源並非無限的。

老師： 沒錯，再來(C)與(E)2 種淡水螺之間存有競爭或是共生關係呢？

學生： (C)2 種淡水螺之間存有競爭關係是正確的，因為池塘資源有限，而這兩種淡水螺的生態區位相近，意味著他們必須競爭有限的資源，因此互為競爭關係。

老師： 非常好！最後看到選項(D)生態棲位無關於生活資源的應用，此推論正確嗎？

學生： 錯誤，生態區位也代表了物種對於生態系中資源利用情形，因此生態區位和生活資源的應用密不可分。

2-4 生態系
Ecosystems

■ 前言 Introduction

生態系，是指生物群集與其生存環境互動而形成的系統。在這一章節裡，我們將了解生物之間如何透過捕食關係形成食物網，及其建立的營養階層。同時，我們也會討論生物和非生物因素之間的相互作用，如何影響能量的流動和物質的循環。

通過提供專業術語列表、使用教學句型以及課堂問答等方式，來幫助學生更好地理解生態系中複雜的相互作用概念。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
ecosystem	生態系	biological factor	生物因子
environmental factor	環境因子	producer	生產者
consumer	消費者	trophic level	營養階層
ecological pyramid	生態塔	nutrient cycles	物質循環
carbon cycle	碳循環	nitrogen cycle	氮循環

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

❶ _____ have an impact on _____.

例句：The destruction of forests can **have a** devastating **impact on** the ecosystem, affecting various species and disrupting the balance of nature.
森林的破壞會對生態系統產生毀滅性影響，影響各種物種並破壞自然平衡。

❷ _____identified _____as _____.

例句：The biologist studied the river ecosystem and **identified** the presence of pollutants **as** a significant biological factor influencing the decline in the population of fish.
生物學家研究了河流生態系統，並確定污染物的存在是影響魚類種群數量下降的一個重要生物因素。

❸ _____play a crucial role in _____.

例句：Nutrient cycles, such as carbon and nitrogen cycles, **play a crucial role in** maintaining the balance of essential elements in the ecosystem, ensuring the sustainability of life processes for various organisms.
碳和氮循環等營養循環對於維持生態系統中必需元素的平衡發揮至關重要的作用，確保各種生物體生命過程的可持續性。

❹ _____serve as _____.

例句：The grass in the meadow **serves as** a producer, capturing sunlight and converting it into energy through photosynthesis, while the rabbits that feed on the grass act as consumers, relying on the energy stored in the plants for their own growth and survival.
草地上的草充當生產者，捕捉陽光並通過光合作用將其轉化為能量，而以草為食的兔子充當消費者，依靠植物中儲存的能量來維持自身的生長和生存。

❺ _____ from _____to_____.

例句：Energy flows **from** the sun **to** plants, then to animals as they eat the plants. This energy transfer sustains life in the ecosystem.

能量從太陽流向植物，然後在動物吃植物時流向動物。這種能量轉移維持了生態系統的生命。

■ 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、學生了解生態系的營養階層。

Students understand the trophic levels in an ecosystem.

二、學生了解生態系中的能量流轉與元素循環。

Students understand the energy flow and element cycles in an ecosystem.

❧ 例題講解 ☙

例題一

說明：學生能了解生態系的能量流動與物質循環。

Students can understand the energy flow and material cycles in an ecosystem.

Which of the following statements regarding energy flow and material cycling in ecosystems are correct?

(A) The length of a food chain is limited by the efficiency of energy conversion between trophic levels.

(B) The number of organisms within an ecosystem generally decreases as the trophic level rises.

(C) Generally, oxygen content is higher downstream in rivers as compared to upstream.

(D) Bacteria and fungi are the primary organisms connecting the world of organic life and the world of inorganic material.

(E) The rapid consumption of carbon fixed by ancient organisms is a major reason for the current increase of carbon dioxide concentration in the atmosphere.

下列有關生態系能量流動與物質循環的敘述，哪些正確？

(A) 食物鏈的長度受限於營養階層間能量轉換的效率。

(B) 一生態系內的生物數量總是隨著營養階層上升而減少。

(C) 一般而言，河川下游較上游氧含量高。

(D) 細菌與真菌是連接有機生命世界和無機物質世界的主要生物。

(E) 快速消耗古生物所固定的碳是今日大氣中二氧化碳濃度升高的主要原因。

（100 年指考 27）

Teacher: Are the lengths of food chains limited by the efficiency of energy transfer between trophic levels?

Student: Yes, because when energy flows to higher trophic levels, most of the energy will be lost. Thus, energy in the trophic levels usually only reaches the fourth or fifth level before becoming negligible, limiting the length of the food chain.

Teacher: Excellent! Now, does the number of organisms in an ecosystem always decrease with rising trophic levels, as stated in (B)?

Student: No, only energy decreases with rising trophic levels, but the number of organisms doesn't necessarily decrease. For example, a single tree can support a large number of insects.

Teacher: Well done. Is it generally true that the oxygen content downstream is higher than the oxygen content upstream in rivers, as mentioned in (C)?

Student: No, upstream rivers have more rocks, greater elevation differences, and faster and stronger currents, hence higher oxygen content. Downstream areas have slower flow and less turbulence, resulting in lower oxygen content.

Teacher: Correct! And is statement (D), which states that bacteria and fungi are the main organisms connecting the organic world and the inorganic world accurate?

Student: Yes, bacteria and fungi often act as decomposers in ecosystems, thus serving as bridges between the inorganic world and the organic world.

Teacher: Right, can you give an example?

Student: Decomposers like bacteria and fungi can transform organic materials from dead organisms and excrement into inorganic substances through decomposition. Nitrogen-fixing bacteria, cyanobacteria, and others can fix atmospheric nitrogen into organic compounds like ammonia.

Teacher: Very good! Finally, is the rapid consumption of carbon fixed by ancient organisms the main reason for the increase in atmospheric CO_2 levels today, as mentioned in (E)?

Student: Yes, because consuming carbon fixed by ancient organisms, such as coal, oil, and natural gas, releases ancient CO_2 back into the current atmosphere, thereby increasing the atmospheric CO_2 concentration.

老師： 同學們，(A)食物鏈的長度會受限於營養階層間能量轉換的效率嗎？

學生： 會，因為能量往更高營養階層流轉時，會散失大部分能量，因此營養階層中的能量通常都只能傳遞至第四或第五層，便已所剩無幾，食物鏈的長度也會因此受限。

老師： 非常棒！接著看到選項(B)一生態系內的生物數量總是隨著營養階層上升而減少嗎？

學生： 只有能量會隨著營養階層上升而減少，但生物數量則不一定會隨著營養階層上升而減少，例如單一棵樹上可以飼養大量的昆蟲。

老師： 很好，選項(C)一般而言，河川下游較上游氧含量高嗎？

學生： 不對，河川上游較多岩石、高低差大、水流湍急且較強，因此氧含量較高；而下游區流速低、水流小，因此氧含量較少。

老師： 正確！再來看到選項(D)細菌與真菌是連接有機生命世界和無機物質世界的主要生物，這個敘述正確嗎？

學生： 正確，細菌和真菌在生態系中常扮演分解者的角色，因此為連接無機物質世界與有機生命世界的橋樑。

老師： 沒錯，那同學可以舉例嗎？

學生： 細菌與真菌這些分解者可以將生物遺骸、排泄物中的有機物經由分解作用，轉化為無機物質。根瘤菌、固氮細菌及藍綠菌等也能進行固氮作用，將無機的氮氣轉變為有機化合物氨。

老師： 非常好！最後我們看到選項(E)快速消耗古生物所固定的碳是今日大氣中二氧化碳濃度升高的主要原因嗎？

學生： 是，因為消耗古生物所固定的碳，例如煤、石油和天然氣等化石燃料，相當於將古代的二氧化碳重新排放到現在的大氣中，進而升高大氣中的二氧化碳濃度。

例題二

說明：學生能了解能量塔，並分析食物網中的生物交互關係。

Students can understand the energy pyramid and analyze the biological interactions within a food web.

