# IBO CHALLENGE II

## 32nd INTERNATIONAL BIOLOGY OLYMPIAD

## Lisbon, PORTUGAL - July 19th, 2021

# THEORETICAL-PRACTICAL TEST

實作題

(Time available: 180 minutes)

作答時間為 180 分鐘

- This test consists of eight parts 本試題包括八大題
- 1 point each correct answer
  答案正確得 1 分
- Maximum score: 170 points 總分為 170 分
- Only answers marked in the ANSWER SHEET will be validated
  只有標記在答案紙上的答案才計分

# GENERAL INSTRUCTIONS 一般說明

1. Your exam is composed of eight parts, some of them with multiple sections to accommodate different subjects.
   本試題包括八大題，有些還會有多個不同主題的細項
2. Some questions involve calculations, and the students are allowed to use basic calculators.
   有些子題需要計算，你可以使用簡易的計算機
3. Your exam is composed of four types of questions:
   試題中有四種類型的子題
   - Multiple choice questions 選擇題
   - True / False questions 是非題
   - Matching items questions 配對題
   - Fill in the spaces questions 填充題
4. The students are not supposed to use words to answer the questions, only codes of letters placed in the appropriate locations.
   不能用文字來回答問題，只能用對應的代碼填在答案紙上的適當處。
   - Multiple choice questions should be answered by selecting the correct answer on the Answer Sheet.
     選擇題的答案須在答案紙上選出正確的答案
   - True / false questions should be answered by selecting either a "**T**" for true or an "**F**" for false, on the Answer Sheet.
     是非題的答案須在答案紙上用"**T**" 代表正確、"**F**" 代表錯誤
   - Matching items questions and fill in the spaces questions should be answered on the Answer sheet by selecting the appropriate letter in the key provided in each case
     配對題和填空題須在答案紙上選用題目所提供適當對應的字母來回答

**ENJOY AND HAVE FUN!!!**

# Introduction and context　前言與背景說明

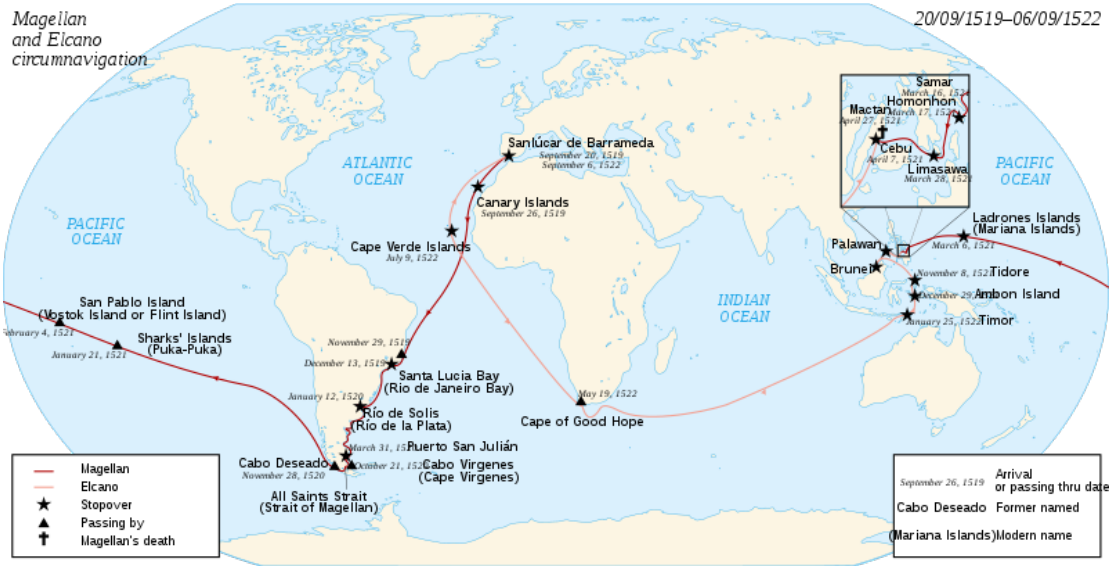
The IBO Challenge II – IBO 2021 is associated with the commemorations of the 500th anniversary (in 2019) of the first voyage around the Globe, initiated by Fernão de Magalhães.
The IBO Challenge II – IBO 2021 與探險家麥哲倫，首度環球航行的 500 週年慶 （2019 年）有關。


