國中自然領域

雙語教學資源手冊 地球科學科英語授課用語

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

〔國中九年級〕

國立彰化師範大學雙語教學研究中心 發行

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The Environment of the Earth

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■ 前言 Introduction

本章旨在從人類生活之水與陸地做為出發，來認識地球外部構造與能量的來源及彼此之間的作用力，和地球上的大氣圈、水圈與岩石圈之間交互作用的關係；並探索地球內部的作用、結構及岩石與礦物，探討各種地形景觀的成因與變化。本章最後再檢視地球的變遷，引導出可能調適變遷的策略，建立永續發展的思維。

1-1 我們的地球
Our Earth

■ 前言 Introduction

本小節以生活中的環境與大氣圈、水圈及岩石圈進行觀念性的連結；再針對水體中有關地表水/地下水、淡水/鹹水的認識與區分，並說明水體在固、液、氣三態之間的變化循環，同時論及全球暖化及地層下陷對於生存環境的衝擊。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
atmosphere	大氣圈、氣圈	groundwater	地下水
biosphere	生物圈	hydrosphere	水圈
brine	滷水（濃鹽水）	land subsidence	地層下陷
condensation	凝結	lithosphere	岩石圈
evaporation	蒸發（作用）	precipitation	降水
fresh water	淡水	hydrosphere	水圈
stratigraphic profile/map	地層剖面圖	saturation	飽和
glacier	冰川	water table	地下水面
global	全球的		

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

❶ The main components of _____ are _____ and _____.

例句：**The main components of** the atmosphere **are** nitrogen **and** oxygen.
大氣圈的主要組成物質為氮氣和氧氣。

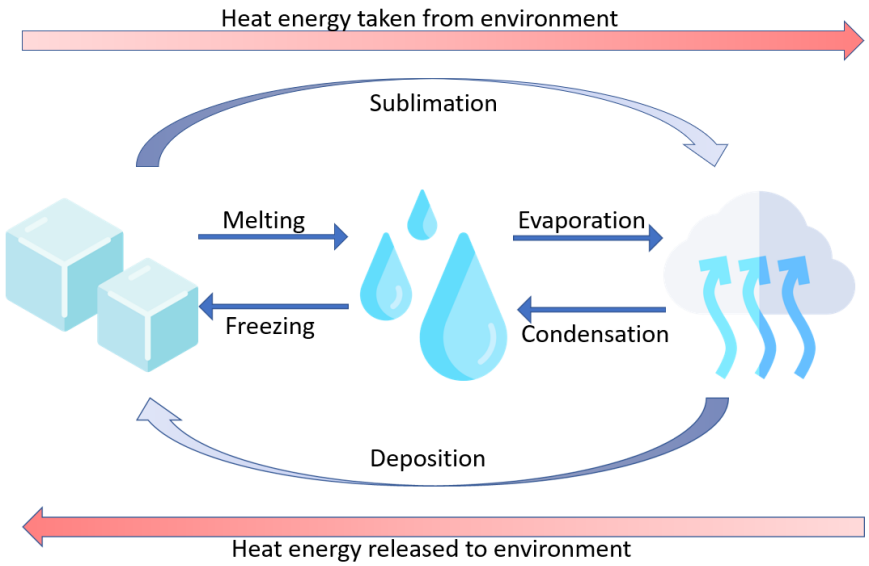
❷ About _____% of _____ is stored in_____. _____ account for _____%. Only less than_____% of is stored in_____.

例句：**About** 97**%** of the earth's water **is stored in** the ocean. Glaciers and snow **account for** 2**%**. **Only less than** 1**%** of the water **is stored in** groundwater, rivers and lakes.
地球的水約有 97%儲存於海洋中，冰川與冰雪占 2%，只有不到 1%的水儲存地下水、河川與湖泊。

❸ When _____ is _____, it _____ into _____.

例句(1)：**When** water **is** heated, **it** evaporates **into** water vapor.
水遇熱會蒸發變成水蒸氣。

例句(2)：**When** water vapor **is** cooled, **it** condenses **into** small droplets.
水蒸氣遇冷會凝結成小水滴。



（編者自行構圖）

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

透過問題的講解，加深學生對本章節之重點的理解：

1. 地下水與岩層分布。
2. 水的三態變化與水循環。

Deepen the students' understanding of the main points in this chapter through the explanation of questions:

1. Groundwater and rock formation.
2. Three states of water and hydrologic cycle.

❧ 例題講解 ☙

例題一

說明：透過地層剖面圖的題型與講解，讓學生更加清楚各岩層與地下水體分布之位置關係。

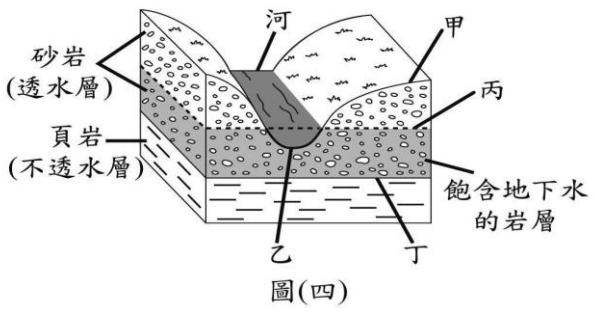
Through the question and the explanations of the stratigraphic profile geological section map, students can be more aware of the relationship between the rock strata and the distribution of groundwater.

（英文）The picture shows a stratigraphic profile of a certain area. The gray part of the rock stratum in the picture is saturated with groundwater. Regarding the various interfaces referred to by 甲, 乙, 丙, and 丁, which one is the water table?

(A)甲 (B)乙 **(C)丙** (D)丁

（中文）圖為某一地區的地層剖面示意圖，圖中灰色部分岩層飽含地下水。關於甲、乙、丙、丁所指的各種交界面，何者為地下水面？

(A)甲 (B)乙 **(C)丙** (D)丁



圖(四)

（111 年國中會考第 15 題）

Teacher: What should you focus on first when you are solving this problem?

Student: I think it's about the definition of "water table".

Teacher: That's right! What is a "water table"? First, let's talk about groundwater. When the water that infiltrates from the surface encounters dense and impermeable rock stratum, the groundwater stops infiltrating downwards. Then, it accumulates upwards, forming a saturated "groundwater", or "saturation zone". The top of the groundwater is called the "water table". So, in this picture, which position is the saturation zone?

Student: The dark gray part.

Teacher: That's right! The top of the groundwater is the "water table". Then, how should we choose the answer?

Student: I know! The answer is 丙.

Teacher: Bingo!

老師： 同學們在解答這題時，首先需要把重點放在哪邊呢？

學生： 我覺得是關於「地下水面」的定義。

老師： 沒錯！何謂「地下水面」呢？首先我們先來談談地下水體，從地表往下滲透的水在遇到緻密而不透水的岩層時，地下水會停止向下滲透，接著往上累積，形成飽和狀態的「地下水體」，或稱「飽和帶」。而地下水體的頂部則稱為「地下水面」。那麼此張圖，哪一個位置是飽和帶呢？

學生： 深灰色部分。

老師： 沒錯，飽和帶的頂部就是我們的地下水面，那麼答案應該怎麼選呢？

學生： 我知道了！答案是丙。

老師： 答對了！

例題二

說明：透過全球水資源循環了解水的三態變化。

Understand the three states of water through the global hydrologic cycle.

（英文）The rivers on the earth have flowed into the sea constantly, but the total amount of seawater has not increased significantly for hundreds of years. Which of the following is the main reason?

(A) Seawater flows from the trenches into the mantle.

(B) Seawater moves to the atmosphere by evaporation.

(C) Seawater seeps into the ground and becomes groundwater.

(D) Seawater enters coastal land at high tide.

（中文）地球上的河水不斷地往海裡流，但是數百年以來海水的總量卻未因此明顯增加，下列何者是最主要的原因？

(A)海水會由海溝流入地函。

(B)海水會藉由蒸發而進入大氣。

(C)海水會滲入地下而變成地下水。

(D)海水會藉由漲潮進入沿海陸地。

（101 年國中基測第 1 題）

Teacher: Can anyone help me figure out the key point of this question?

Student: I think it should be that “the total amount of seawater has not increased significantly”.

Teacher: Yes. The stability of the total amount of seawater is related to the three states of water. Do you know what the three states of water are?

Student: The three states of water are solid, liquid, and gas.

Teacher: Yes. The water on the surface will go through the hydrologic cycle, which involves evaporation, condensation, and precipitation. As a result, seawater will move to the atmosphere through evaporation, which keeps the total amount of seawater constant on a long-term scale.

Student: Then why doesn’t the total amount of seawater remain constant because the seawater goes to the land?

Teacher: Even if seawater goes to the land and seeps into the ground, the groundwater still maintains the characteristics of water, which flows from high to low and eventually flows into the ocean. Thus, if the phenomenon of evaporation does not exist, we can't explain the stability of the total amount of seawater.

Student: I got it! Thank you, teacher.

老師： 有沒有同學能先幫我抓出這題的重點呢？

學生： 我覺得應該是海水的「總量」未變。

老師： 沒錯，海水的總量未變與水的三態變化有關。你們知道水的三態是哪三態嗎？

學生： 水的三態有固態、液態、氣態。

老師： 沒錯，地表的水會有蒸發、凝結、降水的水循環過程，因此海水會藉由蒸發進入大氣，導致海水的總量在長時間尺度來看是維持恆定不變的。

學生： 那為何不是海水跑到陸地上而讓海上的海水總量不變呢？

老師： 因為就算是海水滲入地下變成地下水，地下水也是會保持水的特性，由高處往低處流，最終流入海洋，因此，倘若沒有說到蒸發的現象時，就無法解釋海水總量不變的這個現象。

學生： 了解！謝謝老師。

1-2 地表的改變與平衡
The Change and the Balance of the Earth's Surface

■ 前言 Introduction

本小節旨在說明外營力作用對地形的形貌影響，由地表的風化與侵蝕的地質作用展開說明，再將討論的重點聚焦至河流的變化，論述河川在上、中游與下游等不同區域的主要地質作用與所演化的地形景觀。本節最後探討人為的地表開發與自然力量對河道的影響，以連結人類生活與外營力作用對地表的變化關係，引導學生對於地表變化的深入了解，以及喚起同學們重視與關懷地表形貌發生變化的問題。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
alluvial fan	沖積扇	exogenetic (exogenic) process	外營力作用
coastline	海岸線	gorge (canyon)	峽谷
convergent plate boundary	聚合型板塊邊界	river terrace	河階
delta	三角洲	topography	地形
deposition	堆積作用	transportation	搬運作用
dune	沙丘	valley	河谷
endogenetic process	內營力作用	weathering	風化作用
erosion	侵蝕作用		

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

❶ **The _____ (erosion/transportation/deposition) usually happens in the _____ (upper/middle/lower) reaches of the river.**

例句：**The** erosion **usually happens in the** upper **reaches of the river.**
侵蝕作用經常發生在河流的上游。

❷ **The _____ tends to form _____.**

例句：**The** deposition **tends to form** a delta.
堆積作用容易形成三角洲的景觀。

■ 問題講解 Explanation of Problems

學習目標

透過問題的講解，加深學生對本章節之重點的理解：

1. 外營力作用的辨認—何謂外營力作用？外營力作用包含了什麼？
2. 河川上游、中游與下游的不同地質作用力與其地表形貌。

Deepen the students' understanding of the main points in this chapter through the explanation of questions:

1. The identification of exogenic process—What is exogenic process? What does the exogenic process include?
2. Different geological processes in the upper, middle, and lower reaches of a river and its topography.

例題講解

例題一

說明：將外營力在日常生活的例子引導到題目中，讓學生透過實際案例了解外營力作用的定義。

Introduce the examples of exogenous process in daily life and let the students understand the definition of exogenous process through actual cases.

（英文）Which of the following is not a phenomenon of transportation?

(A) Driftwood in Pingtung drifts with the sea to Liuqiu Island.

(B) Ashes from Iceland are carried by the winds across Europe.

(C) The igneous rocks of Green Island are gradually approaching Taitung as the plates converge.

(D) The marble fragments found in Taroko are brought by the river to the seaside of Hualien.

（中文）下列何者不是搬運作用的現象？

(A)屏東的漂流木隨海水漂流到小琉球。

(B)冰島的火山灰隨風飄送到歐洲各地。

(C)綠島的火成岩隨板塊聚合漸漸往臺東靠近。

(D)太魯閣的大理岩碎塊被河水帶至花蓮海邊。

（104 年國中會考第 9 題）

Teacher: When we are solving this problem, we need to know the meaning of “exogenous process”. Can anyone explain the meaning of “exogenous process” according to your textbook?

Student: According to the textbook, exogenous process refers to how the water, glaciers, winds, and sea waves may affect earth’s topography.

Teacher: That’s right! Is there anyone who could give an additional explanation?

Student: The exogenous process will make the earth’s surface become flat.

Teacher: Great! Let’s go back to the question. We can find out that option (A) includes the effect of seawater. Option (B) includes the effect of winds. Option (D) also shows the effect of rivers on stones. Otherwise, option (C) emphasizes the process of plate movement. Can anyone tell me what kind of process that the plate movement belongs to?

Student: I think it is an endogenic process.
Teacher: That's right! Then how should we choose the answer?
Student: We should choose option (C).
Teacher: You're right!

老師： 當我們在看這一題時，必須注意到何謂「外營力作用」，有同學可以根據課本試著說明看看何謂外營力作用嗎？
學生： 根據課本，外營力作用指的是地表形貌受到流水、冰川、風及海浪等作用力影響。
老師： 沒錯，那是否還有同學可再做補充說明呢？
學生： 外營力的作用會使地表趨於平坦。
老師： 很好。讓我們回到題目，可以發現 A 選項有海水的作用、B 選項有風的作用，而 D 選項也說明了河水對於石塊的作用；反之可以看到 C 選項，卻強調了板塊的作用，請問有同學可以說說看板塊作用是屬於哪一種地表作用力嗎？
學生： 我認為是內營力作用。
老師： 沒錯，所以這一題應該怎麼選呢？
學生： 是 C 選項。
老師： 答對了！

例題二

說明：透過岩石的樣態，分辨出其所在的河段位置，並試著請學生說明不同河段的不同作用力。

Identify the river sections through the locations and appearances of rocks and ask the students to explain the different geological processes for different river sections.

（英文）In the upstream and downstream valleys of the same river, 小美 collected the most appearing stones and divided them into two groups according to their locations. It is known that the composition of these two groups of stones is the same, but the surface of Group 甲 has obvious edges and corners while the surface of Group 乙 is smooth, flat and roughly elliptical, as shown in Figure (5). Which of the following is the most reasonable inference about the location of the stones and the causes of the difference in their appearances?

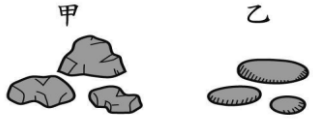
(A) Group 甲 is located in the downstream valley. The edges and corners of the stones are made due to the long distance of transportation.

(B) Group 乙 is located in the downstream valley. The stones are round and flat due to the long distance of transportation.

(C) Group 甲 is located in the upstream valley. It is easy to have edges and corners because the transportation capacity of the upstream river is weaker than that of the downstream river.

(D) Group 乙 is located in the upstream valley. It is easy to be round and flat because the transportation capacity of the upstream river is weaker than that of the downstream river.

（中文）小美在同一條河川的上游與下游河谷，分別採集了當地河谷中主要外觀類型的石頭，並依採集地點分成甲、乙兩組。已知這兩組石頭的組成成分皆相同，但甲組表面具有明顯稜角，乙組表面則光滑平坦且大致呈橢圓形，如圖(五)所示。關於甲、乙兩組石頭的採集地點與造成兩組石頭外觀差異的推論，下列何者最合理？



圖(五)

(A)甲組位於下游河谷，因搬運距離較遠而撞出稜角。

(B)乙組位於下游河谷，因搬運距離較遠而磨圓磨平。

(C)甲組位於上游河谷，因搬運能力較下游弱，容易撞出稜角。

(D)乙組位於上游河谷，因搬運能力較下游弱，容易磨圓磨平。

（108 年國中會考第 11 題）

Teacher: First, I want to ask a person to describe the features of the rocks in this question.

Student: I think rock 甲 has more edges and corners; on the other hand, rock 乙 is relatively round and it doesn't have obvious edges and corners.

Teacher: That's right! Your observation is subtle. Then, for all of you, which river sections where the above rocks appeared may be? Please raise your hand and tell me why you make the inference.

Student: I think that rock 甲 is located in the upstream area where erosion is more obvious. Rock 乙 may be located in the middle and lower reaches where there are more transportation and deposition.

Teacher: Your answer is great! Then let me explain more why option (C) is wrong. In the upstream, stones weren't affected by much transportation and deposition, so they can retain their original edges and corners. It is not because of the low transportation capacity that results in edges and corners. Please pay more attention to this part.

Student: I understand. Thank you, teacher.

老師： 首先老師想先請一位同學說明一下題目中的岩石特徵。

學生： 我認為甲岩石較具有稜角；反觀乙岩石相對來說圓潤許多，沒有明顯的稜角。

老師： 沒錯，同學觀察的很細微。再來想請問同學以上岩石有可能出現在那些河段呢？請同學舉手發言並告訴我你為什麼這樣子推斷。

學生： 我認為甲岩石位在侵蝕作用較明顯的上游區域，而乙岩石本身可能位在搬運與堆積較多的中下游區域。

老師： 同學的答案很棒。老師再額外解釋 C 選項為何錯誤，上游因石頭尚未接觸到太多的搬運與堆積作用，因此較保有原先之稜角，並非因搬運能力低落，而容易撞擊出稜角，請同學要多注意這個部分。

學生： 了解了，謝謝老師。

1-3 人與自然的互動
The Interaction between Humans and Nature

■ 前言 Introduction

本小節從岩石三大種類（沉積岩、火成岩、變質岩）的介紹開始，並討論各類岩石的成因與相互轉變之地質作用而形成岩石循環的過程。再結合岩石與台灣地景的辨識，了解台灣本島岩石的分佈情形；最後透過對岩石的實際觀察，讓學生理解岩石與礦物之間的組成關係。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
basalt	玄武岩	lava	熔岩(沿裂隙到達地表之熔融的岩石物質)
cementation	膠結作用	limestone	石灰岩
coral	珊瑚	magma	岩漿(地球內部之熔融的岩石物質)
diagenesis	成岩作用	metamorphic rock	變質岩
diastrophism	地殼運動	mineral	礦物
geopark	地質公園	solidification	凝固
igneous rock	火成岩	trilobite	三葉蟲
jewel	寶石		

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

❶ **Through the observation of _____ (shape/color/crystalline state), we can know that this is a/an _____ (sedimentary rock/igneous rock/metamorphic rock).**

例句：**Through the observation of** the crystalline state, **we can know that this is an** igneous rock.