Food webs explore the relationships between trophic levels of organisms and also present interactions among species. Based on the food web relationship shown in Figure 7, which of the following statements are correct?

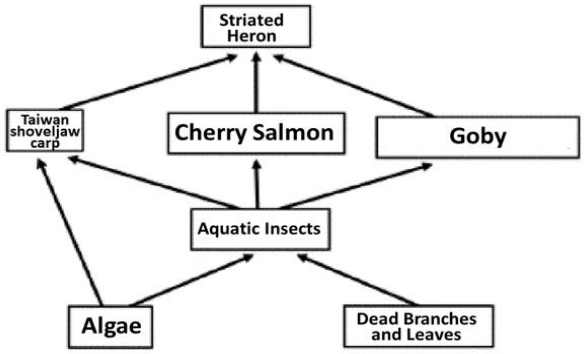


Figure 7

(A) If an energy pyramid is drawn based on this food web structure, the proportion occupied by the Striated Heron tier would be the lowest.

(B) Both the Cherry Salmon and the Goby prey on aquatic insects and may be in competition in terms of their diet.

(C) Since Goby prey on aquatic insects, this can reduce the grazing rate on algae. Therefore, Goby and algae have a commensal symbiotic relationship.

(D) Removing the Striated Heron could lead to an increase in Cherry Salmon, Goby, and Taiwan Shoveljaw Carp. With aquatic insects being heavily preyed upon, this significantly changes the entire community structure, making the Striated Heron a keystone species in this community.

(E) The population dynamics of Taiwan Shoveljaw Carp are mainly dependent on annual fluctuations of aquatic insects.

食物網探討生物營養階層間之關係，也呈現物種間的交互作用，根據圖 7 所示食物網關係，下列敘述哪些正確？

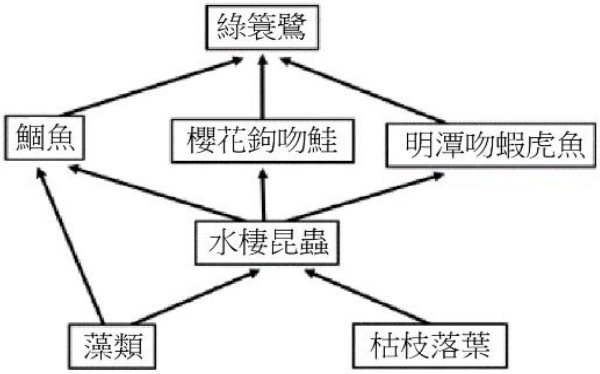


圖 7

(A) 若據此食物網結構繪製能量塔，綠簑鷺階層所占比例最低。

(B) 櫻花鉤吻鮭與明潭吻蝦虎魚皆捕食水棲昆蟲，兩者在食性上可能為競爭關係。

(C) 明潭吻蝦虎魚捕食水棲昆蟲可降低藻類被啃食率，因此明潭吻蝦虎魚與藻類為片利共生之關係。

(D) 移除綠簑鷺可能造成櫻花鉤吻鮭、明潭吻蝦虎魚與鯽魚增加，水棲昆蟲大量被捕食，整個生物群集結構明顯改變，因此綠簑鷺為該群集中重要的關鍵物種。

(E) 鯽魚的族群動態主要取決於水棲昆蟲的年間波動。

（110 年指考 35）

Teacher: In this question, we explore the trophic levels of various organisms in a food web. First, can someone tell me which organism is at the first trophic level?

Student: Algae, dead branches, and leaves.

Teacher: Correct. What role do they play?

Student: Producers.

Teacher: Good, then what organisms feed on these producers? What trophic level are they at, and what role do they play?

Student: Aquatic insects; they are at the second trophic level as primary consumers.

Teacher: Very good, which organisms are at the second or higher trophic levels? And which is at the highest trophic level?

Student: Organisms above the second trophic level include Taiwan Shoveljaw Carp, Cherry Salmon, Goby, and Striated Heron. The Striated Heron is at the highest trophic level.

Teacher: Now, looking at option (A), “If an energy pyramid is drawn based on this food web structure, the Striated Heron tier would be the lowest.” Do you remember what an energy pyramid is?

Student: The energy values transmitted across different trophic levels, displayed in a pyramid shape that diminishes upwards.

Teacher: Excellent! More energy is lost at the top of the pyramid. So, which organism would have the lowest energy proportion?

Student: The organism at the highest trophic level, which is the Striated Heron.

Teacher: Next, looking at option (B), Cherry Salmon and Goby both prey on aquatic insects. What kind of relationship might these two have in terms of diet?

Student: A competitive relationship.

Teacher: Right, option (C) states “Since Goby prey on aquatic insects, this can reduce the grazing rate on algae. Therefore, Goby and algae have a commensal symbiotic relationship.” Is this statement correct?

Student: No, commensalism involves two organisms living together, which is not the relationship between Goby and algae.

Teacher: Correct! Then, what is a keystone species, as mentioned in option (D)?

Student: In a food chain or ecosystem, removing this keystone species would affect the survival and diversity of other species in the community, causing imbalance in the ecosystem. Thus, keystone species play a crucial role in stabilizing ecosystems and maintaining community structure.

Teacher: Well explained. Keystone species also have the characteristic of “having a significant impact on the community biology in the ecosystem they inhabit, but their relative biomass is very small.” They determine the variety and number of species in the community. So, is the Striated Heron considered a key species in this community, as mentioned in option (D)?

Student: Yes!

Teacher: Well done, finally, option (E) states “The population dynamics of Taiwan Shoveljaw Carp are mainly determined by annual fluctuations of aquatic insects." Is this statement correct?

Student: It’s not quite correct, as we can’t determine if Taiwan Shoveljaw Carp have aquatic insects or algae as their main diet.