Fernão de Magalhães (Ferdinand Magellan), in a 16th/17th century anonymous portrait.
第 16/17 世紀時，麥哲倫的畫像

Fernão de Magalhães (1480-1521), also known as Fernando de Magallanes (Spanish) or Ferdinand Magellan (English) was a Portuguese-born experienced sailor who planned, organized and led a naval expedition to the East Indies by following a western route. That voyage was financed and done on behalf of the Spanish king Charles I, the future Emperor of the Holy Roman Empire and father of the Spanish King Philip II (who would become Philip I of Portugal).
麥哲倫 (1480-1521) 誕生在葡萄牙，是一名經驗豐富的航海家。之後，他規劃、組織並率領一個團隊向東印度的探險，再接著西行航道。該航行獲得西班牙國王查理斯(卡洛斯)一世的經濟援助，也代表國王的出航。這位國王後來成為神聖羅馬帝國的國王，且是西班牙國王菲利浦二世(也就是葡萄牙國王菲利浦一世)的父親。
The purpose of the journey was to reach the “Spice Islands”, the Moluccas, located in Southeast Asia in the transition between the Indian and the Pacific Oceans, and to open a new trade route that would not collide with the rights of the Portuguese to control the East route through the Atlantic and the Indian Oceans. In fact, as a result of the Tordesillas Treaty the Moluccas belonged to the Spanish part of the world, but as the eastern route was dominated by the Portuguese, the Spanish could only reach the Moluccas by sailing west.
此次航行的目的是要抵達號稱香料群島的馬魯卡群島，其位於東南亞地區，且在印度洋及太平洋交界處，以便開闢新的貿易航道，且不會和葡萄牙人經由大西洋及印度洋來控制東向航道相衝突。事實上，根據《托德西利亞斯條約》 馬魯卡群島歸屬於西班牙，但是由於東向航道被葡萄牙人所霸佔，西班牙人只能向西航行來到 馬魯卡群島。

An armada of five ships commanded by Fernão de Magalhães left Sanlúcar de Barrameda, in the Gulf of Cadis, Spain, on 20 September 1519 and travelled Southwest through the Atlantic towards the eastern coast of South America down to Patagonia. Once there, the fleet searched for a passage to the Pacific Ocean, a passage that even today bears Magellan's name. Reaching the Pacific Ocean, Magellan sailed in the direction of the Philippine Islands where, on 27 April 1521, during a battle in the Island of Mactan, he was killed by the natives.

麥哲倫率領一支由 5 條海船組成的遠航船隊在 1519 年 9 月 20 日離開西班牙加迪斯灣的桑盧卡爾，向西南航行經過大西洋，行向南美洲的東岸，並向下至巴塔哥尼亞。抵達之後，船隊尋找能通到太平洋的峽道，其後被命名為麥哲倫海峽。抵達太平洋後，麥哲倫航向菲律賓群島，就在 1521 年 4 月 27 日，麥克坦島的一場戰役中，麥哲倫被當地原住民所殺。



Source: https://upload.wikimedia.org/wikipedia/commons/thumb/a/ab/Magellan_Elcano_Circumnavigation-en.svg/800px-Magellan_Elcano_Circumnavigation-en.svg.png

The journey continued and, after reaching the Moluccas, in November 1521, and having laden the ships with spices, Juan Sebastián Elcano, in command of the Victoria, the only surviving ship, returned to Spain on 8 of September 1522 through the Indian Ocean and up the Atlantic coast of Africa, completing what turned out to be the first circumnavigation of the Earth.