透過對結晶狀態的觀察，我們可以知道這是一塊火成岩。

❷ **_____ (sedimentary rock/igneous rock/metamorphic rock) are formed by _____.**

例句：Igneous rocks **are formed by** the solidification of molten magma.

火成岩是由熔融的岩漿經凝固的過程所形成的。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

透過問題的講解，加深學生對本章節之重點的理解：

1. 三大成岩作用的分類。
2. 不同岩石的特色、分布位置與成岩作用。

Deepen the students' understanding of the main points in this chapter through the explanation of questions:

1. The classification of the three major diagenesis.
2. The characteristics, locations, and diagenesis of different rocks.

例題講解

例題一

說明：透過生活案例的引導與關鍵字句的提取，找出相對應的成岩作用，並辨認出其特色。
Through the cases in our life and keywords, find out the corresponding diagenesis and identify its characteristics.

（英文）小文 went to the geopark for a trip and saw a rock outcrop in the park. This outcrop has a layered structure and is inclined as a whole. In addition to many marine bioclastic fossils, we can also find complete coral fossils in the rock strata. Which of the following inferences about this rock formation is the most reasonable?

(A) The rock strata were formed by the cooling and solidification of magma.

(B) The rock strata were forced to tilt after it was formed.

(C) The rock strata were formed in a terrestrial environment

(D) The rock strata tilted due to weathering and erosion.

（中文）小文到地質公園出遊，他在園區內看見一露出地表的岩層，此岩層具有層狀構造且整體呈現傾斜狀態。岩層內除了可發現許多海洋生物碎屑化石外，也可發現完整的珊瑚化石，下列關於此岩層的推論何者最合理？

(A)由岩漿冷卻凝固後所形成。

(B)岩層形成後才受力而傾斜。

(C)當時形成的環境屬於陸地環境。

(D)因風化侵蝕作用而呈現傾斜狀態。

（108 年國中會考第 16 題）

Teacher: The concept of this question is relatively complicated. First of all, option A mainly describes the diagenesis of igneous rocks. I would like to ask you which kind of diagenesis may the “fossils” mentioned in the question appear in?

Student: I know! Fossils will be generated in a sedimentary rock environment.

Teacher: That’s right. Option B is correct because the question mentions that it has “layered structure” and tilt “as a whole”. Therefore, it can be inferred that the layered structure of the rock formation was formed before the surface tilted. Then, what is wrong with option C?

Student: It should have been in a marine environment at that time because there were fossils of coral and marine bioclast.

Teacher: That's right. Finally, let's look at option D. Is it the endogenetic force or the exogenic force that will make the rock formation tilt?

Student: Internal force.

Teacher: Then, is it the exogenic force or the endogenetic force that will cause weathering?

Student: Exogenic force.

Teacher: Excellent!

老師： 這題的觀念相對複雜，首先 A 選項主要描述的是火成岩的成岩作用，想詢問同學，題目所說之「化石」有可能出現在哪一種成岩作用中呢？

學生： 我知道！化石會在沉積岩的環境中找到。

老師： 沒錯。B 選項之所以正確，是因為題目提及「有層狀構造」且「整體」呈現傾斜，故可以推斷，是先形成岩層的層狀構造地表才發生傾斜。那麼 C 選項錯在哪呢？

學生： 當時應該是處於海洋的環境，因為有珊瑚化石與海洋生物碎屑。

老師： 沒錯。最後來看 D 選項，請問是內營力作用還是外營力作用造成岩層傾斜呢？

學生： 內營力作用。

老師： 那麼請問是外營力作用還是內營力作用造成風化作用呢？

學生： 外營力作用。

老師： 非常棒。

例題二

說明：連結地球發展歷程與成岩作用，讓學生做跨章節的知識連結。

Connect the development process of the earth with diagenesis and encourage students to make knowledge connections across chapters

（英文）Certain rock strata have not been affected by diastrophism after its formation. There are a large number of intact trilobite fossils and traces of trilobites in the rock strata. Which of the following is the most likely formation process of the rock strata?

(A) The rock strata were form through sedimentation in a terrestrial environment.

(B) The rock strata were form through sedimentation in a marine environment.

(C) The rock strata were formed by the cooling of magma after an eruption on land.

(D) The rock formation was formed by the cooling of lava after an eruption on the seabed.

（中文）某岩層在形成後未受地殼變動影響，且岩層中有大量完整的三葉蟲化石及其活動痕跡，該岩層的形成過程最有可能為下列何者？

(A)此岩層在陸地的環境沉積而成。

(B)此岩層在海洋的環境沉積而成。

(C)由岩漿在陸地噴發後冷卻而成。

(D)由岩漿在海底噴發後冷卻而成。

（107 年國中會考第 15 題）

Teacher: First of all, I would like to ask you to find out the keywords of this question. Which words are the keywords?

Student: Have not been affected by diastrophism.

Student: Trilobite fossils.

Teacher: Good! The rock strata have not been affected by diastrophism and there are fossils, which means that the main type of diagenesis is sedimentation. Then I want to ask you about the living environment of the trilobites. Did they live in the sea or on land?

Student: I know. Trilobites lived in the ancient sea.

Teacher: That's right. So the answer is (B). This rock strata were formed through sedimentation in a marine environment.

老師： 首先老師想請大家幫我找出這一題的關鍵字，你們會選出哪幾個字呢？

學生： 未受地殼變動影響。

學生： 三葉蟲化石。

老師： 很好。岩層未受地殼變動影響且有化石的出現，代表成岩作用以沉積為主，那麼老師要問同學，三葉蟲的生活環境是在海裡還是在陸地呢？

學生： 我知道，三葉蟲生活在遠古的海裡。

老師： 沒錯！因此答案是 B，此岩層在海洋的環境沉積而成。

★主題二 板塊運動與岩層的祕密★
Plate Movement and the Secret of Rock Formation

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■ 前言 Introduction

本章透過地球內部構造的說明，檢視與闡述地球的分層：地殼、地函和地核之間的差異及其特性。再進一步探討內營力作用與板塊運動對地表形貌的影響；最後再透過岩層與化石的紀錄，了解在地質時間的尺度下所發生的地質事件，試著讓學生能夠整合地球內部構造、板塊運動與岩層紀錄的相關知識外，並增進對地表形貌變化之科學性的了解與關懷。

2-1 地球的構造與板塊運動
The Structure of the Earth and Plate Movement

■ 前言 Introduction

本小節旨在讓學生了解地球內部的組成，並了解地球垂直分層之成因及各分層的特性，並透過岩石圈及板塊之間的相互運動，以連結世界板塊的分布與地貌的情形。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
asthenosphere	軟流圈	mantle	地函
continental crust	大陸地殼	mid-ocean ridge	中洋脊
convergent plate boundary	聚合型邊界	oceanic crust	海洋地殼
core	地核	Pacific Ring of Fire	環太平洋火山地震帶
crust	地殼	plate	板塊
divergent plate boundary	張裂型邊界	seismic wave	地震波

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

❶ The density of _____ is greater/less than _____.

例句(1)：**The density of** the crust **is less than** the mantle.
地殼的密度低於地函。

例句(2)：**The density of** the mantle **is greater than** the crust.
地函的密度高於地殼。

❷ If the plates move ____ (closer to/away from) each other, a ____ (convergent/divergent) boundary will form.

例句：**If the plates move** closer to **each other**, **a** convergent **boundary will form.**
如果板塊相互靠近，則會形成聚合型的板塊邊界。

■ 問題講解 Explanation of Problems

學習目標

透過問題的講解，加深學生對本章節之重點的理解：

1. 地球內部垂直分層結構。
2. 板塊邊界類型。

Deepen the students' understanding of the main points in this chapter through the explanation of questions:

1. The vertical stratification structure of the interior of the earth.
2. The types of plate boundaries.

例題講解

例題一

說明：以地球內部構造密度的分類排序，強化學生對於地球個垂直分層結構之理解。
Strengthen students' understanding of the earth layers vertical cross section by sorting the structure of the earth's interior according to density.

（英文）The teacher divides the class into four groups to discuss the structure of the earth's interior. The teacher first provided the names and density information of the various stratified layers inside the earth on the blackboard, as shown in Table (9). Then the teacher posts a reminder on the blackboard, as shown in Figure (23). We have known that 甲, 乙, and 丙 correspond to different stratified layers in Table (9). If the teacher wants each group to try to deduce the names of the three stratified layers, 甲, 乙, and 丙, based on the above information, which of the following groups gives the most reasonable explanation?

表(九)

名稱	密度(g/cm^3)
大陸地殼	2.7
海洋地殼	3.0
地函	4.5
地核	10.7

提示：
甲、乙、丙三構造中，甲的密度最大。

圖(二十三)

(A)	Group 1 If 丙 is the continental crust, 乙 must be the oceanic crust, and 甲 must be the mantle.	(B)	Group 2 If 甲 is thicker than 乙, 乙 must be the mantle, and 甲 must be the core
(C)	Group 3 If 丙 is the oceanic crust, and 乙 is below 丙, 乙 must be the mantle.	(D)	Group 4 There is no need to make other explanations. According to the hints on the blackboard, we can know that 甲 must be the core.

（中文）老師將班上同學分成四組，討論地球內部構造的分層方式。老師先在黑板上提供地球各部分構造的名稱與密度資料，如表(九)所示。接著並在黑板上貼出提示，如圖(二十三)所示。已知甲、乙、丙分別對應到表(九)中的不同構造，若老師希望各組藉由上述資訊嘗試推論甲、乙、丙三構造的名稱，則下列何組的說明最合理？

表(九)

名稱	密度(g/cm³)
大陸地殼	2.7
海洋地殼	3.0
地函	4.5
地核	10.7

提示：
甲、乙、丙三構造中，甲的密度最大。

圖(二十三)

(A)

組別	第一組
說明	若丙為大陸地殼，則乙一定為海洋地殼，甲一定為地函。

(B)

組別	第二組
說明	若甲的厚度大於乙，則乙一定為地函，甲一定為地核。

(C)

組別	第三組
說明	若丙為海洋地殼，且丙以下為乙，則乙一定為地函。

(D)

組別	第四組
說明	不需要再做其他說明，根據黑板上的提示即可得知甲一定為地核。

（110 年國中教育會考第 44 題）

Teacher: The question shows that layer 甲 has the highest density, so we know that the density of 甲 must be greater than that of 乙 or 丙, but the density of 乙 and 丙 is unknown. Let's first interpret options A, B, C, and D one by one!

Student: OK!

Teacher: First, let's look at option A. It assumes that 丙 is the continental crust, so 甲 must be the mantle, and 乙 must be the oceanic crust. Then, what is the density of 丙?

Student: If 丙 is the continental crust, its density is 2.7.

Teacher: When the density of 丙 is the smallest, 乙 may be the oceanic crust or mantle, and 甲 may be the mantle or core, so option A is wrong. Next, let's look at option B. According to what you have learned, what are the thicknesses arranged from thin to thick?

Student: Oceanic crust, continental crust, mantle, and the core is the thickest.

Teacher: That's right. Option B assumes that 甲 is thicker than 乙, and the question says that 甲 has the highest density, so 甲 and 乙 may be mantle, continental

crust/oceanic crust, or core, mantle/continental crust/oceanic crust. Thus, option B is wrong. Then, why is option C correct?

Student: Option C is correct because the question assumes that 丙 is the oceanic crust, then the part below it must be the mantle. In addition, the question mentions that 甲 has the highest density, so 乙 must be the mantle and 甲 must be the core.

Teacher: That's correct. Then let's see why option D is wrong! If we only know that 甲 has the highest density, what are the possible combinations of 甲, 乙, and 丙?

Student: 乙 and 丙 can be the continental crust or the oceanic crust, and 甲 is the mantle; or 乙 and 丙 can be the continental crust, the oceanic crust, or the mantle, and 甲 is the core.

Teacher: Excellent!

老師： 題幹顯示甲構造的密度最大，由此我們可以得知甲的密度必大於乙或丙，但乙丙的密度未知。因此，我們先來一一解讀選項 A、B、C、D！

學生： 好的！

老師： 首先是 A 選項，它假設丙為大陸地殼，則甲一定為地函、乙一定為海洋地殼，那麼丙的密度是多少呢？

學生： 若丙為大陸地殼的話，密度是 2.7。

老師： 那麼，在丙密度最小時，乙有可能是海洋地殼、或地函，甲有可能是地函或地核，故 A 選項錯誤。接下來我們再看看 B 選項，在題幹給的地球垂直分層結構中，厚度由薄排列到厚分別是什麼呢？

學生： 海洋地殼、大陸地殼、地函，最厚的是地核。

老師： 沒錯。選項 B 假設甲的厚度大於乙，題幹又說甲的密度最大，故甲乙有可能是地函、大陸地殼/海洋地殼，或地核、地函/大陸地殼/海洋地殼，因此 B 選項錯誤。

那麼 C 選項為何正確呢？

學生： C 選項正確是因為題幹假設丙為海洋地殼，則其以下必為地函，又題幹提及甲選項密度最大，因此，乙必為地函、甲必為地核。

老師： 回答正確。那我們再一起看 D 選項為何錯誤吧！倘若只知道甲密度最大，那甲、乙、丙有哪些可能的組合？

學生： 乙丙可以是大陸地殼或海洋地殼，甲為地函；或乙丙可以是大陸地殼、海洋地殼、地函，甲為地核。

老師： 非常好！

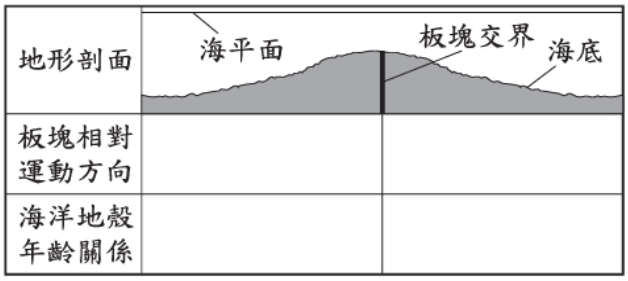
例題二

說明：了解不同板塊交界的成因及其地質年齡的分布。

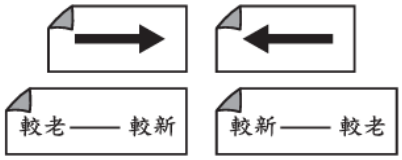
Understand the origin of different plate boundaries and the distribution of their geological age.

（英文）In the class, the teacher uses a poster to ask students to go on stage in groups to explain the characteristics of a certain type of plate boundary, as shown in Figure (23). Figure (24) shows the stickers provided for the students. The teacher also tells them that the arrows or text on the stickers are used to illustrate the relationship between the direction of relative movement of the two plates and the age of the oceanic crust. To present the characteristics of this type of plate boundary correctly, which of the following ways of pasting is the most reasonable?

（中文）老師在課堂上以一張海報來讓學生分組上臺說明某一類型板塊交界的各項特徵，如圖(二十三)所示。圖(二十四)為老師提供學生使用的貼紙，並告訴學生這些貼紙上的箭頭或文字的用途，是用來說明兩板塊相對運動方向與海洋地殼年齡的關係，若要正確呈現這類型板塊交界的特徵，下列哪一種黏貼方式最為合理？

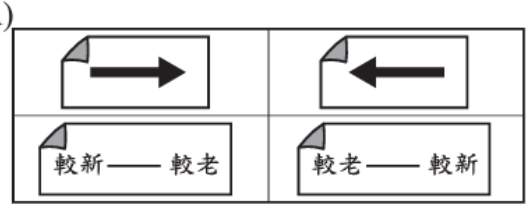


圖(二十三)

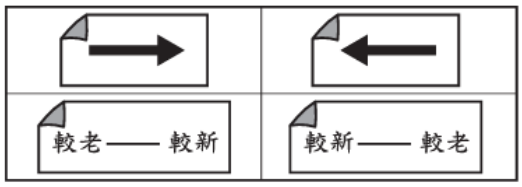


圖(二十四)

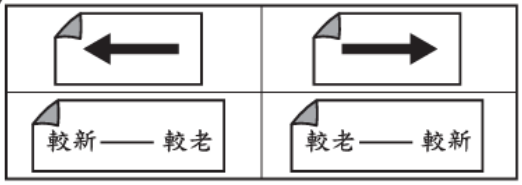
(A)



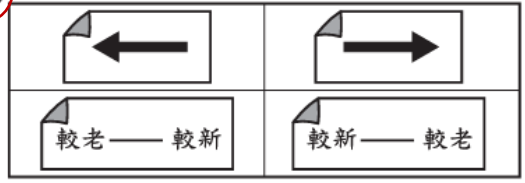
(B)



(C)



(D)



（109 年國中會考第 36 題）

Teacher: According to Figure 23, what geological structure do you think might be at the plate boundary?
Student: Is it the mid-ocean ridge?
Teacher: That's right. Which type of the plate boundary does the mid-ocean ridge belong to?
Student: Divergent plate boundary.
Teacher: That's right. Under the divergent plate boundary, the upper mantle melts to form magma that rises from beneath and forms a new continental segment at the plate boundary. Therefore, what should be the age distribution extending outward from the plate boundary?
Student: The boundary of the plates is newer, and the farther out, the older.
Teacher: Right, so the answer to this question is (D).