老師： 同學們，本題我們將探討此食物網中，各種生物的營養階層。首先請同學回答，誰位於營養階層的第一階？

學生： 藻類和枯枝落葉。

老師： 沒錯，他們所扮演的角色是什麼呢？

學生： 生產者。

老師： 很好，那麼攝食生產者的是什麼生物？他們位於營養階層的第幾階？所扮演的角色又是什麼呢？

學生： 水棲昆蟲，他們是位於營養階層第二階的初級消費者。

老師： 非常好，有哪些生物位於營養階層的二級以上？而位於最高營養階層的生物又是誰？

學生： 位於營養階層的二級以上的生物有鯽魚、櫻花鉤吻鮭、明潭吻蝦虎魚和綠簑鷺。位於最高營養階層的生物是綠簑鷺。

老師： 接下來我們看到選項(A)「若據此食物網結構繪製能量塔，綠簑鷺階層所占比例最低」，請問同學記得能量塔是什麼嗎？

學生： 不同營養階層所傳遞的能量值，呈現向上遞減的金字塔型。

老師： 非常好！能量塔越頂端，能量喪失越多，能量也會越少，因此哪一生物所占有的能量比例會最低？

學生： 位於營養階層最高的生物，也就是綠簑鷺。

老師： 再來看到選項(B)櫻花鉤吻鮭與明潭吻蝦虎魚皆捕食水棲昆蟲，請問這兩者在食性上可能為什麼樣的關係？

學生： 競爭關係。

老師： 沒錯，選項(C)「明潭吻蝦虎魚捕食水棲昆蟲可降低藻類被啃食率，因此明潭吻蝦虎魚與藻類為片利共生之關係」，這個敘述正確嗎？

學生： 錯誤，片利共生要兩種生物共同生活在一起，明潭吻蝦虎魚跟藻類不是共同生活的關係。

老師： 沒錯！接著選項(D)請問同學什麼是關鍵物種？

學生： 在食物鏈或生態系中，若將此關鍵物種移除會影響群集中其他物種的存活與多樣性，造成系統的失衡，因此關鍵物種扮演著穩定生態系、保持群集結構、舉足輕重的角色。

老師： 同學解釋得很好，關鍵物種也具有「對所存在的生態系中相關群集生物的高度影響性，但該物種相對的生物量(Biomass)比例卻很小」的特性，會決定群集中各物種的種類與數量。

因此請同學們判斷選項(D)中的綠簑鷺是否為該群集中重要的關鍵物種？

學生： 是的！

老師： 很好，最後看到選項(E)鯽魚的族群動態主要取決於水棲昆蟲的年間波動，此敘述是否正確？

學生： 不太正確，因為不能判斷鯽魚主食是水棲昆蟲還是藻類。

★ 主題三 生物多樣性 ★
Biodiversity

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國立彰化師範大學英語學系 楊靚熙

■ 前言 Introduction

「生物多樣性」一詞是由美國科學家羅森(Walter G. Rosen)在 1980 年提出，其目的在於了解形成生物多樣性的背景及其所面臨的問題，透過問題改善，進而達到保育地球上有限的資源，以達到永續的概念。生態多樣性涵蓋了遺傳多樣性、物種多樣性及生態系多樣性，三個層面相互影響造就了現在美麗的地球，經過該章節詳細的說明及分析，才可以讓學生了解其中探討的因子，進而意識到多樣性的重要性，培養環保的意識，在日常生活中主動去關心及討論環境保育的議題，最後將環保的概念付諸行動，讓地球達到永續的發展。

3-1 生物多樣性的三個層面
The Three Aspects of Biodiversity

■ 前言 Introduction

本章探討了生物多樣性的三個層面，包括遺傳多樣性、物種多樣性及生態系多樣性，由小至大一一介紹，從個體、群體內到不同的群體間多樣性的定義、舉例以及影響因子。遺傳多樣性又稱基因多樣性，主要在探討個體中的基因重組，造成不同的等位基因、進而表現出不同的性狀，讓個體間存在差異，以面對不同的環境變化。在物種多樣性中將「物種豐富度」及「物種均勻度」作為指標，影響物種多樣性的因素有面積大小、環境複雜度、擾動、地理隔離、棲地零碎化及外來入侵種等因素。最後，生態多樣性主要在著重於生物個體及環境因子之間的交互作用，為不同環境因子複雜度的結合。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
extinction	滅絕	disturbance	擾動
individual	個體	genetic drift	遺傳漂變
inbreeding	近親交配	polymorphism	遺傳多型性
habitat heterogeneity	棲地異質性	genetic diversity	遺傳多樣性
community	群集	species	物種
intermediate disturbance hypothesis (IDH)	中度擾動假說	species richness	物種豐富度
speciation	種化	species diversity	物種多樣性

ecosystem diversity	生態系多樣性	species evenness	物種均勻度
biodiversity	生物多樣性		

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

❶ ____ is an example of _____.

例句(1)：The various breeds of dogs **is an example of** genetic diversity.

狗有不同品種是遺傳多樣性的例子。

例句(2)：A stable food chain **is an example of** species diversity.

穩定的食物鏈是物種多樣性的例子。

❷ There are____, including _____, _____, and _____.

例句(1)：**There are** three aspects of biodiversity, **including** genetic diversity, species diversity, **and** ecosystem diversity.

生物多樣性包含基因多樣性、物種多樣性，以及生態系多樣性三個面向。

例句(2)：**There are** four factors affecting species diversity in an area, **including** area size, environmental complexity, disturbance, **and** geographical isolation.

影響一個地區物種多樣性有四個因素，包含面積大小、環境複雜度、擾動及地理隔離。

❸ ____, also known as (aka) _____, is _____.

例句(1)：Genetic diversity, **also known as (aka)** "gene diversity", **is** the genetic variability among individuals in a population.

遺傳多樣性又稱為「基因多樣性」，指族群中不同個體所具有的遺傳變異性。

例句(2)：Species diversity, **also known as (aka)** "taxonomic diversity", **is** mainly talking about the diversity of different biological groups.

物種多樣性又稱為「分類多樣性」，主要探討不同生物類群階層的多樣性。

❹ ____ is influenced by_____ and _____.

例句(1)：Genetic diversity **is influenced by** the age structure **and** sex ratio of the population.
遺傳多樣性受到族群的年齡結構與性別比例影響。

例句(2)：The distribution of terrestrial ecosystems **is influenced by** climate, distance to the sea, altitude, **and** other factors.
陸域生態系的分布受到氣候、距海遠近、海拔高度和其他因素影響。

❺ _____ may result in _____.
_____ can lead to _____.

例句(1)：Artificial breeding **may result in** loss of genetic diversity.
人工育種可能造成遺傳多樣性流失。

例句(2)：Anthropogenic environmental impacts **can lead to** habitat fragmentation.
人為環境衝擊會導致棲地零碎化。

■ 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、能夠區分三種生物多樣性(遺傳多樣性、物種多樣性、生態系多樣性)。
Be able to differentiate three kinds of biodiversity (genetic diversity, species diversity, ecosystem diversity).

二、能夠了解生物多樣性不同層面相互影響的結果。
Be able to understand the results of interactions between different aspects of biodiversity.

例題講解

例題一

說明：學生能夠辨認不同生活實例中的生物多樣性為何種層面。
Students can identify the aspects of biodiversity in different life examples.