航行繼續前進，在 1521 年 11 月抵達馬魯卡群島，之後，唯一倖存的維多利亞號，滿載著香料，由艾卡諾船長帶領，於 1522 年 9 月 8 日經由印度洋、沿著非洲的大西洋海岸，回到西班牙，完成了首度環繞地球航行的創舉。

This **IBO Challenge II** test is based on the **journey of Fernão de Magalhães** since the departure from the Gulf of Cadis to the Philippines. Along the way, the students will have to answer some questions and solve some problems that are posed in association to locations that represent some selected stopovers of the Magellan's armada along its journey. Each stopover corresponds to one of the eight parts that compose the present test. **ALL ABOARD!**

本次競賽的題目即是根據麥哲倫的航程，從加迪斯灣出發，至菲律賓群島。沿著此航道，你必須回答一些問題，並解決一些與麥哲倫航隊旅程中曾經停留的地點有關的難題。每個停留地點對應本試題的八大題之一。現在開始出航!

# Part 1

# The departure – The Gulf of Cadis I

# 啟程 -- 加迪斯灣 I

**Subject:** Cell Biology and Biotechnology 細胞生物學與生物科技

**Theme:** Plant adaptations to biotic and abiotic factors 植物對生物及非生物因子的適應性

**Time proposed:** 20 min

**Introduction**

Plants interact with the environment using several mechanisms, either against biotic and abiotic detrimental factors, and/or by attracting pollinators and animals for seed dispersal. In Mediterranean climates, plants reveal several adaptations that allow them to succeed and thrive in these dry and hot habitats. Certain characteristics will provide protection for excessive radiation and UV light.

植物透過多種機制來和環境互動，可能是對抗生物及非生物之有害因子，或者是藉由吸引傳粉者以及協助傳播種子的動物。在地中海型氣候，植物顯現出多種適應性，使其能在乾燥且炎熱的棲地中存活並蓬勃發展。其中有些特性可提供保護，避免過量輻射及紫外光的傷害。

**Section I -** Observe the micrographs A and B in **Figure 1,** below.

觀察下圖 1 中的顯微照片 A 與 B。

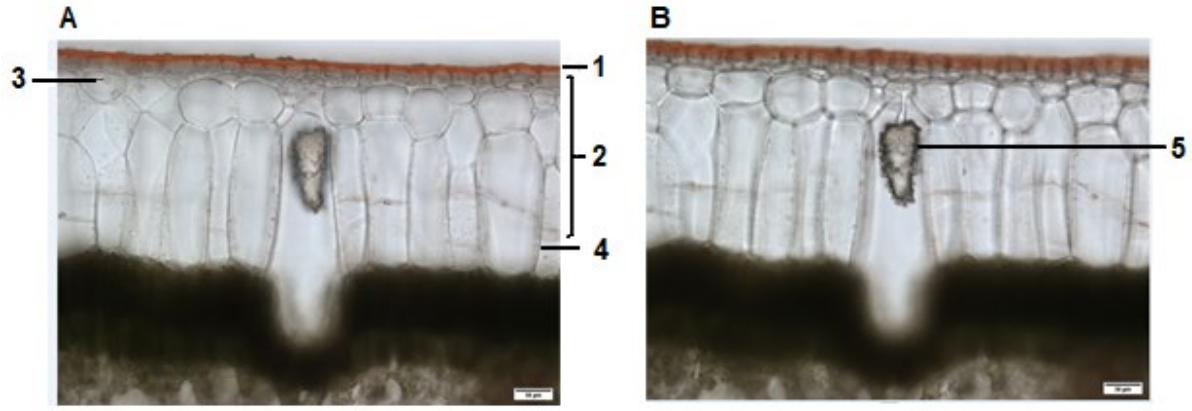



**Figure 1** - Two focusing planes of a transversal leaf section observed under light microscopy. The section was stained with Sudan red IV, a fat-soluble dye that stained in red the general lipids. Scale bar represents 50 µm.