老師： 由圖二十三看來，你們覺得在板塊邊界上有可能是哪個構造呢？
學生： 是中洋脊嗎？
老師： 沒錯，那中洋脊是屬於哪一種板塊交界類型呢？
學生： 張裂型板塊。
老師： 沒錯。在張裂型板塊邊界底下，上部地函熔融形成岩漿由地底上冒，在板塊交界處形成新的陸塊，因此由板塊交界處向外延伸的年齡分布應該為何呢？
學生： 板塊交界處較新，越往外越老。
老師： 沒錯，因此本題答案為(D)。

2-2 板塊運動與內營力作用的影響
Plate Movement and the Effect of Endogenetic Process

■ 前言 Introduction

本小節以地球的內營力作用為核心觀念，以說明內營力作用如何對地表產生形貌上的變化，例如像褶皺、斷層等地表的變形與錯動，並分別介紹正斷層、逆斷層及平移斷層的發生機制與各類斷層的差異，最後再探討與地震相關的名詞。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
continental plates	大陸板塊	hypocenter (focus)	震源
earthquake intensity	地震強度(震度)	normal fault	正斷層
endogenetic process	內營力作用	oceanic plates	海洋板塊
epicenter	震央	reverse fault	逆斷層
fault	斷層	Richter magnitude scale (Richter scale)	芮氏規模
fold mountains	褶皺山脈	seismic wave	地震波
footwall	下盤	strike-slip fault	平移斷層
hanging wall	上盤	faulting	斷層作用

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

❶ The _____ (normal/reverse) fault is formed by the _____ (sliding/upthrust) of the hanging wall.

例句：The shape of the fault depends on the movement between the hanging wall and the footwall.

The normal **fault is formed by** the sliding **of the hanging wall**.

斷層的樣態取決於上下盤間的移動，正斷層是上盤下滑形成的。

❷ The _____, the more _____.

例句：**The** stronger the earthquake, **the more** destructive it is to the earth surface.

地震強度越強，對地表的破壞力越大。

■ 問題講解 Explanation of Problems

學習目標

透過問題的講解，加深學生對本章節之重點的理解：

1. 不同的斷層作用與其影響。
2. 地震規模與強度相關知識。

Deepen the students' understanding of the main points in this chapter through the explanation of questions:

1. Movements of different types of faults and the effects.
2. Knowledge of the earthquake magnitude and intensity.

例題講解

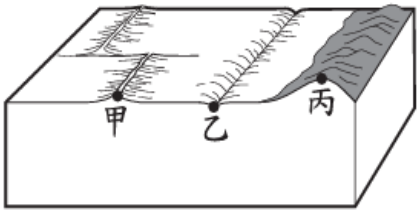
例題一

說明：了解並分辨不同板塊交界處所形成的地表構造。

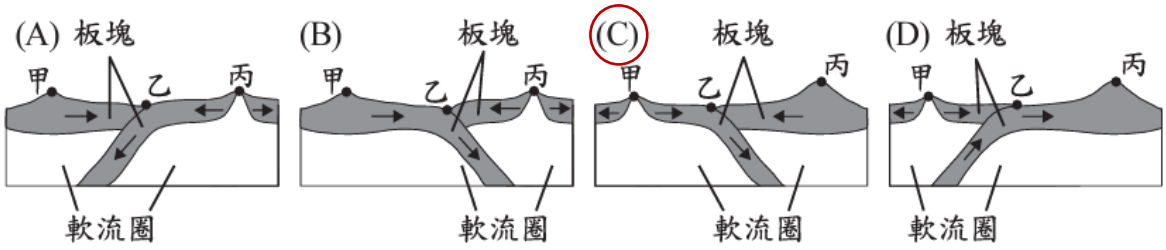
Understand and identify the geological structures of the earth surface formed at the different plate boundaries.

（英文）Figure (9) illustrates the characteristics of the structure of the earth surface in a certain area. In the figure, 甲 is located at the mid-ocean ridge, 乙 is located at the ocean trench, and 丙 is located at a mountain range on land, and this mountain range has volcanic activity. If the underground structure connecting 甲, 乙, and 丙 is illustrated as a cross-section diagram of plate tectonics in this area, and arrows are used to indicate the directions of plate movements, which of the following is the most reasonable?

（中文）圖(九)為某地區的地表構造特徵示意圖，圖中甲位於中洋脊上，乙位於海溝上，丙位於一陸地的山脈上，且此山脈有火山活動。若將甲、乙、丙三地連線的地下構造，繪製成此地區的板塊構造剖面示意圖，並以箭頭表示板塊運動方向，則下列何者最合理？



圖(九)



（108 年國中會考第 23 題）

Teacher: According to 甲 being as a mid-ocean ridge, do you know what kind of plate boundary it is located at?

Student: Divergent plate boundary.

Teacher: That's right. Therefore, the direction of the arrow should be stretched from the center to both sides, so we should delete options A and B first. Next, the question mentions that 乙 is the ocean trench. Do you know which plate subducts downward due to the density difference between the sea and land plates?

Student: Oceanic plates are denser than continental plates, so they subduct downward to form ocean trenches.

Teacher: That's right. So which option should we choose for this question?

Student: The option (C).

Teacher: Excellent!

老師： 各位同學，根據圖可知甲為中洋脊，那麼你知道是位在什麼樣的板塊邊界上？

學生： 張裂型板塊邊界。

老師： 沒錯。因此箭頭方向應該是由中心向兩側拉張，故先將 A、B 選項刪除。接下來題目又說到乙為海溝，則可以知道他是因為海陸板塊之間的密度差異，而導致什麼板塊向下隱沒而成的嗎？

學生： 海洋板塊的密度高於大陸板塊，因此會向下隱沒而形成海溝。

老師： 沒錯，因此本題應該選哪一個選項呢？

學生： (C)選項。

老師： 很好！

例題二

說明：使學生能夠辨認出地震規模與地震強度之間的差異並做應用。

Enable students to identify the difference between the magnitude and intensity of earthquakes and apply the knowledge.

（英文）小麗 felt two obvious earthquakes at home this month. She inquired about the earthquake intensities recorded by the station closest to her home when the two earthquakes occurred. The intensity of the first earthquake was measured as level 3, and the intensity of the second earthquake was measured as level 2. Based on the above information, which of the following is correct for the comparison of the shaking degrees recorded by the station caused by the two earthquakes and the amounts of energy released by the earthquakes?

(A) The shaking degree of the first earthquake is greater, and the energy released is also greater.

(B) The shaking degree of the first earthquake is greater, but the difference in the amounts of energy released cannot be compared.

(C) The energy released by the first earthquake is greater, but the shaking degree caused by it is smaller.

(D) The energy released by the first earthquake is greater, but the difference in the shaking degree between the two earthquakes cannot be compared.

（中文）本月小麗在家中感受到兩次明顯的地震，她查詢這兩次地震發生時，離她家最近測站的震度，得到第一次地震的震度為 3 級，第二次地震的震度為 2 級。根據上述，這兩次地震造成該測站搖晃程度與地震釋放能量大小之比較，下列何者正確？

(A)第一次地震的搖晃程度較大，其釋放的能量也較大。

(B)第一次地震的搖晃程度較大，但無法比較釋放能量的差異。

(C)第一次地震釋放的能量較大，但其造成搖晃程度反而較小。

(D)第一次地震釋放的能量較大，但無法比較兩次搖晃程度的差異。

（109 年國中會考第 35 題）

Teacher: This question mainly hopes that you can identify the difference between the earthquake magnitude and the earthquake intensity. I would like to ask you a question first. What is the earthquake magnitude?

Student: The earthquake magnitude represents the amount of energy released by the earthquake. (The earthquake magnitude represents the magnitude of earthquake energy)

Teacher: That's right. A single earthquake event does not change its magnitude no matter where it is. Then, what is the earthquake intensity?

Student: Earthquake intensity is used to express people's feeling of ground shaking and the degree of damage to buildings.

Teacher: That's right, and the earthquake intensity will vary depending on the distance between the station and the epicenter. The question says that the intensity of the first earthquake is level 3, and the intensity of the second earthquake is level 2. Therefore, we know that the shaking degree of the first earthquake is larger. However, since we don't know how far the station is from the epicenters of the two earthquakes, and the magnitude of the earthquake is not mentioned, it is impossible to know the difference in the amounts of energy released by the two earthquakes. Do you understand?

Student: Yes!

Teacher: Very good.

老師： 這題主要是希望同學們可以辨認出地震規模跟地震強度之間的差異，因此，想先詢問同學們，何謂地震規模呢？

學生： 地震規模代表地震釋放能量的多寡（地震的能量大小）。

老師： 沒錯，而且單一地震事件，無論在何處，地震規模皆不會有數值上的改變。那麼，地震強度又是什麼呢？

學生： 地震強度是用以表示人對地面震動的感受及建築物受破壞的程度。

老師： 沒錯，且地震強度會受到測站與震央位置的差距而有大小的變化。所以，我們由題幹的第一次地震震度為 3 級、第二次地震震度為 2 級可知第一次地震的搖晃程度較大；但由於不知題幹測站距離兩次地震震央多遠，也未提及地震規模，因此無法得知兩次地震釋放能量的差異。同學們了解了嗎？

學生： 了解了！

老師： 非常好。

2-3 岩層的紀錄
The Record of Rock Formations

■ 前言 Introduction

本小節探討沉積岩層的成層分布情形，以及不同地質事件所存在的地質年代，並說明標準化石（指標化石）所代表的地質意義；介紹古生代、中生代及新生代等各地質年代中具代表性的化石，並據以推測當時的地質環境。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
dike	岩脈	index fossil	標準化石
dinosaur	恐龍	sedimentary rock	沉積岩
erosion	侵蝕作用	the Cenozoic Era	新生代
fossil	化石	the Mesozoic Era	中生代
geological time	地質年代	the Paleozoic Era	古生代
Stratigraphic profile	地質剖面圖	trilobite	三葉蟲
igneous intrusion	火成岩侵入		

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

❶ The _____ (lower/upper) rock strata were formed _____ (earlier/later) and were affected by geological events that occurred _____ (earlier/later).

例句：**The** lower **rock strata were formed** earlier **and were affected by geological events that occurred** earlier.

位於下方的岩層其形成的年代較早，同時是受到較早發生的地質事件所影響。

❷ _____ (Trilobite/Dinosaur/Mammal) is a kind of index fossil. It can be judged that the rock stratum is formed in the _____ (Paleozoic/Mesozoic/Cenozoic) Era.

例句(1)：Mammal is **a kind of index fossil. It can be judged that the rock stratum is formed in** the Cenozoic Era.

哺乳類是一種標準化石，可以根據它判斷出該岩層形成於新生代。

例句(2)：Dinosaur is **a kind of index fossil. It can be judged that the rock stratum is formed in** the Mesozoic Era.

恐龍是一種標準化石，可以根據它判斷出該岩層形成於中生代。

例句(3)：Trilobite is **a kind of index fossil. It can be judged that the rock stratum is formed in** the Paleozoic Era.

三葉蟲是一種標準化石，可以根據它判斷出該岩層形成於古生代。

■ 問題講解 Explanation of Problems

學習目標

透過問題的講解，加深學生對本章節之重點的理解：

1. 地質事件先後順序判識。
2. 不同地質年代環境與標準化石之理解與辨認。

Deepen the students' understanding of the main points in this chapter through the explanation of questions:

1. Identify the sequence of geological events.
2. Understand and identify environments and index fossils in different geological time.

例題講解

例題一

說明：透過圖面的判讀，了解地質事件的先後順序。

Understand the sequence of geological events through the interpretation of the profile.

（英文）Figure (21) is the stratigraphic profile of a certain place. It is known that the strata here have not been reversed, and the rock stratum 乙 deposited between 15,000 and 10,000 years ago. The following shows the depositional age or formation age of other rock stratum, which one is the most reasonable?

(A) The rock stratum 甲 was deposited at least 15,000 years ago.

(B) The rock stratum 丙 was deposited less than 10,000 years ago.

(C) The dike was formed at least 10,000 years ago.

(D) The dike was formed less than 15,000 years ago.

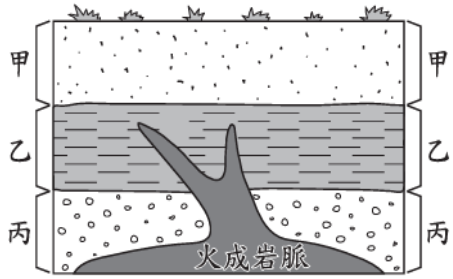
（中文）圖(二十一)為某地的地質剖面圖，已知此地地層未倒轉，且乙岩層的沉積年代為距今 15,000 年～10,000 年前之間，下列有關其他各岩層的沉積年代或形成年代，何者最合理？

(A)甲岩層的沉積年代距今至少 15,000 年。

(B)丙岩層的沉積年代距今不到 10,000 年。

(C)火成岩脈的形成時間距今至少 10,000 年。

(D)火成岩脈的形成時間距今不到 15,000 年。



圖(二十一)

（111 年國中會考第 40 題）

Teacher: The question mentions that "the strata have not been reversed". What is the sequence of the formation time of different rock strata in Figure (21) from old to young?

Student: 丙, 乙, 甲.

Teacher: Correct. Then let's check the options one by one! First of all, option A says that the rock stratum 甲 was deposited at least 15,000 years ago, which should be wrong because the rock formation 乙 beneath 甲 was deposited between 15,000 and 10,000 years ago. The rock stratum 甲 is younger than rock stratum 乙, so the rock stratum 甲 should be deposited less than 15,000 years ago. Then, for the same reason, why is option B wrong?

Student: Because the rock stratum 丙 was formed earlier than rock stratum 乙, it should be deposited at least 15,000 years ago.

Teacher: Correct. Let's take a look at options C and D. It can be seen from the figure that The dike formed later than the rock stratum 乙, but we can't infer the formation time of the dike accurately. The only thing that is certain is that the formation time of the dike must be later than the rock stratum 乙. Therefore, it will not be earlier than 15,000 years ago. After the above deduction, what do you think the answer is?

Student: The answer is (D).

Teacher: Great!

老師： 題幹堤及「地層未倒轉」，表示圖(二十一)的地質年代由老到年輕的排列為何呢？

學生： 丙、乙、甲。

老師： 回答正確。那我們來一個一個選項檢視吧！首先，A 選項說甲地層的沉積年代至少是在距今 15000 年之前，應是錯誤的，因為乙岩層形成的年代是距今 10000-15000 年，甲岩層比乙岩層更加年輕，甲形成的年代距今應該少於 15000 年才對。那麼，同樣的道理，想請同學們告訴老師，為何 B 選項錯誤呢？

學生： 因為丙岩層所形成的年代是比乙岩層更早,因此其沉積的年代應該至少是在距今 15000 年之前。

老師： 回答正確。那我們來看看 C、D 選項，由圖可知，岩脈的侵入是在乙岩層形成之後，但無法確認岩脈侵入時的準確時間，唯一可以確定的是岩脈侵入時的時間必然比乙岩層形成晚，故不會早於距今 15000 年。經過以上推論，同學們覺得答案是多少呢？

學生： 答案是(D)。

老師： 很棒！

例題二

說明：透過圖面的判讀，了解地質事件的先後順序。

Understand the sequence of geological events through the interpretation of the map.

（英文）Figure (6) is a stratigraphic profile in a certain area. Marks with the same symbol or color in the figure represent the same stratum before being dislocated by faulting. It is known that the strata in this area have never been turned upside down. Stratum 乙 contains fossils from 10 million years ago, and stratum 戊 contains fossils from 50 million years ago. If a stratum in the picture contains fossils from 30 million years ago, which of the following is the most likely stratum?

(A)己 or 庚

(B)丁 or 己

(C)丙 or 丁

(D)甲 or 丙

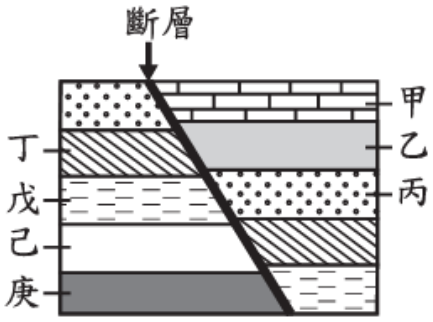
（中文）圖(六)為某區域的地層剖面示意圖，圖中相同符號或顏色的標示，代表其未受斷層錯動前為同一地層。已知此地區地層未曾發生上下翻轉，在地層乙中含有一千萬年前的生物化石，地層戊中則含有五千萬年前的生物化石。若圖中某地層含有三千萬年前的生物化石，則該地層最有可能為下列何者？

(A)己 or 庚

(B)丁 or 己

(C)丙 or 丁

(D)甲 or 丙



圖(六)

（109 年國中會考第 7 題）

Teacher: For this question, you need to pay attention to the fact that the strata are dislocated by faulting and there is no up-down inversion. Considering the left and right sides of the fault plane, which stratum on the right does the stratum 戊 on the left correspond to?

Student: Stratum 戊 corresponds to the bottommost stratum on the right.

Teacher: That's right! Therefore, both stratum 戊 and the bottommost stratum on the right may contain fossils from 50 million years ago. In addition, according to this sequence, it can be known that stratum 乙, which is above stratum 戊, was formed later. And it contains fossils from 10 million years ago.

Student: According to the above information, the stratum containing fossils from 30 million years ago should be placed between stratum 乙 and stratum 戊, shouldn't it?

Teacher: That's right. Can you please try to give more details?

Student: The stratum containing fossils from 30 million years ago should be stratum 丙 or stratum 丁.

Teacher: Correct. Option C is the correct answer.