"Biodiversity" includes 'genetic diversity', 'species diversity', and 'ecosystem diversity'. Below are the matchings of descriptions and aspects of biodiversity, which are correct? (choose two options)

Options	Descriptions of biodiversity	Aspects
(A)	There are monkeys in forests; tropical fish in coral reef areas.	genetic diversity
(B)	The residents of New York City are white, black and beige.	species diversity
(C)	There are Trilobate Wedelia with yellow blossoms and roses with red blossoms on campus.	ecosystem diversity
(D)	**Some of the classmates are single-eyelid, the others are double-eyelid.**	**genetic diversity**
(E)	**There are black mangroves, kandelias, mudskippers, and fiddler crabs in mangrove areas.**	**species diversity**

「生物多樣性」包括有「遺傳多樣性」、「物種多樣性」和「生態系多樣性」三個層次，下列與生物多樣性相關的描述及其層次之配對，哪幾項正確？（應選二項）

選項	生物多樣性相關的描述	層次
(A)	樹林中有猴子；珊瑚礁區有熱帶魚。	遺傳多樣性
(B)	紐約市的居民有白人、黑人和黃種人。	物種多樣性
(C)	校園中有會開黃花的蟛蜞菊，和會開紅花的玫瑰。	生態系多樣性
(D)	**班上同學中，有人是單眼皮，有人是雙眼皮。**	**遺傳多樣性**
(E)	**紅樹林地區有海茄苳、水筆仔、彈塗魚和招潮蟹。**	**物種多樣性**

（98 年生物指考 48）

Teacher: Class, what are the three aspects of biodiversity?

Student: Genetic diversity, species diversity, and ecosystem diversity.

Teacher: That's right. Then according to option (A), what aspect of biodiversity does this option describe?

Student: Different species exist in different areas, which represent that different species will live in different environments, and it is called ecosystem diversity, so genetic diversity in the option is wrong.

Teacher: Very good! And how about option (B)?

Student: The description focuses on the same region. It emphasizes the differences of the same species— humans. For example, if describing white and black, it should be genetic diversity, so species diversity in the option is wrong.

Teacher: Correct! What about option (C)?

Student: Different environment is not mentioned in the option. The description is about there should be different colors among different flowers instead, so ecosystem diversity in the option is wrong.

Teacher: Exactly! How about option (D)?

Student: The same species— humans will have different phenotypes because of genetic diversity. For example, single-eyelid and double-eyelid, so it is genetic diversity, the option is correct.

Teacher: Right! How about option (E)?

Student: There are different species (black mangroves, kandelias, mudskippers, and fiddler crabs) appear in the same environment (mangrove areas), so it refers to species diversity, the option is correct.

老師： 請問同學生物多樣性包括哪三個層面？

學生： 遺傳多樣性、物種多樣性以及生態系多樣性。

老師： 沒錯！那麼針對選項(A)，各位同學覺得這個選項是在說明什麼層面的生物多樣性？

學生： 在不同的區域中存在不同的物種，表示不同的物種會生存在不同的環境中，此為生態系多樣性，故選項中的遺傳多樣性是錯誤的。

老師： 很好！那麼選項(B)呢？

學生： 敘述鎖定在同一個地區，針對同一個物種—人類之間的不同差異，如白人黑人進行描述，應為遺傳多樣性，故選項中的物種多樣性是錯誤的。

老師：　是的！那麼選項(C)呢？

學生：　選項中並未提及不同的環境，而是敘述不同品種的花之間有不同的花色，應為物種多樣性，故選項中的生態系多樣性是錯誤的。

老師：　沒錯！那麼選項(D)呢？

學生：　同一物種—人類因為基因多樣性，所以會有不同的表現型，如單眼皮、雙眼皮，故為遺傳多樣性，此為正確的選項。

老師：　正確！請問選項(E)呢？

學生：　在同一生態環境中（紅樹林地區），出現了不同的物種（海茄苳、水筆仔、彈塗魚、招潮蟹），故為物種多樣性，此為正確的選項。

例題二

說明：學生能夠了解物種多樣性中的豐富度與均勻度意義。

Students can understand the meaning of richness and evenness in species diversity.

A student used uses the same way to investigate the amount of insects at two places in Ali Mountain. The data he collected are shown in Table 1. Which of the explanations below is correct?

Table 1

	Place A	Place B
Specie A	6	18
Specie B	8	2
Specie C	7	1
Specie D	4	3
Specie E	5	2

(A) The species richness of insects at place A is higher than at place B.

(B) The species evenness of insects at place A is higher than at place B.

(C) The species diversity of insects at place B is higher than at place A.

(D) The species diversity of insects at place A and B cannot be directly compared.

某生在阿里山甲、乙兩個地點，以相同的方法調查昆蟲數量，得到數據如表 1，以下解釋何者正確？

表1

	甲地	乙地
物種A	6	18
物種B	8	2
物種C	7	1
物種D	4	3
物種E	5	2

(A) 甲地昆蟲的物種豐富度較乙地高。

(B) 甲地昆蟲的物種均勻度較乙地高。

(C) 乙地昆蟲的物種多樣性較甲地高。

(D) 甲、乙兩地昆蟲的物種多樣性無法直接比較。

（110 年生物指考 17）

Teacher: What is the so-called species richness? And what is species evenness?

Student: Species richness is the amount of species taxa, and species evenness is the index of the relative amount of different species.

Teacher: That's right! Under what circumstances will species diversity be relatively high?

Student: The greater number of different species and the number of individuals of every species are closer represents a relatively high species diversity.

Teacher: Yes, then in the question, which species richness is higher? At place A or place B?

Student: Both of the species numbers are five (A to E), so their species richness are the same.

Teacher: Correct, then which species evenness is higher? At place A or place B?

Student: The individual numbers of species at place A is more even, so place A has a higher species evenness.

Teacher: That's right. In summary, which place has a higher species diversity? Place A or place B?

Student: Species diversity should consider both species richness and species evenness simultaneously. In case of the same species richness at place A and B, place A with a higher species evenness has higher species diversity, so we should choose option (B) instead of option (D).

老師： 請問何謂物種豐富度？何謂物種均勻度？

學生： 物種豐富度為物種的分類群數目，物種均勻度為不同物種之相對數量的指數。

老師： 沒錯！什麼情況下的物種多樣性會比較高呢？

學生： 不同物種的物種數越多，且每一個物種內的個體數越接近，代表物種多樣性愈高。

老師： 是的，那麼請問題目中的甲地與乙地何者的物種豐富度較高呢？

學生： 兩者的物種數都是 5 種（A-E），物種豐富度相同。

老師： 正確，那麼請問題目中的甲地與乙地何者的物種均勻度較高呢？

學生： 甲地的物種間的個體數量較平均，故甲地有較高的物種均勻度。

老師： 沒錯，綜上所述，甲乙兩地何者有較高的物種多樣性呢？

學生： 物種多樣性同時考量物種豐富度及物種均勻度，在甲乙兩地有相同物種豐富度的情況下，有較高物種均勻度的甲地有較高的物種多樣性，故選擇選項(B)而排除選項(D)。