葉之切片在光學顯微鏡下檢視的兩個不同對焦面。切片經由蘇丹紅 IV 的染色，此為脂溶性染料，將脂質染為紅色。比例尺為 50 µm。

1. Use the key below (**options A to J**) to complete the legend of **Figure 1** (**numbers 1 to 5**). Notice that the number of options in the key exceeds the number of correct answers. **[5 points, 1 point each correct answer]**
   **從下方的答案表(選項 A 到 J)中，找出對應圖 1 中的數字(1 到 5)。**
   **注意! 答案表中的選項比正確答案的數目還多。[5 分，每個正確答案得 1 分 ]**

| KEY 答案表 | |
|---|---|
| A | Stratified columnar epithelium 複層柱狀上皮 |
| B | Plant epidermis 植物表皮 |
| C | Cell membrane 細胞膜 |
| D | Cell wall 細胞壁 |
| E | Intercellular space 細胞間隙 |
| F | Chloroplast 葉綠體 |
| G | Cuticle 角質層 |
| H | Nucleus 細胞核 |
| I | Cell Wall modification 細胞壁變形 |
| J | Vacuole with crystal content 內含結晶的液胞 |

2. In Figure 1A the structure marked 1 represents [**choose the correct option**]. **[1 point]**
   圖 1A 中，表示為 1 者顯示的是 (選一個正確選項)**[1 分]**

   a) Secondary cellulosic cell wall 次生的纖維素細胞壁
   b) Lignified secondary cell wall 木質化的次生細胞壁
   c) Suberized secondary cell wall 木栓化的次生細胞壁
   d) Cutinized cell wall 角質化的細胞壁

3. Concerning the cells represented in Figure 1A and 1B, classify as true (T) or false (F) each of the sentences below **[4 points, 1 point each correct answer]**
   有關在圖 1A 和圖 1B 中的細胞，指出下列敘述的正確 (T) 與錯誤 (F)
   **[4 分，每個正確答案得 1 分 ]**

   a) The top layer has a protective function, isolating the cells from the environment
   最上方一層有保護功能，將細胞與外界環境隔開

   b) All the cells in the transparent layer have no intercellular spaces
   透明層的所有細胞沒有細胞間隙

   c) All the cells in the transparent layer have the same function
   透明層的所有細胞有相同功能

   d) Cell lengths vary between 25 µm and 300 µm
   細胞長度不同，介於 25 µm and 300 µm 之間

4. The video associated to this question shows the changes that occur when a microscope slide with leaf sections similar to those presented above is irrigated with a HCl solution that replaces the water of the mounting medium. The event is accelerated 3x to shorten the duration of the time reaction. [video]

此題的影片顯示的改變是發生在選用和上方照片相似的葉之顯微切片，並以鹽酸(HCl) 溶液取代原先的水埋。此影片加速 3 倍播放，以縮短觀察反應過程的時間。[影片]

a) Based on the changes that occurred, what would be the composition (chemical nature) of the structure that "disappears"? [**choose the correct option**] **[1 point]**
根據所發生的改變，請問消失不見的構造之化學組成為何？(選一個正確選項)**[1 分]**

a) Calcium oxalate 草酸鈣
b) Calcium carbonate 碳酸鈣
c) Silica aggregates 矽質聚集
d) Cellulose fibers 纖維素的纖維
e) Lignin deposition 木質素堆積
f) Lipids 脂質
g) Proteins 蛋白質

b) What is the cell location of the aforementioned structure? [**choose the correct option**] **[1 point]**
上述構造是在細胞的何處？(選一個正確選項)**[1 分]**