老師： 此題特別需要請同學們注意到，這是一個有發生斷層錯動且未發生上下反轉的地層。考量斷層面的左右側，左邊的戊地層可以對應到右側的哪一層呢？

學生： 戊地層可以對應到右側最底下的地層。

老師： 沒錯！因此戊地層與右側最底下地層，都有可能含有五千萬年前的化石；且根據這樣的對應方式可以知道乙地層在戊地層之上，形成年代較晚，且含有一千萬年前的化石。

學生： 那麼根據上方所說，含有三千萬年前化石的地層應該就是介於乙到戊之間對嗎？

老師： 沒錯，那麼可否請同學再試著回答得更詳細一些呢？

學生： 含有三千萬年前化石的岩層應是丙或丁岩層。

老師： 回答正確，選 C 選項為正解。

★主題三 浩瀚的宇宙★
The Vast Universe

國立彰化師範大學地理學系　范嵐瑄、蔡昕芮

■ 前言 Introduction

人們對於遙遠的宇宙充滿著許多的想像，為了了解浩瀚無垠的宇宙，各國的研究單位利用他們在太空中的探測器，希望能揭開宇宙的奇幻世界。首先要認識的是宇宙的組成，以及科學家們如何描述太陽系中各行星與太陽之間的距離：接著說明因地球自轉會產生的日夜交替現象，並探討地球為什麼一年之中會有季節的變化？最後再介紹太陽、月球與地球之間在相互運動時所產生的日蝕、月蝕等的天文景象。

3-1 宇宙與太陽系
Universe and Solar System

■ 前言 Introduction

每當人們仰望天空中的滿天星斗，有時也會突然看見劃過天際的流星，它的軌跡彷彿是要掉到地球的盡頭；而在夜晚裡所看到的一顆顆不同光亮的星星是什麼呢？我們又身在何處？由於天文觀測方法的進步，使我們更明白所居住的地球僅僅只是浩瀚宇宙中的滄海一粟，宇宙裡仍有許多的未知，正等待著我們去好好的探索。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
astronomy	天文學	planet	行星
earth	地球	revolution	公轉
galaxy	星系	satellite	衛星
Jovian planets	類木行星	Saturn	土星
Jupiter	木星	Sirius	天狼星
light-year	光年	Solar System	太陽系
Mars	火星	star	恆星
Mercury	水星	Terrestrial planets	類地行星
Milky Way	銀河系	universe	宇宙

Neptune	海王星	Uranus	天王星
orbit	軌道	Venus	金星

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

❶ How far is _____ from _____?

例句：**How far is** the Earth **from** Sun?

地球距離太陽有多遠？

❷ There are _____ in the _____.

例句：**There are** eight planets **in the** solar system.

有八顆行星在太陽系中。

❸ It takes _____ to revolve around _____.

例句：**It takes** the earth about 365 days **to revolve around** the Sun.

地球公轉太陽一圈大概會花上 365 天。

❹ _____ be composed of _____.

例句：Terrestrial planets **are composed of** rocks and metals.

類地行星由岩石和金屬組成。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應習得以下觀念：

After studying this section, students should be able to know that:

一、了解光年為天文學中常用距離單位，並可利用光年進行簡單換算。

Students can understand that light-year, or lightyear, is often used to measure the distance of space in astronomy. They will also be able to calculate astronomical distances with the unit of light-year.

二、學生能對太陽系的行星進行系統性的比較。像是類地行星與類木行星的特質差異等。

Students can compare different planets in a systematic way. For example, they can point out the differences between Terrestrial and Jovian planets.

❧ 例題講解 ☙

例題一

說明：學生能夠熟悉光年所代表的意義及換算上的使用。

Students can know what light year means and how to use it in unit conversion.

（英文）Light travels 9.46 × 1012 km in one year. It is about 8.7 light-years from Earth to Sirius . Based on this information, how many years does light need to travel from Sirius to Earth?

（中文）光走一年的距離為 9.46 × 1012 公里，天狼星距地球約 8.7 光年，由此可知光從天狼星到地球需時多少年？

(A)8.7　(B)8.7×（9.46×1012）

(C)8.7／（9.46×1012）　(D)（9.46×1012）／8.7

（91 年第二次國中基測第 48 題）

Teacher: We know that light years are the distance that light travels in a vacuum in one year. So, are light years used as a unit for measuring distances or time?

Student: Light years are used as a unit of distance.

Teacher: Now, the question tells us that it takes light 8.7 light years to travel from Sirius to Earth. How many light years does light need to travel in a vacuum from Sirius to Earth?

Student: 8.7 light years.

Teacher: Yes, 8.7 light years is correct. Option A is our answer.

老師： 光年是指光在真空中前進一年的距離，所以光年是距離單位還是時間單位？

學生： 距離單位。

老師： 那我們看到題目中提到光從天狼星到地球約 8.7 光年，所以光在真空環境中前進了多少年才抵達？

學生： 8.7 年。

老師： 所以正確答案應該為(A)8.7 年。

例題二

說明：學生能比較太陽系中類地行星與類木行星的特質差異。

Students can tell the difference between Terrestrial and Jovian planets of the Solar System.

（英文）Based on the current knowledge of the Solar System, which of the following statements is correct?

(A) Both Terrestrial and Jovian planets of the Solar System have the same number of planets.

(B) The Milky Way has a similar number of starts to the Solar System.

(C) The Terrestrial planets are composed mainly of gases and ice.

(D) The Jovian planets are less dense and smaller than the Terrestrial planets.

（中文）有關目前對太陽系的認識，下列敘述何者正確？

(A)八大行星中類地行星與類木行星數量相同。

(B)銀河系與太陽系擁有的恆星數量大致相同。

(C)類地行星主要是由氣體、冰等物質所組成。

(D)類木行星的密度以及體積皆小於類地行星。

（109 年國中會考第 22 題）

Teacher: Let's start with Option A first. Do both Terrestrial and Jovian planets have the same number of planets? What are they?

Student: The Terrestrial planets include Mercury, Venus, Earth, and Mars. The Jovian planets also have four planets. They are Jupiter, Saturn, Uranus, and Neptune.

Teacher: That is correct! How about Option B? In fact, there are so many stars in the Milky Way – around 200 billion stars. However, Sun is the only star in our Solar System, so Option B is wrong.

Teacher: Next, The Terrestrial planets are composed mainly of rocks and metals. So, Option C is wrong either.

Teacher: Finally, Option D is also wrong. We have just mentioned that the Terrestrial planets are composed mainly of rocks and metals. In contrast, the Jovian planets are composed mainly of gases and ice. About density, are the Jovian planets denser or less dense than the Terrestrial planets? Why is that?

Student: The Terrestrial planets are denser than the Jovian planets. Their volumes as a whole are greater than that of the Terrestrial planets, and the Terrestrial planets are made of solid surfaces.

Teacher: That is right. The mass and volume of the four Terrestrial planets are relatively smaller, but their average density is greater than that of the four Jovian planets. In other words, the four Jovian planets have low densities despite their sizes. Saturn is a case in point. Saturn is lighter than water.

Teacher: Now, tell me which of the given statements is correct?

Student: Option A is correct.

Teacher: Great job.

老師： (A)選項，類地行星與類木行星分別都有四顆行星，請問各是哪四顆行星呢？

學生： 類地行星有水星、金星、地球和火星，而類木行星則是木星、土星、天王星和海王星。

老師： 答對了！那(B)選項的敘述對不對呢？實際上銀河系中有很多恆星，大概兩千億顆以上，太陽系只有太陽一顆恆星；所以(B)是錯誤的敘述。

老師： (C)選項的正確敘述應該是類地行星主要是由岩石、金屬等物質所組成，所以(C)的敘述也是不正確的。

老師： 再來看(D)選項的內容，剛剛提到類地行星的成分大都是由岩石和金屬所組成的，而類木行星的成分主要是由氣體、冰組成的，同學想一想這樣類地行星的密度會比類木行星大還是小呢？為什麼？

學生： 類地行星的密度會比類木行星大，因為類木行星的體積比類地行星大了許多，且類地行星的表面多為固體。

老師： 是的。雖然類地行星的四顆行星質量與體積都較小，但平均密度還是比較高的；而類木行星的四顆行星的體積和質量雖然比較高，但是平均的密度卻是比較低的，像土星的密度就比水還要低了許多。

老師： 所以這一題的正確敘述應該是選哪一個呢？

學生： (A)的敘述內容才是正確的。

老師： 非常好。

3-2 晝夜與四季
Day & Night and the Seasons

■ 前言 Introduction

為什麼在一天之中，我們會經歷一個白天、一個夜晚呢？又為什麼有時候會覺得白天的時間很長，而夜晚的時間很短？在經過一段時間之後卻又相反了呢？想要了解這些生活中的日夜變化，就必須要先了解地球繞太陽的公轉位置與地球自轉的關係，以及太陽對地球產生了什麼樣的影響？

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
rotation	自轉	solstice	至日/至點
axis of rotation	自轉軸	perpendicular incidence	直射
revolution	公轉	daylength	日照長短
vernal equinox	春分	polar day	永晝
summer solstice	夏至	polar night	永夜
autumnal equinox	秋分	Arctic Circle	北極圈
winter solstice	冬至	Tropic of Capricorn	南回歸線

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

❶ _____ revolves around _____.

例句：The Earth **revolves around** the Sun.

地球繞著太陽公轉。

❷ _____ is now polar night/day.

例句：The North Pole **is now polar night/day.**

北極現在是永夜／永晝。

❸ _____ not only _____ but also _____.

例句：The Earth is **not only** rotate **but also** revolute around the Sun.

地球不只會自轉也會繞著太陽公轉。

❹ My favorite season is _____.

例句：**My favorite season is** summer.

我最喜歡的季節是夏天。

■ 問題講解 Explanation of Problems

學習目標

在學習完本單元後，學生應習得以下觀念：

After studying this unit, students should be able to know the following concepts:

一、學生能清楚知道不同季節太陽光的直射位置不同，日照長短會受此影響。

Students clearly understand that the locations of perpendicular incidence of sunlight vary in different seasons. The daylength consequently is affected.

二、學生能清楚知道地球在對太陽公轉的軌道上的位置以及太陽光直射在地球上位置的會改變而影響地球接收的太陽照射能量，進而造成季節變化。

Students clearly understand that the Earth's position in the revolution orbit around the Sun and the location of perpendicular incidence of sunlight on Earth are constantly changing, which result in different energy from the sun received by Earth. The consequence is the seasonal changes.

∞ 例題講解 ∞

例題一

說明：學生能夠知道太陽直射地球不同位置時，會使不同地方的晝夜長度不同。

Students know that when sunlight irradiates perpendicularly at different locations on the Earth, the daylength could vary.

（英文）The picture shows the sunlight irradiating the Earth someday of the year. According to the picture, which of the following statements is true?

(A) Comparing the daylength at different locations, 乙＞甲＞North Pole.

(B) Comparing the daylength at different locations, 甲＞乙＞North Pole.

(C) There is no sunlight at North Pole at all.

(D) There is no sunlight at South Pole at all.

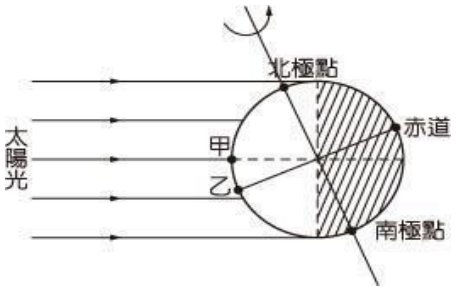
（中文）右圖為一年中某日陽光照射地球的示意圖，由圖中所提供的資料判斷，下列何者正確？

(A)當天日照總時數比較，乙＞甲＞北極點。

(B)當天日照總時數比較，甲＞乙＞北極點。

(C)北極點當天完全看不到太陽。

(D)南極點當天完全看不到太陽。



（94 年第二次國中基測第 28 題）

Teacher: According to the picture, we learn that sunlight perpendicular incidence occurs at North Hemisphere. Do you know what possible season the Northern Hemisphere is in?

Student: It could be summer.

Teacher: Where does polar day happen in this picture?
Student: At the North Pole.
Teacher: Meanwhile, the South Pole should be…?
Student: The South Pole should be polar night.
Teacher: Then, which is the correct answer?
Student: (D).

老師： 根據圖片，我們可以知道太陽直射北半球，所以同學們可以知道北半球現在可能是哪個季節嗎？
學生： 可能是夏季。
老師： 所以在圖片中哪個地方會出現永晝現象？
學生： 在北極點的位置。
老師： 所以這個時候的南極點應該是.....？
學生： 南極點應該是永夜的狀態。
老師： 那麼正確的選項應該是哪一個？
學生： (D)。

例題二

說明：學生能理解太陽的運動軌跡及高度角的變化與日照時長的關係。
Students can understand how the trajectory of the Sun's motion and changes in the solar altitude angle relate to the length of sunshine.

（英文）The schematic diagram below shows Bobo's one-year observation of the noon Sun's positions in the sky. He found that the noontime shadows are the shortest at Point X (The length of the shadows is shorter than the body height). The noontime shadows are half of the body height at Point Y (The length of the shadow equals ½ of the body height). The noontime shadows are the longest at Point Z (The length of the shadows is larger than the body height). If the noon Sun is at Point Z that day, which of the following statements is true?
(A) That day, the day is longer than the night.
(B) That day, the day is equal with the night.
(C) Over the year, the Sun is at Point Z for two days.
(D) Over the year, the Sun is at Point Z for one day.

（中文）有關目前對太陽系的認識，下列敘述何者正確？

(A)八大行星中類地行星與類木行星數量相同

(B)銀河系與太陽系擁有的恆星數量大致相同

(C)類地行星主要是由氣體、冰等物質所組成

(D)類木行星的密度以及體積皆小於類地行星

（109 國中會考自然科第 22 題）

Teacher: Let's look at the diagram. What do you see?

Student: This is a schematic diagram. It shows at what angle and in what position the Sun radiates over the horizon at different times.

Teacher: that's great. Have you also noticed the English letters in the diagram? What do those letters represent?

Student: I think they represent the noontime, meaning the highest position the Sun reaches in a day.

Teacher: That's right. Let's go back to the question. From the question, we know the Sun now is at Point Z, the midday position at the Winter Solstice. That is when the day is shorter than the night with the fewest hours of sunlight.

老師： 讓我們來看這個圖片。你們能告訴我這個圖描述了什麼情況嗎？

學生： 這個圖是一個示意圖，顯示了太陽在不同時間投射在地平線的位置和角度。

老師： 很好。那你們有注意到圖中有一些英文標記嗎？那代表什麼意思呢？

學生： 我猜那些點代表正午時分，也就是太陽所在的最高點的位置。

老師： 沒錯。那我們看題目，題目說，現在太陽的位置在 Z 點，也就是冬至時太陽在正午時的位置。當天白晝較黑夜短，所以這是冬天日照最短的一天。

3-3 日地月的相對運動
Relative Motion of the Sun, Earth and Moon

■ 前言 Introduction

月球是地球的衛星，本身並不會發光。晚上因月球表面反射了太陽光線才讓我們看到了月亮。根據太陽、地球與月亮三者相對位置的變化，讓我們得以觀察到月相的盈虧，日蝕與月蝕及潮汐等現象，其中潮汐的漲潮與退潮對漁業尤為重要。為什麼我們每天看到的月亮都長得不大一樣呢？猶如神秘的千變女郎。而太陽幾乎每天都長得一樣，但久久卻會突然消失一陣子？到底為什麼會如此呢？讓我們一起探個究竟吧！

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
counter-clockwise direction	逆時針方向	new moon	新（朔）月
ebb tide	退潮	relative position	相對位置
estuary	河口	revolution	公轉
flood tide	漲潮	shadow zone	陰影區
full moon	滿（望）月	shooting star	流星
first quarter moon	上弦月	solar eclipse	日蝕
last quarter moon	下弦月	lunar eclipse	月蝕
high tide	滿潮	tides	潮汐

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

❶ _____ when _____ are aligned.

例句：A lunar eclipse occurs **when** the sun, earth, and moon (in order) **are aligned**.

當日、地、月（依序）排列成一直線時，月蝕現象發生。

❷ It takes _____ to revolve around _____.

例句：**It takes** the moon about 30 days **to revolve around** the earth.

月球公轉地球一周大約會花上 30 天。

❸ The tide is in, we _____.

例句：**The tide is in**, **we**'d better get back.

漲潮了，我們最好回去吧。

❹ _____, waiting for high tide.

例句：We moored in the estuary, **waiting for high tide.**

我們在河口停泊，等待漲潮。

■ 問題講解 Explanation of Problems

學習目標

在學習完本單元後，學生應習得以下觀念：

After studying this section, students should be able to know the following concepts:

一、學生能夠從日地月相對位置關係判別不同月相與相對應發生的時間。

Students can tell different phases of the moon from the relative positions of sun, earth, and moon and their related occurring time.

二、學生能計算並運用潮汐規律。

Students can infer and apply the regulation of the tides.

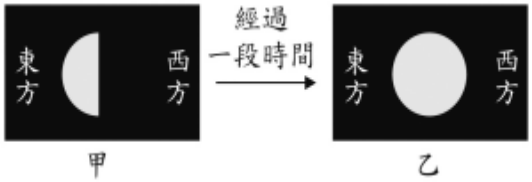
例題講解

例題一

說明：學生能夠由圖中日地月相對位置判別月相與推算相對應時間。
Students can tell the phases of the moon and infer the corresponding time from the relative position of sun, earth, and moon.

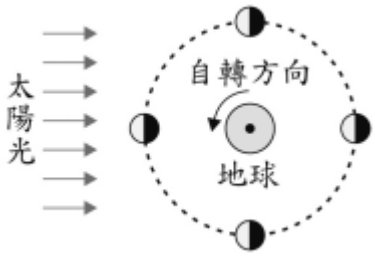
（英文）One day, Ming took a picture 甲 of the sky over his head. At some other time within 30 days, he took picture 乙 of the sky at the same place. As shown in the upper right pictures, the white part was the phase of the moon that Ming saw. The lower right picture shows the relationship between the Moon, Sun, and Earth. The black point represents the North Pole. Consider the lower right picture, based on the phase of the moon and the picture taken position, what is the time interval of these two pictures?

(A) The time interval is 7 days.
(B) The time interval is 14 days.
(C) The time interval is 21 days.
(D) The time interval is 30 days.



（中文）某次出遊時，小明朝自己頭頂附近的天空拍攝得到甲照片，在 30 天內的某日舊地重遊，於同一地點朝自己頭頂附近的天空拍攝得到乙照片，兩張照片如右上圖所示，其中白色部分是當時小明看到的月相。右下圖是月球、地球與太陽光相對關係示意圖，黑點代表地球北極，參考右下圖並根據月相與拍攝方位判斷，下列有關兩照片拍攝時間間隔的推論，何者較合理？

(A) 相隔約 7 天。
(B) 相隔約 14 天。
(C) 相隔約 21 天。
(D) 相隔約 30 天。



（104 年國中會考第 45 題）

Teacher: In the upper right pictures, picture 甲 shows the first quarter moon, and picture 乙 shows full moon.

Teacher: According to the lower right picture, what phases of the moon we will observe

between first quarter moon and full moon?

Student: In counter-clockwise direction, we will observe new moon after first quarter moon, and then last quarter moon before the full moon.

Teacher: How many days between first half-moon to full moon?

Student: Because Moon revolved around the Earth and rotates simultaneously in a cycle of 28 days. And, from first quarter moon to full moon is just three-fourth of the cycle, therefore, the answer is 28 × (3/4) = 21 days.