3-2 台灣的生物多樣性
The Biodiversity in Taiwan

■ 前言 Introduction

介紹完生物多樣性的三層面後，將所學用至我們的家鄉——臺灣，臺灣的面積雖然不大，但是由於地理位置、造山運動、氣候、海流及在冰河時期曾為生物的避難所等因素相互作用之下，造就了臺灣高生物多樣性的環境。在第二小節中，介紹了臺灣主要的生態系，依照生態系受人為干擾影響的程度不同，可大致分為自然生態系及人為生態系，自然生態系再進一部細分為陸域生態系、水域生態系、溼地生態系，每一個生態系獨有的環境孕育出多樣的生物生存於此，不同生物間、不同生態系間的交互作用，堆疊出了美麗的寶島臺灣。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
ice age	冰河時期	neritic province	近海區（淺海區）
freshwater marsh	淡水沼澤	lentic habitat	靜水水域
freshwater ecosystem	淡水生態系	salt/ brackish marsh	鹹水沼澤
endemic species	特有種	conifer-broadleaf forest	針闊葉混合林
farmland ecosystem	農田生態系	intertidal zone	潮間帶（近岸區）
lotic habitat	流動水域	wetland ecosystem	溼地生態系
land bridge	陸橋	dune (ecosystem)	沙丘(生態系)

terrestrial ecosystem	陸域生態系	artificial forest/ plantation	人工林
alpine vegetation	高山植群帶	artificial ecosystem	人工生態系
broad-leaved forests	闊葉林	orogeny	造山運動
ocean current	海流	subalpine coniferous forest	亞高山針葉林
aquatic ecosystem	海洋生態系	oceanic province	遠洋區（大洋區）

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

❶ ____ plays an important role in _____.

例句(1)：Ocean current **plays an important role in** the distribution of coastal plants.
海流在沿海植物的分布中扮演了重要角色。

例句(2)：Paddy fields **play an important role in** the water supply of the wetland ecosystem.
水田對溼地生態系中的棲地水分供給發揮了重要作用。

❷ ____ can be categorized into _____, _____, and _____.

例句(1)：The coastal sediment **can be categorized into** sandy coast, mud coast, rocky coast, and reef coast.
海岸底質可分為沙岸、泥岸、岩岸、礁岸。

例句(2)：The ocean **can be categorized into** seawater realm and undersea realm.
海洋可分為海水領域和海底領域。

❸ _____ is/are distributed in _____.

例句(1)：The alpine vegetation zone **is distributed in** alpine areas above 3,600 meters.
高山植群帶分布於 3600 公尺以上的高山地區。

例句(2)：Salt marshes **are distributed in** offshore and coastal wetlands.
鹹水沼澤分布於近海與海岸溼地。

❹ Organisms living in ____ usually have the characteristics of _____.

例句(1)：**Organisms living in** dune **usually have the characteristics of** wind, drought, and salt resistance.

生活在沙丘的生物通常具有耐風、耐旱、耐鹽的特性。

例句(2)：**Organisms** living in intertidal zones **usually have the characteristics of** adapting rapid changes in moisture and salinity.

生活在潮間帶的生物通常具有適應水分和鹽分急遽變化的特性。

❺ Although _____, they provide _____.

例句(1)：**Although** artificial ecosystems are constructed with the purpose of satisfying human needs**, they** also **provide** important ecological values.

人工生態系雖然是為了滿足人類需求而建造，但這些人工生態系也提供了重要的生態價值。

例句(2)：**Although** the natural lakes in Taiwan are small in area**, they provide** important water sources and habitats for organisms.

台灣的天然湖泊面積雖小，但提供了生物重要的水源與棲地。

■ 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、能夠說出使台灣擁有高度生物多樣性的原因。

Being able to name the reasons why Taiwan has high biodiversity.

二、能介紹台灣的生態系組成、分布及特性。

Being able to introduce the composition, distribution, and the features of the ecosystems in Taiwan.

例題講解

例題一

說明：學生能了解臺灣的生態系類型及特性。

Students will be able to understand the types and features of ecosystems in Taiwan.

Students are interested in the ecosystems in Taiwan, so they visit the Mountains to Sea Greenway together. The place is a national hiking trail starting from estuary to mountain, which permeates the history, geography, and ecology of Taiwan.

They setted out from the outfall of Yanshui River, traveled Jianan Irrigation Canal, and visited Wushantou Reservoir. After that, they moved on to higher altitude areas to visit the Ali Mountain area, then spent three days getting to the main peak of Jade Mountain. They have seen the diverse climate zones and ecosystems in Taiwan. According to the descriptions above, which assumptions are correct?

(A) The estuaries of Taiwan only have the desert-like dune ecosystem, the scope of animals and plants is quite simple.

(B) Low altitude areas are hot and rainy, and the primary forests are dominated by bamboo and acacia forests.

(C) Both coniferous and broad-leaved trees can be seen in mid-altitude mountainous areas, which is a characteristic of the intersection of ecosystems.

(D) High-altitude pure fir forest habitats are simple and have low average annual temperatures, which cannot support the survival of predators.

(E) Yushan juniper forms low shrubs as an adaptation to strong winds and barren bare rocks.

學生對臺灣生態環境十分感興趣，因而相偕探訪「山海圳國家綠道」，這是一條從河口至高山串聯臺灣歷史、地理與生態的國家級步道。他們從鹽水溪口出發、遊歷嘉南大圳、參觀烏山頭水庫；往更高海拔移動，他們探訪阿里山區、再花三天的時間登頂玉山主峰。他們見識了臺灣多樣的氣候帶與生態系，以下 推論哪些正確？

(A) 臺灣河口僅有類似沙漠環境的沙丘生態系，動、植物相十分單純。

(B) 低海拔高溫多雨，原始林以竹林、相思林為主。

(C) 中海拔山區可以同時看到針葉樹與闊葉樹，是生態系交會的特徵。

(D) 高海拔冷杉純林棲地單純且年均溫低，無法支持掠食者生存。

(E) 玉山圓柏形成低矮灌叢是對強風與貧瘠裸岩的適應。

（110 年生物指考 48）

Teacher: Let's take a look at option (A) first, what are the ecosystems included in the estuarine ecosystems of Taiwan?

Student: The estuarine ecosystems of Taiwan include the dune ecosystem, mangrove ecosystem, and river mouth forest ecosystem, so option (A) is the wrong one.

Teacher: That's right, and how about option (B)? Is this correct?

Student: Bamboo forests and acacia forests are both artificial forests. Bamboo forests are agricultural artificial forests, and their rapid growth can help carbon fixation. Acacia trees were planted in large quantities during the Japanese colonial period to provide fuel wood. Neither the bamboo forest nor the acacia forest is virgin forest, so option (B) is incorrect.

Teacher: Yes, and how about option (C)? Is this correct?

Student: Coniferous forests grow in places with cold climates, such as frigid zones and high sea areas. Broadleaf forests grow in warmer places, such as low altitude areas. From previous descriptions, we can know that mixed forests are distributed in mid-altitude areas about 1500 to 2500 meters, so option (C) is correct.

Teacher: Correct! And how about option (D)? Is this correct?