a) Vacuole 液胞
b) Cell wall 細胞壁
c) Cytoplasm 細胞質
d) Cell membrane 細胞膜

**Section II -** Observe the micrographs A and B in **Figure 2,** below.

觀察下方圖 2 顯微照片 A 和 B

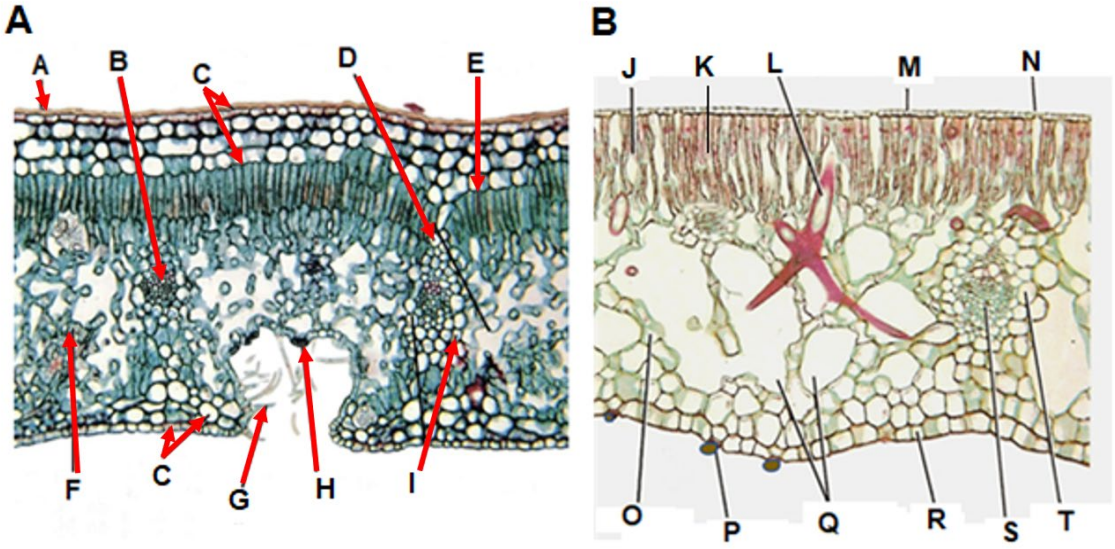



**Figure 2** - Transverse sections of leaves from two distinct species.
兩種不同植物葉片的橫切面

5. Use the key below (**options 1 to 20**) to choose in the optional term that would best designate each of the labelled structures and complete the figure captions Figure 2 (**letters A to T**) .Note: Not all terms are necessarily used and some might be used more than once.
**[20 points, 1 point each correct answer]**
從下方的答案表中(選項 1 到 20)，分別選出最適當的名詞來代表標示的構造，並且填入數字對應圖 2 中的大寫字母**(A to T)**。注意：不是所有名詞都會用到，有些可能選用一次以上。
**[20 分，每個正確答案得 1 分 ]**

| **KEY** 答案表 | |
|---|---|
| 1 | Stomata 氣孔 |
| 2 | Glandular trichome (glandular hair) 腺毛 |
| 3 | Abaxial epidermis 背軸面的表皮 |
| 4 | Palisade parenchyma 柵狀薄壁組織 |
| 5 | Branched sclereid (Astrosclereid) 星狀厚壁細胞 |
| 6 | Bundle sheath 維管束鞘 |
| 7 | Spongy parenchyma 海綿薄壁細胞 |
| 8 | Cuticle 角質層 |
| 9 | Lacunae 空腔 |
| 10 | Sclerenchyma 厚壁組織 |
| 11 | Multiple epidermis 多層表皮 |
| 12 | Chlorenchyma 厚角組織 |
| 13 | Intercellular space 細胞間隙 |
| 14 | Metaxylem 後生木質部 |
| 15 | Covering trichome (non-glandular trichome) 覆蓋毛(非腺毛) |
| 16 | Crystal 結晶 |
| 17 | Vascular bundle 維管束 |
| 18 | Adaxial epidermis **近**軸面表皮 |
| 19 | Cambium 形成層 |
| 20 | Resin duct 樹脂道 |

6. Still considering **Figure 2**, classify each of the following statements as true (T) or false (F).
根據圖 2，判斷下列敘述正確 (T) 或錯誤(F)。

a) **Concerning image A [4 points, 1 point each correct answer]**
根據 A 圖 **[4 分，每個正確答案得 1 分 ]**

a) The palisade cells are perpendicularly elongated to the leaf surface
柵狀細胞呈現垂直於葉表面的長柱狀

b) The mesophyll pattern organization is characteristic of an isobilateral leaf
葉肉的組織模式特徵為等面葉

c) The vascular bundles are double open and collateral
維管束是雙開放且外韌並列型

d) The leaf exhibits anatomical features that can be interpreted as adaptations to habitats with low water availability and high light intensity
此葉片呈現的解剖特徵可解釋為適應於水分較少且強光下的環境

b) **Concerning image B [4 points, 1 point each correct answer]**
根據 B 圖 **[4 分，每個正確答案得 1 分 ]**

a) The mesophyll pattern organization is characteristic of a dorsiventral leaf
葉肉的組織模式特徵為背腹葉(異面葉)

b) The sclerenchyma is poorly developed
厚壁組織發育不良

c) In what concerns the stomata position, the leaf is epistomatic
根據氣孔位置，此葉片為氣孔上生型

d) The leaf anatomy suggests that the species is a hydrophyte with submerged leaves
此葉片解剖顯示此物種為水生且具沉水葉