Teacher: That's right! The correct answer is (C), 21 days.

老師： 題目中右上方的甲圖為下弦月、乙圖為望月(滿月)時所拍攝的照片。

老師： 從下方的圖可知下弦月到滿月之間我們會看到哪些月相呢？

學生： 依逆時鐘方向，下弦月之後會看到朔月，再來看到上弦月之後才會到滿月。

老師： 所以從下弦月到滿月，總共要經過幾天呢？

學生： 因月亮繞地球的公轉與自轉同步，週期約為 28 天，且從下弦月到望月正好是經歷週期的四分之三，因此 28 × (3/4) = 21 天。

老師： 沒錯！所以正確的選項為(C) 21 天。

例題二

說明：學生能知道潮汐規律並能計算運用。

Students understand the regulation of tides and apply the calculation.

（英文）Qiang unfortunately drifted to a desert island. After observing the tides for a while, he found out that in a month, there were two days of high tides having the highest water level. The phases of the moon of the two days might be either full moon or no moon. The best timing of taking the raft to leave was one of the two days. Accordingly, he started to craft the raft on some full moon day. If it took Qiang 7 days to make the raft and he could leave the island once the water reaches the highest level, how long did he have to wait to leave at least?

(A) The day he finished making the raft.

(B) Seven days.

(C) Fifteen days.

(D) Twenty-one days.

（中文）阿強不幸漂流到無人島，他在觀察潮汐一段時間之後，發現每個月有兩天滿潮的水位最高。這兩天的月相，可能是滿月或是整天都看不到月亮，且為乘坐木筏離開的最好時機，因此他在某個滿月的日子開始製作木筏。若阿強用了 7 天做好木筏，只要等到有上述滿潮水位最高的日子就能離開，則他最快要再等大約多久才可離開？

(A) 完工當天。

(B) 7 天。

(C) 15 天。

(D) 21 天。

（106 年國中會考第 23 題）

Teacher: In each month, high tide happens when it is dates of new moon and full moon, which is the first day and the fifth day of the month. Therefore, the time interval is two weeks from full moon to the next flood tide.

Teacher: Qiang started making the raft on the full moon day, how long did he take to make the raft?

Student: Seven days.

Teacher: In how many days will high tide happen?

Student: Since the time interval of the two high tides is 15 days, (15 − 1) − 7 = 7 days.

Teacher: Exactly! In about 7 days. So, what is the answer?

Student: (B).

老師：每個月滿潮發生在朔、望月，也就是初一和十五。因此從滿月到下一次漲潮時間間隔半個月。

老師：阿強是從滿月當日開始製作木筏，阿強經過幾天製作好了木筏？

學生：7 天。

老師：那麼還要再經過幾天才會遇到滿潮？

學生：因兩次最高水位的滿潮約相隔 15 天，所以(15−1) − 7 = 7 天。

老師：沒錯！大約再經過 7 天，所以那一個選項才是正確的答案呢？

學生：(B)。

★主題四 變幻莫測的大氣★
Unpredictable Atmosphere

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■ 前言 Introduction

因受到地球自轉軸傾斜，以及地球繞太陽公轉的影響，使得地球在一年之中因位於不同的公轉位置時，地表可地表獲得的太陽照射的能量也會有所不同，因此除了產生四季的變化之外，也造就了各種天氣的現象！首先介紹地球上大氣的組成及成分，接著藉由風和雨的說明來切入介紹天氣的分類，以便於理解生活中的天氣現象是如何產生的。第三部分則解釋影響天氣現象的重要因子-氣團與鋒面。最後介紹台灣的災變天氣，例如寒流、梅雨、颱風及乾旱等天氣現象，使學生能夠理解並解釋生活中所遭遇到的天氣現象。

4-1 地球的大氣
Earth's atmosphere

■ 前言 Introduction

圍繞在地球周圍的空氣稱為大氣層，大氣的存在使生物得以生存，大氣的循環平衡了地球的能量，也產生天氣的變化。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
absorption/ absorb	吸收	stratosphere	平流層
atmosphere	大氣	altitude	高度
atmospheric profile	大氣層	kilometer	公里
air pressure	大氣壓	nitrogen	氮
carbon dioxide	二氧化碳	oxygen	氧氣
constant gases	固定氣體	pollution	汙染
earth	地球	troposphere	對流層
gas	氣體	variable gases	可變氣體
gravity	重力	water vapor	水氣

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

❶ **We show the composition of ____, _____, and ____, etc. Among them, _____ is necessary for _____.**

例句：Hello everyone, we're Group 2. **We show the composition of** the Earth's atmosphere, including nitrogen, oxygen, argon, carbon dioxide **and** water vapor**, etc**. **Among them,** oxygen **is necessary for** human survival.

大家好，我們是第二組。我們展示了有關於地球大氣的組成成分，包含氮氣、氧氣、氬氣、二氧化碳、水(蒸)氣等，其中氧氣是人類生存所必需的氣體。

❷ **You can mark ___ and ____ on the presentation.**

例句：**You can mark** constant gases **and** variable gases **on the presentation.**

你們在報告時可以將恆定氣體與可變氣體標示出來增加在簡報上。

❸ **____ contain a variety of _____. Among them, ___ be.V ____, and _____ be.V _____.**

例句：Air **contains a variety of** different gases. **Among them**, nitrogen, oxygen, and argon **are** called the constant gases, **and** water vapor **is** a variable gas.

空氣中含有多種不同的氣體，其中氮氣、氧氣、氬氣稱為恆定氣體，水氣則為可變氣體。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

After studying this section, students should be able to know the following concepts:

一、大氣的主要成分為氮氣和氧氣等固定氣體，並含有水氣、二氧化碳等變動氣體。

The atmosphere is mainly composed of constant gases, such as nitrogen and oxygen, and variable gases such as water vapor, carbon dioxide and others.

二、大氣可由溫度變化分層並應用在生活情境中。

Studnets should know that atmosphere can be stratified by temperature changes and apply this in life situations.

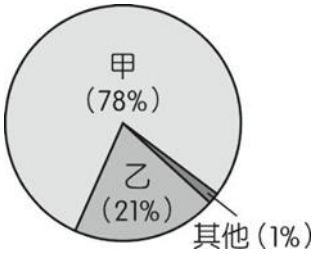
❧ 例題講解 ☙

例題一

說明：學生能確切理解地球上大氣組成成分，以及固定氣體的種類與意義。

Students will be able to understand the composition of the Earth's atmosphere, and the types and significance of constant gases.

（英文）The diagram on the right shows a pie chart of the composition of air near the Earth's surface. In general, the composition of the air near the surface is dominated by gases 甲 and 乙. According to this diagram, which of the following statements is correct?



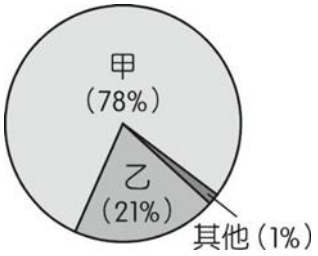
(A) 甲 is called a constant gases, and 乙 is not a constant gas.

(B) 乙 is called a constant gases. and 甲 is not a constant gas.

(C) 甲 is argon, the proportion of the air near the surface varies greatly with the locations.

(D) 乙 is oxygen, the proportion of air near the surface almost does not change with the locations.

（中文）右圖為地球地表附近乾燥空氣組成比例的圓餅圖。在一般情況下，地表附近的空氣組成以甲、乙兩氣體為主。根據此圖，下列敘述何者正確？



（A）甲被稱為恆定氣體，乙則不是恆定氣體。

（B）乙被稱為恆定氣體，甲則不是恆定氣體。

（C）甲為氬氣，在地表附近空氣中所占的比例隨地點有很大變化。

（D）乙為氧氣，在地表附近空氣中所占的比例幾乎不隨地點改變。

（110 年國中會考第 12 題）

解題 Solution:

由圖可知甲是氮氣，乙是氧氣，兩者皆是不隨時間地點改變的恆定氣體。故選（D）。

"甲" is Nitrogen and "乙" is oxygen. Both of them are constant gases, which do not change with time or place.

Teacher: What do you think are the most and the second most abundant gases in this pie chart?
Student: Nitrogen and Oxygen.
Teacher: That's right! Will the proportion of them change with time or places?
Student: No. Both 'nitrogen' and 'oxygen' are in fixed proportion.
Teacher: So are they constant gases?
Student: Yes!
Teacher: Then can you tell me what kind of gases change with time and places?
Student: Water vapor, because the water vapor will have different proportions at different relative humidity.

老師： 地球大氣的組成成分占比最高與第二高的氣體是什麼？
學生： 氮氣與氧氣。
老師： 沒錯！「氮氣」與「氧氣」在空氣中的比例會隨著不同的時間地點變動嗎？
學生： 不會~「氮氣」與「氧氣」都是固定比例的。
老師： 這兩種氣體是不是恆定氣體？
學生： 是！
老師： 那可以請你們告訴我哪些氣體會隨著不同的時間地點變動嗎？
學生： 水氣，因為在不同相對濕度的時候水氣會有不一樣的比例。

例題二

說明：此題不僅能夠測驗學生是否能記憶大氣中的分層，並結合實際案例區別大氣在不同海拔高度的特性。

This question can check whether students can memorize the atmospheric profle and distinguish features of atmosphere at different altitudes with authentic cases.

（英文）On a winter vacation trip abroad, 小哲 found that there were no clouds above the plane, but there was a cloud sea below, when the full moon in the east was just rising. He took a picture out of the right-hand window of his seat, as shown in the picture, where the plane was located near 35 degrees north latitude at an altitude of about 12,000 meters. After searching for the data at home, 小哲 thought that when he took the picture, the airplane was flying near the middle of the top of layer A and the bottom of layer B in the atmospheric profile in this picture. Which of the following should be the names of the layers A and B at the double line?

(A) Layer A：Stratosphere；Layer B：Mesosphere

(B) Layer A：Mesosphere；Layer B：Troposphere

(C) Layer A：Stratosphere；Layer B：Troposphere

(D) Layer A：Troposphere；Layer B：Stratosphere

（中文）某次小哲寒假出國旅行途中，發現飛機上方無雲，但下方卻有一片雲海，此時東方的滿月剛好升起。他朝向座位右側窗外拍攝了一張照片，如圖所示，此時飛機位於北緯 35 度附近、高度約為 1 萬 2 千公尺。小哲回家查詢資料後，認為拍攝此照片時，飛機高度大致位於大氣分層中的甲層頂部和乙層底部之交界附近。

關於上述畫雙底線處甲、乙兩層的名稱，應為下列何者？

(A)甲層：平流層，乙層：中氣層

(B)甲層：中氣層，乙層：對流層

(C)甲層：平流層，乙層：對流層

(D)甲層：對流層，乙層：平流層

（109 年國中會考第 49 題）

解題 Solution:

國際航班為求長時間飛行平穩，會將飛行機飛行於大氣分層中的平流層，因平流層以水平運動為主，飛行時較為穩定，平流位於大氣分層中的「對流層頂部」和「平流層底部」之交界附近。故選(D)。

For international flights, the aircraft will fly in the stratosphere of the atmospheric stratification in order to have a stable flight over a long period of time. Clouds only appear in the troposphere. Therefore, the altitude of the aircraft is roughly near the junction of the "top of the troposphere" and the "bottom of the stratosphere" in the atmospheric stratification. Therefore, choose (D).

Teacher: Do you know which layer of atmosphere that civil aircrafts usually fly in?
Student: Stratosphere.
Teacher: And why do they have to fly in the stratosphere instead of the troposphere?
Student: Because the air in stratosphere is moving horizontally, and the flight is more stable,
Teacher: On the other hand, the air in the troposphere moves vertically. In the troposphere, turbulence happens easily and the clouds are developed here as well.
Teacher: To be precise, where in the atmosphere profile will the aircraft cruise?
Student: Near the area between the "top of the troposphere" and the "bottom of the stratosphere".

老師： 同學們知道平常搭飛機時飛行在哪個大氣層嗎？
學生： 平流層！
老師： 知道為什麼要飛行在平流層而不是對流層嗎？
學生： 因為平流層空氣是水平運動，飛行會比較穩定。
老師： 而對流層的空氣是垂直運動，容易有亂流，也是一般雲層能夠發展的位置喔~
老師： 精準地說，飛機巡航高度會在大氣分層中的哪裡？
學生： 「對流層頂部」和「平流層底部」之交界附近。

4-2 天氣的變化
Changes of Weather

■ 前言 Introduction

天氣是指某一地區在短時間內的大氣狀態，而天氣的變化與當時的大氣溫度、氣壓、運動以及水氣量的變動有著密切關聯，是造成不同天氣現象的主要原因。例如氣溫下降、風變強、晴天轉雨天等等的情況都是天氣變化的表現。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
apparent temperature	體感溫度	ice crystals	冰晶
atmospheric pressure	氣壓	isobar	等壓線
Coriolis Force	科氏力	northern hemisphere	北半球
condensation	凝結	precipitation	降水
dewpoint temperature	露點溫度	Relative humidity	相對溼度
evaporation	蒸發(作用)	saturated humidity	飽和溼度
frost	霜	wind direction	風向
fog	霧	wind speed	風速

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

❶ The _____ in the _____ comes mainly from _____, and partly from _____.

例句：**The** water **in the** air **comes mainly from** evaporation from oceans, lakes and rivers, **and partly from** evaporation from plant leaves.

空氣中的水氣主要來自海洋、湖泊和河川的蒸發，部分則來自植物葉片的蒸散。

❷ In addition, _____ is called _____.

例句：**In addition,** the maximum value of air at a certain temperature and volume **is called** "saturation". When the relative humidity reaches 100%, water vapor has the opportunity to condense into droplets or ice crystals.

另外，空氣在一定的溫度與體積之下達到的最大值稱為「飽和」，此時相對溼度達到 100%，水氣有機會凝結成水滴或冰晶。

❸ _____ is made of _____. When _____ are heavier than _____, they will _____.

例句：A cloud **is made of** condensed water. **When** some water droplets or ice crystals **are heavier than** buoyancy in the air, **they will** fall to earth, which is called precipitation.

雲是由水氣凝結而成，當其中凝結的水滴或冰晶過重大於空氣浮力時，就會掉落形成降水(precipitation)。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應能：

After studying this section, students should be able to:

一、理解南北半球高低氣壓的特性，並推論正確的等壓線數值。

Know the characteristics of high and low pressure in the southern or the northern hemisphere and infer the correct isobaric line.

二、應用氣溫與相對溼度表格，正確推論體感溫度與酷熱指數等級的意義。

Apply the tables of temperature and relative humidity and infer correctly the meaning of apparent temperature and heat index.

❧ 例題講解 ☙

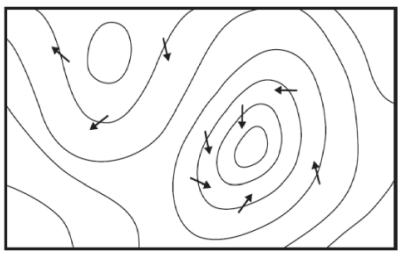
例題一

說明：測驗學生是否理解南北半球高低氣壓的特性，並推論正確的等壓線數值。

To test if students know the characteristics of high and low pressure in the southern or the northern hemisphere and infer the correct isobars.

（英文）The picture shows the distribution of isobars on the surface of a place in the northern hemisphere. The arrows represent the main air flow direction on the surface then. Which of the following pressure values (hPa) on the isobars best matches the atmospheric conditions at the time?

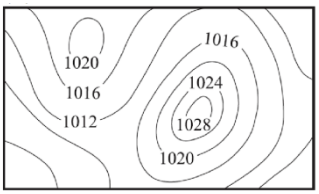
（中文）圖為北半球某地地表的等壓線分布圖，箭頭代表當時地表主要的空氣流動方向，關於下列圖中等壓線上的氣壓值（單位為百帕），何者最符合圖當時的大氣情況？



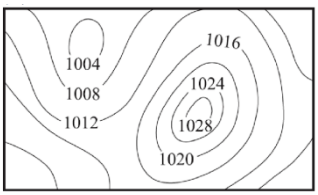
圖(十六)

（109 年國中會考第 23 題）

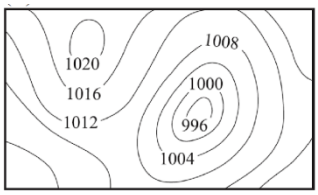
(A)



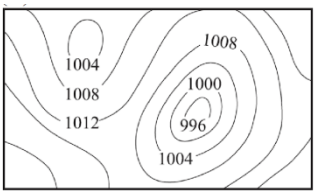
(B)



(C)



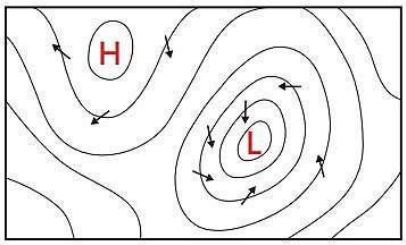
(D)



解題 Solution:

在北半球，由於空氣流動會偏向右邊，故高氣壓中心附近的空氣會以順時鐘方向向外流出，而低氣壓中心附近的空氣會以逆時鐘方向向內流入。故能判斷左側輻散處為高氣壓，越靠中心數字越大；右側輻合為低氣壓，越靠中心數字越小。故選(C)。

In the northern hemisphere, circulating air is deflected toward the right. Therefore, air around the center of a high pressure system flows outward in a clockwise direction while air around the center of a low pressure system flows inward in a counterclockwise direction. Accordingly, we can determine that the left side is a high pressure system, and the closer to the center, the higher the values. Meanwhile, the right side is a low pressure system, and the closer to the center, the lower the values. Therefore, the answer is (C).



Teacher: If the air in an area has higher pressure than the adjacent areas, a high pressure center will be created. For the counter case, it is called a low pressure center.

Teacher: The air around the center of a high pressure system flows inward or outward?

Student: Flows outward.

Teacher: That's right! And the closer to the center of high pressure, the atmospheric pressure value will be higher or lower?

Student: Higher!

Teacher: The air around the center of a low pressure system flows inward or outward?
Student: Flows inward.
Teacher: Great! Then, on the other hand, the closer to the center of low pressure, the atmospheric pressure value will be higher or lower?
Student: Lower!