Student: Taiwan's firs grow in subalpine coniferous forests, in mountainous areas with an altitude of 2,500 to 3,600 meters. The average annual temperature is about 5 to 11 degrees Celsius. There are still predators in this area, such as formosan salamanders, Hsuehshan grass lizards, and formosan black bears, etc., so option (D) is incorrect.

Teacher: Yeah, and how about option (E)? Is this correct?

Student: Taiwan's alpine zone is located in mountains above 3,600 meters. The ground surface is composed of gravel. Moreover, the harsh living conditions such as the shallow soil, intense sunlight, strong winds, poor water retention forced single -seed juniper to be in the shape of tangled and twisted low plate for survival, so option (E) is correct.

老師： 首先，看到選項(A)，請問台灣的河口生態系中包括了什麼樣的生態系？

學生： 台灣的河口生態系包括沙丘生態系、紅樹林生態系及溪口林生態系，故選項(A)為錯誤的選項。

老師： 沒錯，那麼選項(B)是否正確？

學生： 竹林及相思林皆為人造林，竹林為農業人造林，其快速生長可幫助固碳；相思樹在日治時期被大量栽種以提供薪炭材所需。竹林及相思林皆非原始林，故選項(B)錯誤。

老師： 是的，那麼選項(C)是否正確？

學生： 針葉林生長於氣候寒冷的地方，如寒帶、高海地區；闊葉林則是生長在較溫暖的地方，如低海拔區，故混合林分布於中海拔，約 1500～2500 公尺區域，可得選項(C)正確。

老師： 正確，那麼選項(D)是否正確？

學生： 台灣的冷杉生長於亞高山針葉林，海拔介於 2500~3600 公尺山區，年均溫約為 5～11°C之間，此區仍有掠食者存在，如臺灣山椒魚、雪山草蜥及臺灣黑熊等，故選項(D)錯誤。

老師： 是的，那麼選項(E)是否正確？

學生： 台灣的高山群帶區域位於 3600 公尺以上的高山，地表由碎石組成，土壤淺薄，日照強烈、強風吹襲、保水力差等等，生存條件嚴苛的情況，玉山圓柏樹身為尋找生存方向，形成糾結扭曲的矮盤狀造型，可得選項(E)正確。

例題二

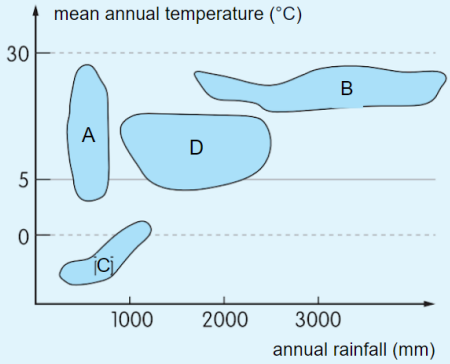
說明：學生能判讀圖表的訊息推測未知生態系，並依台灣的環境判斷敘述。

Students will be able to identify the information in the chart to infer the unknown ecosystem with the description based on the environment in Taiwan.

Picture 3 is the distribution graph of precipitation and temperature in A, B, C, D ecosystems.

Try to answer the following question:

What kinds of biological landscape can be observed in these four ecosystems in Taiwan?



Picture 3

(A) You can see little egret stops by the river in ecosystem A.

(B) You can see cloud-capped red cypress and hinoki in ecosystem B.

(C) Barringtonia trees living around lakes in ecosystem C.

(D) Formosan salamanders occur in the moist area at the bottom of trees in ecosystem D.

(E) There is a chance to see Taiwan rosefinches in ecosystem C.

圖 3 為甲、乙、丙、丁 4 種生態系的雨量及溫度的分布圖。試回答下列問題：

在臺灣，可從這些生態系觀察到哪些生物景觀？

(A) 在甲生態系見到小白鷺駐足在河邊 。

(B) 在乙生態系中可見高聳入雲的紅檜和扁柏。

(C) 棋盤腳樹生長在丙生態系的湖邊。

(D) 臺灣山椒魚出現在丁生態系的樹木底層潮溼帶。

(E) 在丙生態系中有機會見到酒紅朱雀。

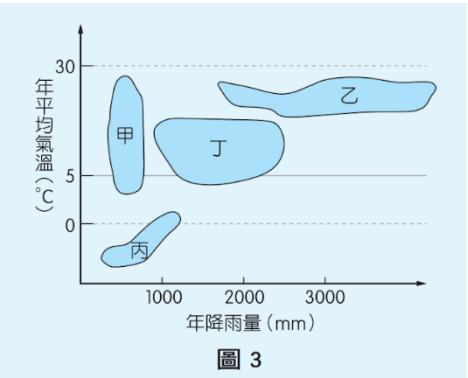


圖 3

（109 年生物指考 31）

Teacher: First, we have to identify ecosystems A, B, C, D refer to which kind of ecosystem based on the annual average temperature and annual precipitation provided in the graph.

Student: The annual precipitation is lower than 1000 mm, and the annual average temperature is around 3-30°C, which refers to temperate rainless areas, so we assume that ecosystem A is grassland.

The annual precipitation in ecosystem B is higher than 2000 mm, and the annual average temperature is around 25-30°C, which refers to high temperature and rainy areas, so we infer that ecosystem B is a tropical rainforest.

The annual precipitation of ecosystem C is around 500-1200 mm, and the annual average temperature is around -5 to 5°C, which we infer that ecosystem C is tundra.

The annual precipitation of ecosystem D is around 1000-2500 mm, and the annual average temperature is around 5 to 20°C, which we infer that ecosystem D is forest.

Teacher: Right. Then is option (A) correct?

Student: Little egrets usually live around lake shores, river banks, beaches and coastal streams rather than grassland ecosystems, so option (A) is wrong.

Teacher: Yes, then how about option (B)? Is this correct?

Student: Red cypress and hinoki live in mid-altitude mountainous areas. They will not occur in low-altitude rainforests, so option (B) is wrong.

Teacher: That's right. How about option (C)? Is this correct?

Student: Barringtonia is a plant that drifts to tropical and subtropical coasts, so it cannot be found in tundra ecosystems.

Teacher: Correct. And how about option (D)? Is this correct?

Student: The distribution of forests in Taiwan is in mid-altitude areas, which corresponds to the habitat of Formosan salamanders, so option (D) is correct.

Teacher: You're right. How about option (E)? Is this correct?

Student: Taiwan rosefinch is the bird living in intermediate altitude mountainous areas. It can be seen in ecosystem C, so option (E) is correct.