**Section III -** The effects of environmental factors on leaf morphology and anatomy have produced a wide variety of adaptations in different taxa. Adaptations enable plants to survive in adverse conditions. Observe carefully **Figure 3**, below.

環境因子對葉片形態及解剖的影響，其適應性在不同分類群中有著大範圍的差異。適應性使植物能在不利的狀態下存活。請仔細觀察下方圖 3。

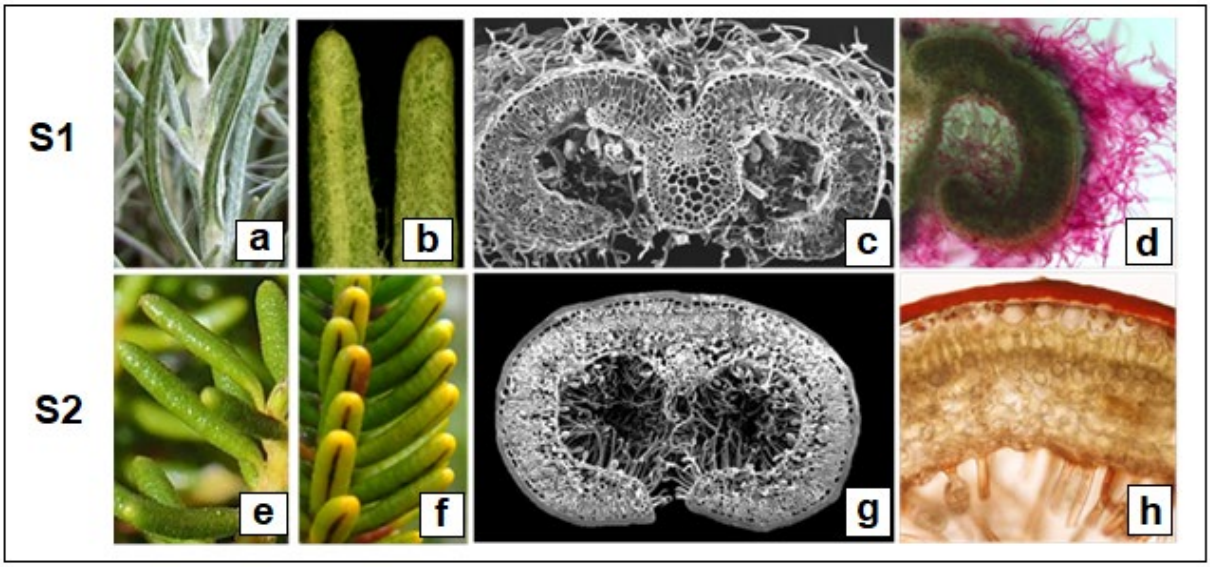



**Figure 3** - Features of the leaves of two distinct species S1 and S2. **a, b** and **e, f** are macrographs of the adaxial and abaxial leaf surface; **c** and **g** are SEM micrographs of leaf cross sections; **d** and **h** are light micrographs of leaf cross sections stained with Ruthenium Red (d) and Sudan IV (h) to identify cell compounds through histochemical techniques. Ruthenium Red stained pectins, highly hydrophilic compounds well known by their ability to form gels with water, with a pink color; and Sudan IV-stained red general lipids.