老師： 如果一個地區的氣壓較周圍高，會形成高氣壓中心，反之稱為低壓中心。
老師： 請問高氣壓中心附近的空氣會往中心還是往外流出？
學生： 往外流出。
老師： 沒錯！ 而且越靠近高壓中心氣壓值會越高還是越低？
學生： 越高。
老師： 請問低壓中心的風如何流動？
學生： 往內流入。
老師： 很好！相反的越靠近低壓中心氣壓值會越高還是越低？
學生： 越低。

例題二

說明：學生能使用氣溫與相對溼度表格，可以正確地推論出體感溫度與酷熱指數等級之間的意義。
Students will be able to use the tables of temperature and relative humidity to infer correctly the meaning of apparent temperature and heat index.

（英文）Apparent temperature is what the temperature feels like to the humans body, and the heat index (HI) is an index that combines air temperature and relative humidity to represent apparent temperature. The human body cools down through sweating, during which water evaporates and carries away heat from the human body. When the human body fails to carry away excess heat from the human body in time, it may cause symptoms such as heat stroke. The table below shows the comparison of apparent temperature at different temperatures and humidity levels. The effect of apparent temperature on the human body can be divided into four different levels of heat index. According to the table on the right, which of the following statements is correct?

(A) No matter how the temperature and the humidity change, apparent temperature will always be higher than the current air temperature.

(B) No matter how the temperature changes, when the humidity reaches 100%, the heat index may show the level of extreme danger.

(C) When the temperature is 30℃ and the humidity is more than 50%, apparent temperature will be higher than the current air temperature.

(D) When the temperature is 31°C and the humidity is high, the heat index may reach the level of extreme dange.

（中文）人體真正感受到的溫度稱為體感溫度，而酷熱指數是其中一種綜合氣溫和溼度來代表體感溫度的指數。人體透過排汗來降溫，過程中水分會蒸發並從人體帶走熱量，當人體未能及時將人體多餘熱量帶走時，可能會使人出現中暑等症狀，故從事戶外活動時可參考酷熱指數，以避免中暑。附表為不同氣溫與溼度下的體感溫度對照表，而體感溫度對人體的影響又可分為四個不同酷熱指數等級。根據右表，下列敘述何者正確？

表(四)

體感溫度(℃)	氣溫(℃)												
溼度(%)	27	28	29	30	31	32	33	34	36	37	38	39	40
40	27	27	28	29	31	33	34	36	38	41	43	46	48
45	27	28	29	31	32	34	36	38	40	43	46	48	51
50	27	28	29	31	33	35	37	39	42	45	48	51	55
55	27	29	30	32	34	36	38	41	44	47	51	54	58
60	28	29	31	33	35	38	41	43	47	51	54	58	
65	28	29	32	34	37	39	42	46	49	53	58		
70	28	30	32	35	38	41	44	48	52	57			
75	29	31	33	36	39	43	47	51	56				
80	29	32	34	38	41	45	49	54					
85	29	32	36	39	43	47	52	57					
90	30	33	37	41	45	50	55						
95	30	34	38	42	47	53							
100	31	35	39	44	49	56							

警告　嚴重警告　危險　極度危險

酷熱指數等級	可能的影響
警告	長時間曝曬與活動可能導致疲勞
嚴重警告	長時間曝曬容易出現中暑、熱衰竭等症狀
危險	長時間曝曬相當容易出現中暑、熱衰竭等症狀
極度危險	長時間曝曬極度容易出現中暑、熱衰竭等症狀

(A)不管外界氣溫與溼度如何變化，體感溫度都會比當時的氣溫還高。

(B)不管氣溫如何變化，當溼度為 100%，酷熱指數皆屬極度危險等級。

(C)當氣溫為 30℃且溼度超過 50%時，體感溫度都會比當時的氣溫高。

(D)當氣溫為 31℃且溼度很高時，酷熱指數可能會達到極度危險等級。

（107 年國中會考第 53 題）

解題 Solution:

查看圖表可以得知，當氣溫在 31℃以下且濕度低時，體感溫度會小於或等於當氣溫，故(A)錯誤；且能察覺濕度 100%時氣溫須達到 32℃，酷熱指數才會達到「極度危險等級」，故(B)(D)錯誤；當氣溫為 30℃且溼度超過 50%時，體感溫度均大於 30℃，故選(C)。

According to the chart, when the temperature is below 31 ℃ and humidity is low, the apparent temperature will be lower than or equal to the current air temperature. Therefore, (A) is incorrect. Further, it can be found that when the humidity is 100%, the air temperature needs to reach 32 ℃ for the heat index to reach the level of "extreme danger," Accordingly, (B) (D) is incorrect. When the temperature reaches 30 ℃ and the humidity is higher than 50%, the apparent temperature would be higher than 30℃. Therefore, (C) is correct.

Teacher: Do you know what are the two factors that affect apparent temperature?

Student: Air temperature and Relative humidity.

Teacher: Look at the picture on the right. Under the same air temperature, what condition will make apparent temperature higher?

Student: The higher the humidity, the higher the apparent temperature will be.

Teacher: Did you find any conditions where the apparent temperature is lower than air temperature?

Student: In the case of 28~30°C and humidity of 40%, the apparent temperature is lower than the current air temperature.

Teacher: That's right! What is the temperature above which the heat index may reach the level of extreme danger?

Student: When the temperature reaches 32℃ or higher, the heat index will reach an extremely dangerous level.

老師： 同學們是否知道人體感溫度會受到哪兩種因素的影響嗎？

學生： 氣溫與濕度。

老師： 看一下右邊的圖表，在同樣的氣溫下什麼樣的條件會使得體感溫度會比較高？

學生： 濕度高的時候體感溫度會比較高。

老師： 同學們有找到體感溫度比氣溫還低的條件嗎？

學生： 在 28~30℃且濕度在 40%的情況，體感溫度小於當時氣溫。

老師： 沒錯！再請問同學在氣溫達到多少度以上酷熱指數可能會達到極度危險等級？

學生： 氣溫達到 32℃以上，酷熱指數將會達到極度危險的等級。

4-3 氣團、鋒面與季風
Air Mass, Front and Monsoon

■ 前言 Introduction

台灣在各季節裡會出現許多不同的天氣現象，例如大陸冷氣團、太平洋高壓、鋒面等等的天氣情況，因此本節將介紹這些天氣現象與系統是如何形成的，以及對台灣地區所產生的天氣影響。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
air mass	氣團	density	密度
Central Weather Bureau(CWB)	中央氣象局	front	鋒面
Central Mountain Range	中央山脈	monsoon	季風
climate	氣候	northeast monsoon	東北季風
climb	爬升	ocean	海洋
convective rain	對流雨	warm front	暖鋒
cold front	冷鋒	stationary front	滯留鋒
continental	大陸	weather forecast	天氣預報
probability of precipitation	降雨機率		

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

❶ _____ not only _____ but also _____.

例句：Air masses that affect Taiwan are **not only** Siberian High which is cold and dry **but also** Pacific High which is warm and wet.

影響臺灣的氣團不但有性質寒冷乾燥的西伯利亞高壓，也有性質溫暖潮溼的太平洋高壓。

❷ Because _____.

例句：**Because** the northeast monsoon is blocked by the Central Mountain Range during winter in Taiwan, the windward side of the northern and northeastern areas are prone to rain.

因為台灣冬季時東北季風受到中央山脈阻擋，所以迎風面的北部、東北部地區容易下雨。

❸ There are _____ such as_____.

例句：**There are** some common fronts, **such as** cold fronts, warm fronts and stationary fronts. Among them, cold fronts and stationary fronts will affect weather in Taiwan.

常見的鋒面有冷鋒、暖鋒、滯留鋒等。其中影響臺灣天氣的鋒面是冷鋒和滯留鋒。

■ 問題講解 Explanation of Problems

學習目標

在學習完本單元後，學生應能：

After studying this section, students should be able to:

一、說明氣團的定義，以及大陸、海洋與冷、暖氣鋒的性質。

Define the meaning of air mass, and the characteristics of continent, ocean, cold front and warm front.

二、闡述因海陸性質差異使冬、夏季的高壓氣團產生季風，影響台灣天氣系統的過程與實例。

Explain the process and give examples of how the monsoons are generated by high

pressure air masses in winter and summer due to the natural difference between land and sea, affecting the weather system in Taiwan.

三、解釋鋒面形成的方式與意義，並就冷鋒、暖鋒、滯留鋒個別說明。

Explain the way fronts form and the meaning, and explain cold fronts, warm fronts, and stationary fronts individually.

例題講解

例題一

說明：測驗學生是否能閱讀實際天氣資料，理解鋒面的觀念並做出正確判斷。

To test whether students can read the weather data in real life and can understand the concepts of fronts to make correct judgments.

（英文）Table below shows the data observed by Taichung Observatory of the Central Weather Bureau's at 4:00 p.m. for several consecutive days. It is known that a cold front will pass Taichung. Try to check the correct answers to the following questions based on the data shown on the table.

Date	wind speed(m/s)	wind direction	weather	air temperature (℃)
11／16	2.7	S	partly cloudy	26.5
11／17	1.4	SW	clear	26.8
11／18	0.6	SSW	clear	27.0
11／19	3.1	N	cloudy	23.8
11／20	3.5	N	clear	23.0
11／21	1.5	WNW	partly cloudy	24.2

1. When will the cold front arrive?

(A)11/17~11/18

(B)11/18~11/19

(C)11/19~11/20

(D)11/20~11/21

2. How will the weather change after the cold front passed, compared to the days before the cold front arrives?

(A) Turn from sunny to rainy. (B) Turn from rainy to sunny.

(C) Stay sunny. (D) Stay rainy.

3. What might be the reason for the weather turned sunny on the 20th when the 19th of Nov. was rainy?

(A) The southward moving of the continental air mass affects Taiwan.

(B) The Pacific warm air mass affects Taiwan.

(C) The fronts affect Taiwan continuously.

(D) Because this place is on the leeward side, the weather is more likely to turn sunny.

（中文）下表是中央氣象局臺中觀測站連續數日下午 4 時的觀測資料，已知有冷鋒通過，試根據表中資料勾選下列問題的正確答案：

日期	風速（m／s）	風向	天氣	氣溫（℃）
11／16	2.7	南	多雲	26.5
11／17	1.4	西南	晴	26.8
11／18	0.6	南南西	晴	27.0
11／19	3.1	北	陰雨	23.8
11／20	3.5	北	晴	23.0
11／21	1.5	西北西	多雲	24.2

1. 冷鋒是在下列哪兩日之間到達？

(A) 17 日～18 日　　**(B)18 日～19 日**

(C) 19 日～20 日　　(D)20 日～21 日

2. 相較於冷鋒到達前，冷鋒經過後天氣有何種變化？

(A) 晴轉陰雨　(B) 陰雨轉晴　(C) 維持晴天　(D) 維持陰雨

3. 19 日有雨，20 日天氣轉晴的原因可能為何？

(A) 大陸冷氣團南下影響臺灣　　(B) 太平洋暖氣團影響臺灣

(C) 鋒面持續影響臺灣　　(D) 此地位於背風面，天氣較易轉晴

（改編自南一版 9 下課本例題 3）

解題 Solution:

1. 觀察觀測資料表格 11/18~11/19 風速劇增且風向由南南西大幅度轉為北風，天氣由晴轉為陰雨氣溫也下降 3 度，都是冷鋒過境的特徵，故選(B)。

2. 冷鋒過境前(11/18)原為晴天，過境時(11/19)天氣轉為陰雨型態，故選(A)。

3. 因大陸冷氣團為大陸冷高壓形成沉降氣流，導致晴天天氣，故選(A)。

1. According to the data from 11/18 to 11/19, the wind speed increased dramatically and the wind direction changed from South-South-West to North. The weather turns from sunny to rainy and the temperature drops by 3 degrees. These characteristics suggest a cold front passing by. Therefore, (B) is correct.
2. Before the cold front arrived (11/18), it was sunny. When the cold front was passing (11/19), it turned from sunny to rainy. So, (A) is correct.
3. Because the continental air mass, which is a cold high pressure system, results in downdrafts, the weather becomes sunny. So, (A) is correct.

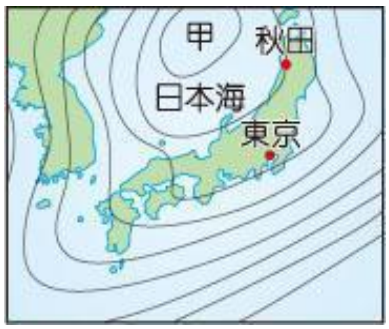
Teacher: What will happen when a cold front is passing by an area?
Student: As the pressure changes, the wind direction changes, the wind becomes stronger, and the temperature becomes cooler, the weather will change from sunny to rainy as well.
Teacher: Excellent! Can you guys identify two days in tables which have the most dramatic changes in meteorological data?
Student: 11/18-11/19.
Teacher: Yes, so what will happen after a cold front passes an area?
Student: The front will leave, and the continental cold high pressure air mass will move south and affect Taiwan.
Teacher: Then, how is the weather?
Student: It will be sunny.

老師： 如果冷鋒通過一個地區，會有什麼樣的情況出現？
學生： 氣壓變化、風向轉變、風力增強、氣溫變低，天氣也會由晴轉雨。
老師： 沒錯！ 所以大家能發現表格中是哪兩天的氣象資料變化最劇烈？
學生： 18 日～19 日。
老師： 是的！ 在冷鋒過境之後會發生什麼情況？
學生： 鋒面會離開，緊接著大陸冷高壓會南下籠罩影響台灣。
老師： 大陸冷高壓籠罩會使天氣如何？
學生： 晴朗。

例題二

說明：測驗學生能否理解高氣壓與低氣壓的觀念，並透過文本資料推論其他地區的風向。
To test whether students can understand the concept of high pressure and low pressure, and to make inferences about the wind direction in other regions through text information.

（英文）The picture is a simple weather map around Japan in the northern hemisphere on a certain day. The black curves in the figure are isobars. It is known the weather in Japan is mainly affected by weather system 甲 above the Japan Sea , and the surface winds in Tokyo on that day blows roughly from the south due to the influence of Weather System 甲. Without taking the effect of terrain into consideration, which of following statements about weather system 甲 and the main surface wind direction in Akita（秋田）that day is correct?



(A) 甲 is low pressure, and the wind direction is mainly southeast.
(B) 甲 is low pressure, and the wind direction is mainly northeast.
(C) 甲 is high pressure, and the wind direction is mainly northwest.
(D) 甲 is high pressure, and the wind direction is mainly southwest.

（中文）圖為某日北半球的日本周邊地面天氣簡圖，圖中黑色曲線為等壓線，已知此時日本天氣主要受到日本海上方的天氣系統甲影響，且當天東京的地面風向受到天氣系統甲的影響以偏南風為主。若不考慮地形的影響，下列有關此天氣系統甲與當天秋田主要地面風向的敘述何者正確？

(A)甲為低氣壓，風向以東南風為主。
(B)甲為低氣壓，風向以東北風為主。
(C)甲為高氣壓，風向以西北風為主。
(D)甲為高氣壓，風向以西南風為主。

（108 年國中會考第 29 題）

解題 Solution:

因東京的地面吹偏南風，可判斷風流入甲，起因於一個逆時針的低壓系統。故秋田的風會因逆時針低壓而吹東南風。故選(A)。

Since the ground wind in Tokyo is blowing roughly from the south, it can be judged that the wind that flows into 甲 is generated by a counterclockwise low pressure system. Therefore, the wind in Akita is blowing from the southeast due to counterclockwise low pressure. Therefore, choose (A).

Teacher: Look at the picture on the right. Weather system 甲 cause a southerly wind to blow in Tokyo. Does this mean that the wind is flowing out of the system or into it?
Student: The wind flows inward to the weather system.
Teacher: If the wind of a weather system is flowing inward, does the system have a high or low pressure center?
Student: Low pressure system.
Teacher: Okay, then, are the winds flowing into the low pressure system in the northern hemisphere in the clockwise or counterclockwise fashion?
Student: Counterclockwise.
Teacher: Great. Weather system 甲 is a counterclockwise low pressure system, so the wind direction in Akita will be?
Student: Southeast wind.

老師： 看看右邊的圖片，甲天氣系統使東京吹南風，代表風是從系統中流出還是流入？
學生： 向內流入。
老師： 如果一個天氣系統的風是向內流入的，請問該系統是高壓還是低壓中心？
學生： 低壓。
老師： 接著要問的是，北半球低壓系統的風是順時針還是逆時針流入？
學生： 逆時針。
老師： 很好！所以甲是逆時針的低壓天氣系統，推論秋田的風會是向什麼方向呢？
學生： 東南風。

4-4 台灣的氣象災害
Meteorological Disasters in Taiwan

■ 前言 Introduction

「氣象災害」是天氣劇烈或自然變化所造成的自然災害，可臺灣常見的氣象災害包括颱風、梅雨、寒潮（寒流）和乾旱等情形。本章節將介紹上述的氣象災害的成因以及災害對台灣的影響。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
cold damage	寒害	landslide	山崩
cold wave	寒潮	Mei-yu	梅雨
desertification	沙漠化	satellite cloud imagery	衛星雲圖
dip slope	順向坡	tropical depression	熱帶低壓
disaster	災害	typhoon	颱風
drought	乾旱	southwesterly flow	西南氣流
evaporation	蒸發	storm surge	暴潮
extremely heavy rain	豪雨	smog	煙霧
lifting	舉升	unstable	不穩定的
		water resource	水資源

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

❶ S + be the -est (N) of + the Ns

例句：In Taiwan, economic damage caused by typhoons **is the highest of** all the natural disasters.
在台灣，颱風所帶來的經濟損失是所有自然災害中最高的。

❷ There is (a lot of) rain/snow +_____ (a place).

例句：Generally speaking, when typhoons hit Taiwan from east Taiwan, without terrain barriers, **there will be** server and strong **wind and rain in** east Taiwan. **There will be** less **wind and rain in** middle and south Taiwan, due to the terrain barriers from the central mountain range.
一般來說由東部侵台的颱風，由於沒有地形阻隔，因此東部會出現最強烈的風雨，中南部則受到中央山脈的屏障，風雨較弱。

中央山脈：central mountain range
地形阻隔：terrain barrier

❸ If + S + 現在式, S + 現在式(事實、狀態).