老師： 首先，我們需要依這張表格提供給我們的年均氣溫與年降雨量去判斷甲、乙、丙、丁四個地區分別為何種生態系。

學生： 甲地的年降雨量低於 1000mm，年均溫約介於 3-30°C，為溫帶少雨地區，故推測甲生態系為草原；乙地的年降雨量大於 2000mm，年均溫約介於 25-30°C，為高溫多雨地區，故推測乙生態系為熱帶雨林；丙地的年降雨量介於 500-1200mm，年均溫約介於-5-5°C，故推測丙生態系為寒原；丁地的年降雨量介於 1000-2500mm，年均溫約介於 5-20°C，故推測丁生態系為森林。

老師： 正確，那麼選項(A)是否正確？

學生： 小白鷺多活動於湖沼岸邊、河岸、沙灘及沿海小溪流，而非草原生態系，故選項(A)錯誤。

老師： 是的，那麼選項(B)是否正確？

學生： 紅檜與扁柏生長於為中海拔山區，並不會出現在低海拔的熱帶雨林，故選項(B)錯誤。

老師： 沒錯，那麼選項(C)是否正確？

學生： 棋盤腳是會漂流到熱帶、亞熱帶海岸邊生長的植物，因此無法在寒原生態系中被發現。

老師： 正確，那麼選項(D)是否正確？

學生： 台灣的森林分布於中海拔區域，與山椒魚的棲地相符，故選項(D)正確。

老師： 沒錯，那麼選項(E)是否正確？

學生： 酒紅朱雀為生長於中高海拔山區的鳥類，可在棲地丙見到其身影，故選項(E)正確。

3-3 生物多樣性的保育
The Conservation of Biodiversity

■ 前言 Introduction

「生物多樣性」的保育包含了遺傳、物種和生態系三個不同的層次，包括個體、族群、群集、生態系、地景以及地球圈等各種生命形式的層級。因此，生物多樣性的保育需要嚴謹地考慮各個層面。本章以櫻花鉤吻鮭為例，說明如何將先前課本內容提及的知識點學以致用，基於生態學理論建立櫻花鉤吻鮭在個體、族群、群集和生態系等不同層次的保育研究基礎資料，以此作為制定保育策略的基礎。

櫻花鉤吻鮭是臺灣冰河時期的陸封型鮭魚，對於位於亞熱帶的臺灣來說，具有極高的生物地理重要性。在 1960 年代前，櫻花鉤吻鮭廣泛分布於大甲溪上游的七家灣溪、高山溪、羅葉尾溪、有勝溪、合歡溪、南湖溪、司界蘭溪等溪流。然而，在 1960 年代後，由於水庫工程建設和溫帶農業的開發，大甲溪上游沿岸植被遭到嚴重破壞。依 1988 年的調查顯示，櫻花鉤吻鮭僅分布於七家灣溪和高山溪，且數量急劇減少，處於存續危機中。對於數量逐漸減少的櫻花鉤吻鮭，本章將會探討要如何透過在個體至生態系等不同層次的有效行動，以實現復育目標。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
restoration	復育	ex situ conservation	移地保育
in situ conservation	就地保育	genetic variation	遺傳變異
inbreeding	近親繁殖	artificial propagation	人工繁殖

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

❶ In addition to _____, _____ also _____.

例句(1)：**In addition to** increasing the number of individuals for species restoration**,** it is **also** important to track population changes in the wild.

物種復育除了需要增加個體數目，後續對野外族群數量變化的追蹤也很重要。

例句(2)：**In addition to** increasing the number of individuals for species restoration**,** conservationists **also** attach great importance to variation within racial groups.

物種復育除了需要增加個體數目，保育學家也相當重視種族群內的變異。

❷ The more adj./adj. + -er _____, the more _____ adj./adj.+ -er_____.

例句(1)：**The greater** the genetic variation of a population, **the higher** the genetic diversity of the population.

族群遺傳變異愈大，表示族群的遺傳多樣性愈高。

例句(2)：**The greater** the ability of a species to adapt to environmental changes, **the greater** its chances of survival.

物種適應環境改變的能力愈強，表示其生存機會愈大。

❸ _____ found that _____.

例句(1)：Investigation conducted in 1988 **found that** Taiwan Landlocked Masu Salmons only live in Qijiawan Creek and Gaoshen Creek.

1988 年的調查發現，櫻花鉤吻鮭僅分布於七家灣溪與高山溪。

例句(2)：Biotechnological research **found that** the genetic variation of Taiwan Landlocked Masu Salmons is very small.

生物技術研究發現，櫻花鉤吻鮭的遺傳變異非常小。

❹ _____ is/are affected by _____.

例句(1)：The population changes of Taiwan Landlocked Masu Salmons **are affected by** the severity of plum rains and typhoons.
櫻花鉤吻鮭的族群數量變化受到梅雨和颱風的劇烈程度影響。

例句(2)：The genetic variation of Taiwan Landlocked Masu Salmons **is affected by** inbreeding
櫻花鉤吻鮭的遺傳變異受到近親繁殖影響。

❺ If _____ mainly exist among _____, _____.

例句(1)：**If** the genetic variation of a rare species **mainly exists among** individuals within a population, species conservation can only be carried out for this populations.
若某稀缺物種的遺傳變異主要存在於族群內的個體間，僅針對此族群進行物種保育即可。

例句(2)：**If** the genetic variation of a rare species **mainly exists among** different populations, conservation needs to be carried out for all of them.
若某稀缺物種的遺傳變異主要存在於不同族群間，則需要針對所有的族群進行保育。

■ 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、能分析不同層級(個體、物種、生態系)需要的不同復育策略與目標。
Be able to analyze different restoration strategies and goals required by different hierarchies (individuals, species, ecosystems).

二、能與同儕討論並規劃啟動復育計畫。
Be able to discuss with peers as well as arrange and begin the restoration project.

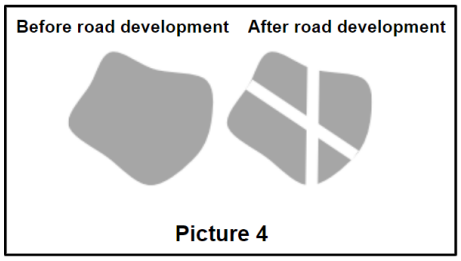
三、能蒐集並整理啟動復育計畫所需要的資料。
Be able to collect and compile the data required for beginning the restoration project.

例題講解

例題一

說明：學生能了解在生態系保育層面中，開發棲地造成棲地破碎化的後果與邊緣效應。
Students will be able to understand the results and edge effects of habitat fragmentation due to habitat development in the aspect of ecosystem preservation.

Picture 4 shows the changes of a certain animal's habitat before and after road development. After the development, the habitat became several small units.
Which of the following statements is correct?



Picture 4

(A) Because the habitat is divided into several small units, the genetic diversity of the species will increase.
(B) As the unit habitat area becomes smaller, the edge effect will increase accordingly.
(C) The existence of roads can increase the opportunities for genetic exchange of organisms in different units of habitat.
(D) The continued development of roads will not affect the biological species within each small unit of habitat.

圖 4 為某動物棲地在道路開發前後的變化，開發後棲地成為數個小單位。
下列敘述何者正確？

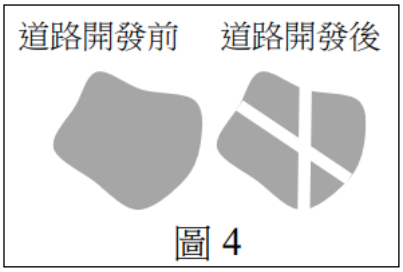


圖 4

(A) 因棲地被劃分為數個小單位，該物種之基因多樣性會增高。
(B) 因單位棲地面積變小，因此邊緣效應（邊際效應）會隨之提升。
(C) 道路的存在可提升不同單位棲地生物的基因交流機會。
(D) 道路的持續開發不會影響每個小單位棲地內部的生物種類。

（106 年生物指考 19）

Teacher: What is the phenomenon due to man-made development causing the division of habitat?