例句：**If** the rainfall **is not** enough during rainy seasons, Taiwan **is** more prone to drought in the south than in the north during the dry spell from November to April.
若該年雨季的降水不足，則台灣在十一月至隔年四月的枯水期中南部會比北部更容易發生乾旱。

■ 問題講解 Explanation of Problems

學習目標

在學習完本單元後，學生應習得以下觀念：
After studying this section, students should be able to:
一、描述台灣的四種常見的災變天氣，並說明造成災害的背景環境。
Describe four common catastrophic weathers in Taiwan and explain the backgrounds and environments of them.

二、說明梅雨發生的時間、成因以及對於台灣的影響。

Explain the timing, causes and effects of Mei-yu in Taiwan.

三、介紹颱風好發的季節與生成的原因，並說明颱風的結構特色、風雨的時空變化以及颱風所帶來的各種災害，延伸至對於颱風防災準備。

Introduce the timing and causes of typhoons, and explain the structural characteristics of typhoons, the temporal and spatial changes of wind and rain, and various disasters brought about by typhoons, and then extend to the preparations for typhoon disaster prevention.

四、說明因豪大雨造引發的坡地災害。

Explain the hillslope disasters caused by heavy rain.

五、介紹寒潮的發生季節與災害。

Introduce cold surge season and disasters.

六、介紹台灣發生乾旱的時間地點，以及引發乾旱的原因與造成的災害。

Introduce the timing and places of occurrence of the drought in Taiwan, as well as the cause and effect of it

∞ 例題講解 ∞

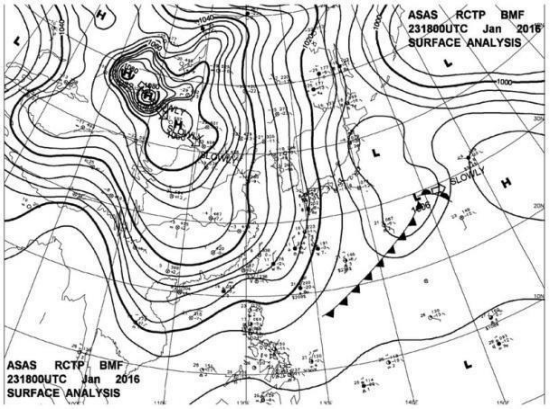
例題一

說明：測驗學生是否理解各種天氣現象對應的地面天氣圖中的氣壓特性。

To test if students understand the atmospheric pressure characteristics in the surface weather map corresponding to various weather phenomena.

（英文）The picture is a surface weather map in East Asia. According to the atmospheric pressure data on it, what kind of disasters will Taiwan encounter?

(A) Mei-yu
(B) Typhoon
(C) Cold damage
(D) Drought.



（中文）附圖是東亞地區的地面天氣圖，根據圖上氣壓資料，此時台灣可能遭受何種氣象災害？

(A)梅雨　(B)颱風　**(C)寒害**　(D)乾旱

（改編自 91 年第一次基測第 38 題）

解題 Solution:

因蒙古地區有強烈冷高壓籠罩，為西伯利亞高壓帶來冷空氣並南下影響台灣，形成寒潮，造成台灣低溫寒害。故選 (C)。

Because of the strong cold high pressure covered over the Mongolian area, it brings cold air to the Siberian high pressure which moves southerly and affect Taiwan with cold wave that leads to cold damages in Taiwan.

Teacher: There is a weather system in this surface weather map. Is it high or low pressure?
Student: High pressure.
Teacher: A high pressure like this in the continent with a cold front formed in the southeast, would it be a warm or cold high pressure system?
Student: Cold high pressure.
Teacher: That's right. Then what kind of weather phenomenon will it bring to Taiwan?
Student: Cold scourge.
Teacher: The cold surge will cause low temperatures and cold damages.

老師： 在這張地面天氣圖中有一個天氣系統，請問它是高壓還是低壓？
學生： 高壓。
老師： 像這樣在大陸(continent)的高壓，而且在東南方形成冷鋒，會是溫暖還是寒冷的高壓系統？
學生： 寒冷的高壓。
老師： 沒錯！那會造成台灣有什麼樣的天氣現象？
學生： 寒流。
老師： 而且寒流來襲還會造成低溫，引發寒害。

例題二

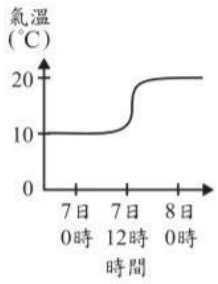
說明：應用高低氣壓的觀念與颱風的知識，判斷氣壓值的變化。

To apply the concept of high and low pressure and the knowledge of typhoon to determine the change of air pressure value.

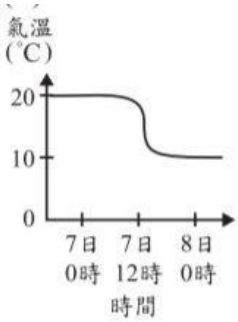
（英文）After a typhoon passed by an island, A-Long checked the surface weather observation data of the island during the typhoon. He correctly inferred that the center of the typhoon is closest to the island at 12 o'clock on the 7th day of the month. According to the characters of the typhoon center, which of the following is most likely to be the information he used to make his inference?

（中文）某次颱風通過一小島後，阿龍檢視了該小島在受颱風影響時的地面天氣觀測資料，由某個觀測值正確推得颱風中心最接近該小島的時間點為該月的7日12時。根據颱風中心的性質，下列何者最可能是他作出推論所利用的資料？

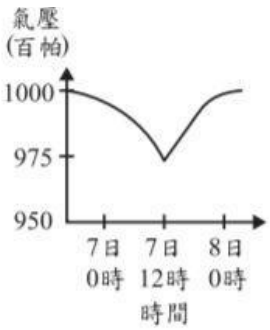
(A)



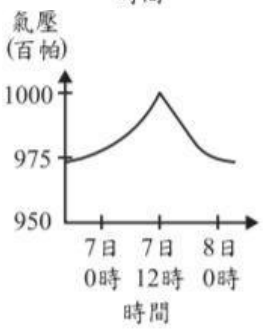
(B)



(C)



(D)



（109 年國中會考第 21 題）

解題 Solution:

由於颱風是熱帶性低壓系統，中心為低氣壓，也就是氣壓值的最低處，而溫度並不會有顯著變化。在氣壓圖發現 7 日 12 時的氣壓值呈現最低點，故可以對應颱風中心在 7 日 12 時通過小島。故選(C)。

Because the typhoon is a tropical low pressure system, the center has the low pressure, which is the lowest point of the pressure value, and the temperature will not change significantly. It can be found that the pressure value at 12 o'clock on the 7th of the month is the lowest point on the pressure map, so the center of the typhoon passed through the island at 12 o'clock on the 7th day of the month. Therefore, choose (C).

Teacher: Is a typhoon a low or high pressure system?
Student: Low pressure system.
Teacher: Great! It's a low pressure system, and also a kind of tropical depression.
Teacher: So what kind of pressure value will be shown at the center of the typhoon?
Student: The pressure value will be lower than the outer cyclone.
Teacher: Inferring from the changes of air pressure, what will be the air pressure at 12 o'clock on the 7th of the month?
Student: The pressure value will reach the lowest at 12 o'clock on the 7th of the month.
Teacher: Very good. What is the temperature above which the heat index may reach the extreme dangerous level?

老師： 請問颱風是一種低壓還是高壓系統？
學生： 低壓。
老師： 沒錯！是低壓系統，而且是熱帶性低氣壓的一種。
老師： 所以颱風的中心會呈現怎麼樣氣壓數值？
學生： 氣壓的數值會最低。
老師： 所以可從氣壓的變化中推斷，7 日 12 時的氣壓會如何？
學生： 7 日 12 時會達到氣壓值的最低點。
老師： 沒錯！所以要選擇氣壓值在 7 日 12 時達到最低點的圖表。

★主題五 永續的地球★
Sustainable Earth

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■ 前言 Introduction

本章探討地球上的海洋與大氣，如何透過各自的環流系統將能量 傳播到世界各地；而兩系統也會在海平面附近進行能量交換，此能 量的交換又如何影響了地球的氣候變化。第二部分則介紹溫室效應的概念，並說明溫室氣體的作用對現今大氣中溫室氣體的含量逐年升高所帶來全球暖化的影響。第三部分介紹臺灣常見的天然災害， 並且引導學生使用相關資源以了解所在地是否有災害的潛勢，學習如何防災、並尋求人類與大自然永續共存的相處之道。

5-1 海洋與大氣的互動
The Interaction between the Ocean and the Atmosphere

■ 前言 Introduction

了解海水運動包括潮汐、波浪、洋流三種主要面向，並且透過各地區的氣候、物產、飲食文化讓學生了解生活的許多面向和環流系統的關係。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
Antarctica	南極洲	northeast monsoon	東北季風
circulation system	環流系統	ocean current	洋流(海流)
climate	氣候	resource	資源
delivery	輸送	sea level	海平面
earthquake	地震	solar radiation	太陽輻射
El Niño and Southern Oscillation(ENSO)	聖嬰-南方振盪現象	southwest monsoon	西南季風
energy	能量	specific heat capacity	比熱
equatorial easterlies	赤道東風	Taiwan Strait	台灣海峽
frictional force	摩擦力	temperature	溫度
humidity	濕度	tide	潮汐

isotherm	等溫線	tropical zone	熱帶地區
Kuroshio	黑潮	tsunami	海嘯
littoral current (longshore current)	沿岸流	volcanic eruption	火山爆發
middle latitude	中緯度	warm current	暖流
monsoon	季風	wave	海浪
north pacific ocean	北太平洋	westerlies	西風帶

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

❶ _____ spread _____ around the world through _____.

例句：The ocean and the atmosphere **spread** the heat **around the world through** their respective circulation system.
地球上的海洋與大氣，透過各自的環流系統，將熱量傳播至世界各地。

❷ There are _____ main _____ of _____: _____.

例句：**There are** three **main** phenomena **of** eustatic movement: tides, waves and ocean currents.
海平面的升降運動主要有潮汐，波浪與洋流等三種主要現象。

❸ _____ are common in _____.

例句：Tsunamis **are common in** submarine volcanic eruptions and seaquakes.
海嘯常見於海底火山爆發、海底地震發生時。

❹ _____ due to _____.

例句：When the waves in the abyssal zone are transmitted to the shallow, the wave height increases **due to** the decreasing wave speed.
當深海區的波浪傳遞到淺水區的時候，會因波速遞減而加大波高。

❺ _____ is affected by _____.

例句：In winter, the Taiwan Strait in the western sea area **is affected by** the northeast monsoon, which drives the seawater to move from north to south to form the cooler China Coastal Current.
在冬季臺灣海峽(西部海域)受到東北季風的影響，帶動海水由北往南移動形成溫度較低的中國沿岸流。

❻ In addition to _____, _____.

例句：**In addition to** affecting the climate, ocean currents also affect the activities and the distribution of organisms.
洋流除了影響氣候外，也影響生物的活動與分布。

■ 問題講解 Explanation of Problems

學習目標

在學習完本單元後，學生應能：：
1.了解海流流向所帶來的影響。
2.學習等溫線的判讀。

After studying this section, students should be able to:
1. Understand the impacts by the directions of the ocean currents.
2. Learn to interpret isotherms.

例題講解

例題一

說明：學習判讀圖片的海流流向，了解海水流向對周邊所帶來的影響。

Learn to interpret the direction of ocean current in the picture and understand its impact on the surrounding areas.

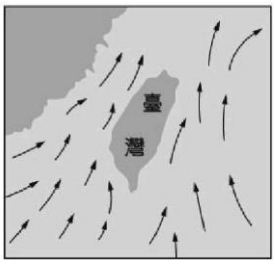
（英文）The picture shows the direction of surface currents in a certain season near Taiwan. Which of the following is the most reasonable inference?

(A) The ocean currents in the Taiwan Strait flow from the southwest to the northeast, which are affected by the northeast monsoon.

(B) At this time, most of the silt deposited on the southwestern coast in Taiwan was eroded by the ocean currents along the northern coast.

(C) The ocean currents in the picture come from the tropics, which increase the temperature and humidity in the coastal areas of Taiwan.

(D) Ocean currents bring warm seawater which increases the temperature of seawater near Taiwan and causes the El Niño phenomenon.



（中文）圖為臺灣附近某季節之表面海流方向示意圖，下列何者為最合理之推論？

(A)臺灣海峽中之海流由西南流向東北，應是受到東北季風的影響。

(B)此時臺灣西南部沿海沉積的泥沙大多是由北部沿岸受海流侵蝕而來。

(C)圖中海流來自熱帶地區，使臺灣沿海地區氣溫與溼度上升。

(D)海流帶來溫暖海水，使臺灣附近海水溫度上升，造成了聖嬰現象。

（97 年第一次國中基測第 14 題）

Teacher: What kind of monsoons will Taiwan be affected by?

Student: In summer, it is the southwest monsoon. In contrast, it is the northeast monsoon in winter.

Teacher: That's right. From the direction of the ocean current in the picture, we know that it was summer in Taiwan. The ocean current flows from the southwest to the northeast because it is affected by the southwest monsoon. Therefore, the current mentioned in option (A) should be affected by the southwest monsoon. Then what's the problem with option (B)?

Student: Because of the influence by the southwest monsoon, the silt deposited on the southwestern coast should come from the southern coast eroded by the ocean current.

Teacher: Bingo. Option (C) is correct. From the picture, we can see that the ocean current from southwest to northeast come from tropical regions at low latitudes. The warm water will increase the temperature and humidity in the coastal areas of Taiwan. Then how about option (D)?

Student: The El Niño phenomenon is the result of the interaction of a wide range of atmospheric and oceanic systems. It is not simply the rise in seawater temperature that causes the El Niño phenomenon.

老師： 台灣會受到哪些季風的影響呢？

學生： 夏天受到西南季風的影響，冬天則是東北季風。

老師： 沒錯。從圖片的海流方向可以知道，台灣此時是夏季，因為受到西南季風影響會使海流由西南流向東北。因此(A)的海流應是受到西南季風的影響。那(B)哪裡有錯？

學生： 因為受到西南季風影響，所以西南部沿海沉積的泥沙應由南部沿岸受海流侵蝕而來。

老師： 答對了。而(C)選項是正確的，從圖中可以看出由西南向東北的海流，是來自低緯度的熱帶地區，溫暖的海水會讓台灣沿海地區的氣溫和濕度都升高。那(D)選項呢？

學生： 聖嬰現象是大範圍的大氣、海洋系統交互作用的結果，並不是單純海水溫度上升就會造成聖嬰現象。

例題二

說明：學習等溫線的判讀方法，了解哪區域為冬季海水表面溫度最高的地方。.

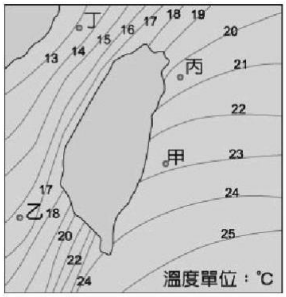
Learn how to interpret the isotherms and understand which sea area has the highest surface temperature in winter.

（英文）The picture shows the average temperature distribution on the sea surface near Taiwan in winter. From the picture, which of the following sea areas has the highest surface temperature in winter?

（中文）如圖為臺灣附近海水表面冬季平均溫度分布狀況。

由圖可知，下列哪一區域的冬季海水表面溫度最高？

(A)甲　(B)乙　(C)丙　(D)丁



（96 年第二次國中基測第 4 題）

Teacher: When an area is between two isotherms, it means that the temperature in this area is between the temperatures of the two isotherms. Can you try to talk about the temperatures of the four options?

Student: 甲 is between 22°C and 23°C. 乙 is between 16°C and 17°C. 丙 is between 20°C and 21°C. 丁 is between 13°C and 14°C.

Teacher: That's right! Accordingly, we know that 甲 is the sea area that has the highest surface temperature in winter.

老師：某一區域位在兩條等溫線之間，就代表該區域的溫度介於兩條等溫線的溫度之間。同學們可以說說看四個選項的溫度嗎?

學生：甲介於 22℃ 和 23℃ 之間，乙介於 16℃和 17℃ 之間，丙介於 20℃ 和 21℃ 之間，丁介於 13℃和 14℃ 之間。

老師：沒錯，因此可以知道冬季海水表面溫度最高的是在甲所在的海域。

5-2 溫室效應與全球暖化
The Greenhouse Effect and Global Warming

■ 前言 Introduction

了解溫室效應的過程，以及溫室氣體在此過程中所扮演的角色。而隨著工業革命後能源需求的大增，了解溫室氣體含量增加會帶來的全球暖化現象，世界各地也因此出現一些衝擊。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
absorb absorption	吸收(動詞) 吸收(名詞)	groundwater overexploitation	超抽地下水
air temperature	氣溫	groundwater	地下水
atmosphere	大氣	industrial revolution	工業革命
carbon dioxide	二氧化碳	infrared ray	紅外線
climate change	氣候變遷	land subsidence	地層下陷
climate refugees	氣候難民	land development	開發土地
coal	煤炭	landslide	山崩
coastal	沿岸的(沿海的)	methane	甲烷
debris flow	岩屑流	natural gas	天然氣
deforestation	砍伐森林	north pole	北極

developed countries	已開發國家	Paris Agreement	巴黎協定
developing countries	開發中國家	penetrate	穿透
disaster	災難	petroleum	石油
energy balance	能量平衡	reflect	反射
energy saving and carbon reduction	節能減碳	sea level rise	海平面上升
extinction	滅絕	sea level	海平面
extreme weather	極端天氣	south pole	南極
fossil fuels	化石燃料	species	物種
glacier	冰川	synthetic fertilizers	化學肥料
global warming	全球暖化	thermal equilibrium	熱平衡
greenhouse effect	溫室效應	visible light	可見光
greenhouse gas	溫室氣體		

單字說明：climatic change 是指某個地方的氣候特性發生改變，而 climate change 是氣候變遷的專有名詞。

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

❶ _____, part of _____, part of _____, and about half of _____.

例句：When the solar energy radiates to the earth, **part of** the energy is reflected back into space by the earth's surface and clouds, **part of** it is absorbed by the atmosphere, **and about half of** the solar energy will be absorbed by the earth's surface.