Student: It is habitat fragmentation.

Teacher: Correct. What are the consequences of habitat fragmentation?

Student: Artificially built roads block genetic exchanges between species, which lower the opportunities for genetic exchanges, and ultimately reduce their genetic diversity. At the same time, the original human interference around the habitat will enter there with the development of roads, directly affecting species in their habitat, so options (A), (C), and (D) are incorrect.

Teacher: That's right. Then what is the so-called edge effect?

Student: Edge effect refers to the changes of biological population in the intersection or edge of different habitats. It will be more obvious especially in fragmented habitat areas and may affect the whole area. Therefore, option (B) indicates that as man-made development divides the habitat, the edge effect will be increased, so it is correct.

老師： 因為人為的開發將物種的棲地分割，這一現象為何？

學生： 為棲地破碎化。

老師： 是的，棲地破碎化會造成什麼現象？

學生： 人為建築的道路阻隔了該物種間的基因交流，降低了基因交流的機會，最終會降低其基因多樣性，同時，原先在棲地周圍的人為干擾會隨著道路的開發進入棲地內，直接影響棲地中的物種，故選項(A)、(C)、(D)為錯誤的選項。

老師： 沒錯，那麼何謂邊緣效應？

學生： 邊緣效應是指生態系統中，生物種群在不同棲息地交界或邊緣的變化，特別是在破碎的棲息地區域，邊緣效應更為明顯，有可能影響整個區塊，故選項(B)隨著人為開發將棲地分割，會增強邊緣效應，為正確的選項。

例題二

說明：學生能夠分析生態系中考量的不同因素。

Students will be able to analyze the different factors considered in the ecosystem.

Which of the following descriptions related to the ecosystem are correct?

(A) Ecosystem diversity has the same meaning as environmental diversity.

(B) The community constitution changes with physical and chemical factors.

(C) Without the changes of other conditions, if environmental heterogeneity increases, ecosystem diversity will increase.

(D) Ecosystem diversity refers to the amount of species and the length of food chains.

(E) The species diversity in habitat A is higher than habitat B, so the species richness in habitat B must be low.

下列與生態系相關的敘述，哪些正確？

(A) 生態系多樣性與環境多樣性同義。

(B) 其群集組成會隨理化因子而變化。

(C) 其他條件不變，環境異質性增高，則生態系多樣性增高。

(D) 生態系多樣性指的就是物種數多寡及食物鏈的長短。

(E) 甲棲地物種多樣性高於乙，則乙棲地的物種豐富度必低。

（104 年生物指考 29）

Teacher: What are ecosystem diversity and environmental diversity? Are these two terms synonyms or not?

Student: The term ecosystem diversity simultaneously discusses the organisms and environment in the habitat. It refers to the different ecosystems presented by different habitats in a region. Therefore, it is not the same as referring to the environmental diversity of different living environments alone. Therefore, option (A) and (D) are incorrect.

Teacher: What is the relationship between community and physical and chemical factors?

Student: Ecological balance factors include physical and chemical factors and biological factors in the ecosystem. Physical and chemical factors include physical factors such as water, atmosphere, temperature, etc., and chemical factors such as nutrients, pH value, dissolved oxygen, etc. Variations in the community will cause changes in the physical and chemical factors in the ecosystem, and changes in the physical and chemical factors will further affect changes in the community, so option (B) is the correct option.

Teacher: When all conditions in the ecosystem are the same, what is the relationship between environmental heterogeneity and ecological diversity?

Student: Environmental heterogeneity is the differences existing in different areas of certain regions. The differences can include topography, soil structure, vegetation type, climate conditions and other factors. In areas with higher environmental complexity, the more habitats are provided so that more species can survive in this area, thus increasing species diversity and the diversity of ecosystems, so option (C) is the correct option.

Teacher: Is the description of option (E) correct?

Student: When discussing species diversity, the two factors, species richness and species evenness, will be considered at the same time. The species diversity in habitat A is higher, which is probably because "the species richness in habitat A is higher, but the species evenness is lower." "The species evenness of habitat A is high, but the species richness is low", or "the species richness and species evenness of habitat A are both high", so the description "the species richness of habitat B must be low" is incorrect. Option (E) is wrong.

老師： 生態系多樣性和環境多樣性分別為何？這兩個名詞是否為同義詞？

學生： 生態系多樣性一詞同時探討了棲地內的生物與環境，是指一個地區中不同棲地所呈現出的不同生態系，故不等同於單指不同生存環境的環境多樣性，故選項(A)、(D)為錯誤的選項。

老師： 有關群集與理化因子的關係為何？

學生： 生態的平衡因素包含生態系中的理化因子與生物因子，理化因子包括物理因子如水、大氣、溫度等，以及化學因子如營養鹽、酸鹼度、溶氧量等。群集中的變動會引起生態系中理化因子的變化，而理化因子的變化又會進一步影響群集的變動，故選項(B)為正確的選項。

老師： 在生態系中各種條件都相同的情況下，環境異質性與生態多樣性的之間關係如何？

學生： 環境異質性是指在特定地區中不同地方存在著差異性，此差異性可包含地形、土壤結構、植被類型、氣候條件等因素。在環境複雜度較高的地區，提供更多不同的棲息環境，讓更多的物種可以生存於此區域中，故提高了物種多樣性，而生態系統的多樣性也隨之增加，故選項(C)為正確的選項。

老師： 選項(E)的敘述是否正確？

學生： 在探討物種多樣性時，會同時考慮物種豐富度及均勻度兩個因素，甲棲息地的物種多樣性較高，可能是「甲地的物種豐富度較高，而均勻度較低」、「甲地的物種均勻度較高，而豐富度較低」，或是「甲地的豐富度及均勻度皆較高」，故「乙棲地的物種豐富度必低」，敘述有誤，選項(E)錯誤。

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

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- 學科諮詢：駱奕帆
- 語言諮詢：儲湘君
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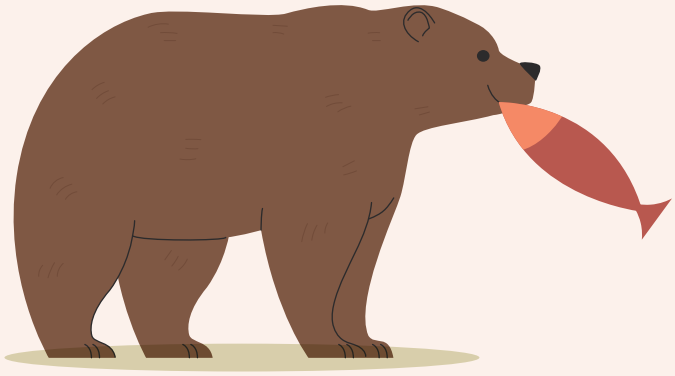

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