當太陽的能量輻射至地球時，有一部分的能量被地表和雲層反射回太空，一部分被大氣吸收，有大約一半的太陽能量會被地表吸收。

句型說明：part of 指某物當中的一部分；half of 則指某物當中的一半

❷ _____, such as _____, _____ and _____, _____.

例句：Greenhouse gases in the atmosphere, **such as** water vapor, carbon dioxide and methane, can absorb the infrared rays radiated from the surface, leave the energy in the atmosphere near the surface, **and** increase the temperature.

大氣中的溫室氣體，例如：水氣、二氧化碳及甲烷等，能吸收由地表輻射出來的紅外線，將能量留在地表附近的大氣層中，使氣溫升高。

※ gas 的複數型可以是 gases 或 gasses，不過 gases 較常使用

句型說明：such as… and… 像是... 和

such as 常用於舉例，後面接舉例的事物，且可以列舉一個以上。因所舉的例可能不只一種，所以後面會有 such as… and… 這樣的句型出現。

❸ _____ in line with _____.

例句：According to the research, the average temperature of the globe has continued to rise over the past century. It is roughly **in line with** the changes in the content of carbon dioxide.

根據研究，近百年以來全球平均溫度持續上升，約略地與二氧化碳含量的變化相符合。

句型說明：in line with 與... 相符

in line with 後面可接人或事物，表示與某人或某事物一致/相符。

❹ Since _____, _____ have/has _____(past participle).

例句：**Since** the Industrial Revolution, the demand for energy **has increased** dramatically.
自從工業革命以來，人類對於能源的需求大增。

句型說明：since 意為「自從...」，經常搭配現在完成式 (have/has+p.p.) 的句型。

❺ Simultaneously, _____.

例句：**Simultaneously,** the heavy use of chemical fertilizers and the increase in the amount of livestock have also increased the content of methane.
同時，化學肥料的大量使用及牲畜的飼養量上升，同樣增加了甲烷的含量。

句型說明：simultaneously 為副詞，意為「同時地」。

❻ Apart from _____, _____.

例句：**Apart from** causing changes in the natural environment, global warming also forces human beings to make adjustments to adapt to changes in climate.
全球暖化除了造成自然環境的改變外，也迫使人類必須做出調整，以適應氣候環境的變化。

句型說明：apart from 除… 之外
apart from 可以是將後面的人事物排除在外 (不包括在內)，也可以是將後面的人事物包含在內 (除… 外還有…)。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應能：

1.了解溫室效應增強的主要原因。

2.了解全球暖化對臺灣沿海地區陸地面積所造成的影響。

After studying this section, students should be able to:

1. Understand the main reasons for the enhanced greenhouse effect.

2. Understand the impact of global warming on the land in Taiwan's coastal areas.

❧ 例題講解 ☙

例題一

說明：學生能在看似直觀的問題下，了解溫室效應增強的主因是因為大氣中的溫室氣體吸收了地表長波(紅外線)的輻射而造成，其他的輻射吸收對於暖化的作用是有限的。Through this seemingly intuitive question, students are able to know that the main reason for the enhanced greenhouse effect is because atmospheric greenhouse gases absorb the outgoing longwave (infrared) radiation. The warming due to the absorption of other types of radiation is limited.

（英文）The absorbing states and routes of solar radiation between the surface and the atmosphere are represented by 甲, 乙, 丙, and 丁,as the illustration shown in the table. According to the scientific research that has been found in recent decades, the increase of which of the following is the most probable one that result in the enhanced greenhouse effect?

code	routes of absorption
甲	the surface radiation absorbed by the atmosphere
乙	the solar radiation absorbed by the atmosphere
丙	the solar radiation absorbed by the surface
丁	the atmospheric radiation absorbed by the surface

（中文）若將地表與大氣之間的太陽輻射量的吸收情形及途徑，以表中的甲、乙、丙、丁來表示，而根據近數十年的科學研究，下列何者是找到增強溫室效應的最可能的主要原因？

代號	甲	乙	丙	丁
吸收途徑	大氣吸收的地表輻射量	大氣吸收的太陽輻射量	地表吸收的太陽輻射量	地表吸收的大氣輻射量

(A)甲 (B)乙 (C)丙 (D)丁

（106 年國中會考第 31 題）

Teacher: After the solar energy radiates to the earth, half of the energy will be absorbed by the earth's surface; however, the surface should reach the energy balance as well. Then, how will the energy radiate to the atmosphere?

Student: The earth's surface will radiate the energy to the atmosphere via infrared.

Teacher: That's right! To keep the surface at an appropriate temperature, when the energy radiates to the atmosphere, by which greenhouse gases will it be absorbed and be released back to the surface?

Student: Greenhouse gases include water vapor, carbon dioxide, and methane.

Teacher: Will the behaviors and the needs of humans after the Industrial Revolution, such as the massive combustion of fossil fuels, deforestation, land development, and the use of chemical fertilizer, change the gases in the atmosphere?

Student: The amount of greenhouse gases such as carbon dioxide and methane in the atmosphere will increase.

Teacher: Back to the original question, which route will be enhanced by the increase in greenhouse gases?

Student: The atmosphere will absorb the surface radiation more intensively.

老師：太陽的能量輻射到地球後，有一半的能量會被地表吸收，不過地表也要達到能量平衡，那會以什麼方式輻射到大氣中呢？

學生：地表會利用紅外線將能量輻射到大氣中。

老師：沒錯！那這些能量輻射到大氣中時，會被哪些溫室氣體吸收再釋放回到地表，而使地表保持適當溫度？

學生：溫室氣體有水氣、二氧化碳、甲烷。

老師：工業革命後，人類的行為與需求如：大量燃燒化石燃料、砍伐森林開發土地、化學肥料的使用會讓大氣中的氣體有什麼改變嗎？

學生： 大氣中的二氧化碳、甲烷等溫室氣體含量會增加。
老師： 再回到原先的問題。溫室氣體的增加會讓哪一個途徑增強？
學生： 大氣層將增強對地表輻射的吸收。

例題二

說明：此題不僅能夠讓學生了解全球暖化對台灣的衝擊，同時也讓學生了解其他可能造成台灣沿海地區陸地面積逐漸減少的原因。

This question can not only make students comprehend the impact of global warming on Taiwan, but also make them understand other possible causes of the gradual reduction of the land in Taiwan's coastal areas.

（英文）According to the news coverage, the land in Taiwan's coastal areas is gradually decreasing. Which of the following is not related to this phenomenon?

(A) land subsidence caused by groundwater overexploitation
(B) sea level rise caused by global warming
(C) the reduction in river sediment caused by building reservoirs
(D) the reduction in vegetation cover on hillslope caused by deforestation

（中文）新聞報導指出，臺灣沿海地區的陸地面積正逐漸減少中，下列何者與此現象並無關聯？

(A)超抽地下水使地層下陷。
(B)全球暖化使海平面上升。
(C)興建水庫使河川泥沙減少。
(D)砍伐森林使得山坡植被減少。

（翰林版國中自然三下課本 Ch4）

Teacher: Do you know the impact of land subsidence caused by groundwater overexploitation?
Student: It may likely result in flooding and seawater intrusion.
Teacher: That's right. Thus, it is one of the reasons for the reduction of the land in coastal areas. The concept of sea level rise resulted from global warming is similar. Low-lying areas will first be submerged by seawater. What about option (C)?
Student: It will result in the retrogradation of the coastline and the gradual reduction in land.

Teacher: Right. For option (D), the reduction in vegetation cover on hillslope is susceptible to rain wash, which is likely to result in natural disasters such as debris flow and landslides. It has nothing to do with the reduction of land area. As a result, we should choose option (D).

老師： 同學們知道超抽地下水使地層下陷所帶來的影響嗎？

學生： 容易造成水患或是海水倒灌。

老師： 沒錯。所以是沿海地區陸地面積減少的其中一個原因。而全球暖化使海平面上升也是類似概念，低窪地區也會先被海水所淹沒。那(C)選項呢？

學生： 會導致海岸線後退，國土逐漸縮小。

老師： 對。那(D)選項，山坡植被減少容易受到雨水沖刷，造成土石流、山崩等天然災害，和陸地面積減少無關。因此選(D)選項。

5-3 人與自然的互動
The Interaction between Humans and Nature

■ 前言 Introduction

了解台灣地區地震、颱風、洪水、乾旱、山崩和土石流等自然災害發生的原因，並且運用相關資源查詢各地自然災害發生的潛勢，以及進一步了解所居住的位置是否存在著安全上的疑慮。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
aquifuge	不透水層	flood	洪水
aspect	坡向	flow	流量
barrier lake	堰塞湖	heavy rain	大雨
confined aquifer	受壓含水層	inclined plane	傾斜面
dip direction	傾向	fallow	休耕
dip slope	順向坡	natural disaster	天然災害
drought	乾旱	Philippine Sea Plate	菲律賓海板塊
embankment	堤岸(河堤)	plum rain (Mei-yu)	梅雨
escarpment (scarp) slope	逆向坡	rock formation	岩層
Eurasian Plate	歐亞板塊	soil liquefaction	土壤液化
eutrophication	優養化作用(過程)	soil loss	土壤流失

evacuate	撤離	torrential rain	大豪雨
extreme climate	極端氣候	typhoon	颱風
extremely heavy rain	豪雨	volcano	火山
extremely torrential rain	超大豪雨	watershed	集水區
floodplain	氾濫平原		

降雨量強度與範圍 Intensity and Distribution of Rainfall
50mm < 豪雨 < 130mm (24hr)
130mm < 大雨 < 200mm (24hr)
200mm < 大豪雨 < 350mm (24hr)
超大豪雨 > 350mm (24hr)

註：豪雨在 24 小時中至少有 1 小時雨量達 15mm 以上之降雨現象。(表為中央氣象局所訂定降水強度之定義，其中(24hr)為 24 小時連續觀測的累積降雨量。)

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

❶ _____ be located (adverb of place) _____.

例句：Taiwan **is located** at the main invading path of typhoons in the western Pacific Ocean.
臺灣地處於西太平洋颱風的主要侵襲路徑上。

❷ _____ refers to _____.

例句：Flood **refers to** the phenomenon that a large amount of precipitation in a short period causes the river to surge and overflow the river course.
洪水是指短時間內大量降水，引起河水暴漲而溢出河道而氾濫的現象。

❸ _____ leads to _____.

例句：Because the terrain is steep and the rivers are short, the rainfall during the plum rain(Mei-Yu) season and typhoon often **leads to** floods.
由於地勢陡峭又河流短（水流急），在梅雨和颱風來襲期間所帶來的降雨，常常會導致洪水的發生。

❹ _____ occur _____.

例句：Landslides usually **occur** after heavy rain.
山崩好發於大雨過後。

❺ _____; otherwise, _____.

例句：If the slope inclines in the same direction as the dip direction of the rock formation, the slope is called a dip slope**; otherwise**, it is called an escarpment slope.
當坡面與岩層傾斜面方向一致時，此山坡稱為順向坡；反之，稱為逆向坡。

❻ _____ be mixed with _____.

例句：Debris flow refers to the phenomenon that rocks and sand of different sizes **are mixed with** a large amount of water to become fluid and flow downward rapidly along the slope.
岩屑流是指大小不一的岩塊與泥砂，混合大量水分成為流體狀，沿著坡面向下快速流動的現象。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應能：

1. 了解水土保持與地層、水質、泥沙淤積量的關係。
2. 判讀順向坡、逆向坡。

After studying this section, students should be able to:

1. Understand the relationship between soil and water conservation and strata, water quality, and the amount of sedimental deposition.
2. Interpret the dip slopes and the escarpment slope.

❧ 例題講解 ☙

例題一

說明：了解人類的行為對大自然的影響，並且透過題目了解背後的原因。

Understand the impacts of human behaviors on nature and know the reasons behind it through the question

（英文）Which of the following statements about soil and water conservation is incorrect?

(A) Drawing large amounts of groundwater in low-lying areas could easily cause land subsidence.

(B) Raising livestock by the river could cause the excessive growth of algae downstream.

(C) Cutting trees upstream of the reservoir could reduce the amount of sediment deposited in the reservoir.

(D) Planting fruits and vegetables on steep mountains could cause soil loss.

（中文）下列有關水土保持的敘述，何者不正確？

(A)在低窪地區大量抽取地下水，容易造成地層下陷。

(B)在河邊養殖家禽家畜，可能使下游藻類過量孳生。

(C)在水庫上游砍伐樹木，會減少水庫的泥沙淤積量。

(D)在坡度陡峭的高山上種植蔬果，會造成土壤流失。

（92 年第一次國中基測第 2 題）

Teacher: What is the impact of massive drawing of groundwater in low-lying areas?

Student: The support for the aquifuge at the upper end of the confined aquifer is reduced, as a result, the weight on the aquifuge increases relatively causing the land subsidence.

Teacher: That's right. Therefore (A) is correct. Then what will be the impact of raising livestock by the river?

Student: Because too much nutrient salt will be discharged, it may cause algae to grow rapidly, which would carry out a large amount of respiration and reduce the dissolved oxygen in the water. Eventually, it will result in eutrophication.

Teacher: Bingo! For option (C), when trees upstream of the reservoir are felled, the soil and rocks on the ground will lose the protection of vegetation. Then the rainwater may wash the soil and rocks into the reservoir, which increase the amount of sediment deposited in the reservoir. What about option (D)?

Student: The vegetables and fruits planted are shallow-rooted crops, which will make it hard for the soil to grip the ground. The geological condition will also become fragile and cause soil loss when it rains heavily.

老師： 低窪地區大量抽取地下水時，會有什麼影響呢？

學生： 受壓含水層的上端不透水層的支撐力減少，承受的重量相對增加，造成地層下陷。

老師： 沒錯。因此(A)是正確的。那河邊養家禽、家畜會有什麼影響呢？

學生： 因為會排入過多的營養鹽，有可能造成藻類生長快速，進行大量的呼吸作用而使水中的溶氧量下降，最終造成水質優養化。

老師： 答對了。那(C)選項，水庫上游砍伐樹木時，地面土石缺乏植被的保護，雨水就有可能沖刷這些土石進到水庫，增加水庫的泥沙淤積量。那(D)選項呢？

學生： 種植的蔬果是淺根作物，會讓土壤的抓地力不好，地質變得脆弱，下大雨時就有可能造成土壤流失。

例題二

說明：根據圖片上地層傾斜方向、地表傾斜方向，對照定義判斷順、逆向坡。
Compare and determine the dip slopes and the escarpment slope based on the dip direction of the strata and the ground surface on the picture.

（英文）As shown in the picture, which of the descriptions of the aspects of 甲 and 乙 is correct?

(A) Both 甲 and 乙 are escarpment slope.

(B) Both 甲 and 乙 are dip slopes.

(C) 甲 is a dip slope while 乙 is an escarpment slope.

(D) 甲 is an escarpment slope while 乙 is a dip slope.

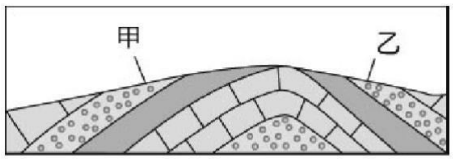
（中文）如圖所示，甲、乙兩地的坡向敘述，何者正確？

(A) 甲、乙兩者都是逆向坡。

(B) 甲、乙兩者都是順向坡。

(C) 甲是順向坡，乙是逆向坡。

(D) 甲是逆向坡，乙是順向坡。



（96 年第二次基測第 7 題）

Teacher: What's the definitions for the dip slopes and the escarpment slope?

Student: A dip slope refers to the slope inclined in the same direction as the dip direction of the rock formation; otherwise, it is an escarpment slope anti-dip slope.

Teacher: That's right. The aspect and the dip direction of the rock formation of 甲 and 乙 in the picture are the same, so they are both dip slopes.

老師：順向坡和逆向坡的定義是什麼？

學生：順向坡是指坡面與岩層傾斜面方向一致，反之則為逆向坡。

老師：沒錯。圖片中的甲乙兩處坡向和岩層傾斜方向都是一致的，因此都為順向坡。

國內外參考資源 More to Explore

NASA Earth Science | Science Mission Directorate 美國 NASA，提供最新地球科學相關知識。 https://science.nasa.gov/earth-science	
BGS (British Geological Survey) 地質相關主題。 https://www.bgs.ac.uk/discovering-geology/	
NOAA-Basic Weather Education 提供給教師關於大氣層單元的教學資源網站。 https://www.weather.gov/crp/weather_education	
AMS (American Meteorological Society) education-program 提供給 K-12 教師地球科學相關資源。 https://www.ametsoc.org/index.cfm/ams/education-careers/education-program/	
MIT opencourseware 地震學課程知識。 https://ocw.mit.edu/courses/12-510-introduction-to-seismology-spring-2010/	

PBS LearingMedia	
有科學類的影片，分年級分類別，推薦影片及提供影片內可詢問學生的問題，部分影片有閱讀材料。 https://www.pbslearningmedia.org/	
Khan Academy	
可汗學院，有分年級的地球科學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，除了地球科學，還有其他自然科。 https://phet.colorado.edu/	

雙語教學資源手冊：地球科學科 英語授課用語

[九年級]

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

[9th grade]

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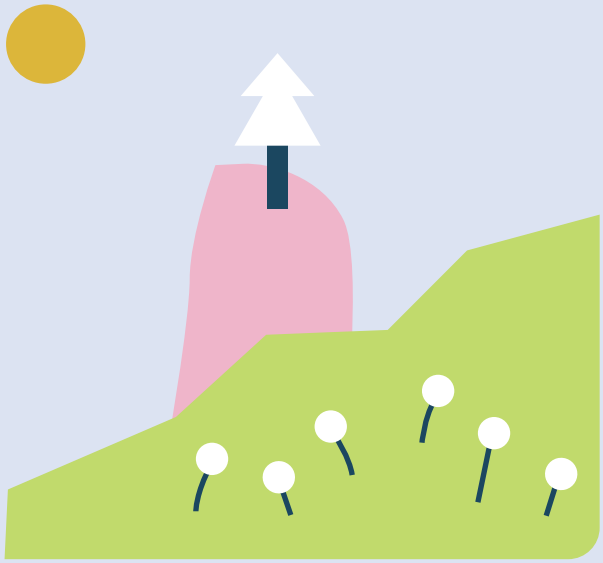

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