圖 3. 兩種不同植物(S1 and S2)的葉片特徵。a, b and e, f 分別是近軸面和背軸面的巨觀照片；c and g 是葉片橫切面的 SEM 顯微照片； d and h 是葉片橫切面以釕紅染色(d)以及蘇丹 IV (h)染色的光學顯微照片，以利辨識細胞化學組成，其中釕紅染果膠(高親水性，且會和水形成膠質)，呈現粉紅色；蘇丹 IV 會將一般的脂質染成紅色。

7. Considering **Figure 3, classify each of the statements in the following items as true (T) or false (F).**
根據圖 3，判斷下列各小題的敘述正確 **(T)**或錯誤 **(F)**。

a) Concerning the images of both species **[4 points, 1 point each correct answer]**
根據兩個物種的照片 **[4 分，每個正確答案得 1 分 ]**

a) The leaves exhibit a mesophytic structure characteristic of species that grow in temperate zones with average or optimal water availability
葉片顯示為具中生性構造特徵的物種，其生長在水分平均或充足的溫帶區域

b) The leaves show features that are often associated with water plants (hydrophytes)
葉片特徵顯示通常為水生植物

c) The leaves present features that are characteristic of plants adapted to dry or seasonally dry habitats
葉片特徵顯示此植物適應於乾燥或季節性乾燥的棲地

d) The leaves possess a typical structure of plants living on forest floors
葉片具有生活在森林底層植物的典型構造

b) **Which leaf features help species to deal with the environment stress factors in the respective habitats? [4 points, 1 point each correct answer]**
哪些葉片特徵有助於物種應付在各自棲地之環境逆境因子？ **[4 分，每個正確答案得 1 分 ]**

a) Leaves with a cylindrical outline and prominent enrolled margins
葉片呈現圓柱形且葉緣明顯捲起

b) Leaves with flattened blades and thin cuticles
葉片平展且角質層薄

c) Stomata confined to hair-lined grooves
氣孔集中在有毛覆蓋的凹槽中

d) A high leaf surface/volume ratio
其葉表面積與體積比值高

c) **The hairs covering the leaves of S1 may have the following functions: [4 points, 1 point each correct answer]**
S1 物種的葉片有毛覆蓋，可具有下列功能： **[4 分，每個正確答案得 1 分 ]**

a) Increase light absorption
增加光的吸收

b) Regulate leaf internal temperature
調節葉片內部的溫度

c) Increase the diffusion of gases across the leaf and air interface
增加氣體在葉片及空氣界面間的擴散

d) Reduce predation by insects and herbivores
降低被昆蟲及植食者掠食

**d) According with the results of the histochemical tests performed (images d and h)**
**[4 points, 1 point each correct answer]**
根據組織化學染色結果(d and h 照片) **[4 分，每個正確答案得 1 分 ]**

a) The grey-whitish appearance of S1 leaves is due to the non-glandular trichomes (hairs) that covering the leaf surface absorb the visible light
S1 葉片是因為有非腺毛覆蓋在葉表面，吸收可見光而呈現灰白色

b) The smooth, long, and flexuous non-glandular trichomes of S1 leaves can entrap and retain dew and fog water
S1 葉片的平滑、長而波狀的非腺毛，可抓住露水及霧水

c) The glossy appearance of S2 leaves is due to the thick hydrophobic cuticular layer that reflects the light as a mirror
S2 葉片的光滑表面是因為有厚的疏水性角質層，可像鏡子般反射光

d) The cutinized upper epidermal cells of S2 leaves reduce the evapotranspiration water loss
S2 葉片角質化的上表皮細胞，可降低水分經由蒸散喪失

# Part 2

# The departure – The Gulf of Cadis II

# 出發 - 卡迪斯灣 II

**Subject:** Ecology

**學科**：生態學
**Theme:** The passage of fire over the soil
**主題**：火在土壤上的通道
**Time proposed:** 30 min
**建議時間**：30 分鐘

**Introduction**
The Mediterranean basin is a human made ecosystem traditionally shaped by agriculture and fire. Fire affects ecosystems in many and complex ways, but several scientists have highlighted the need to assess the fire impact on soil biodiversity and functionality as a driving force of post-fire land degradation independently from that of the removal of vegetation, soil roughness and other fire-induced changes. Many wildfire events leave behind a mosaic of burned and unburned areas that can be used to study the fire effects on soil.
地中海盆地是一個人造的生態系統，傳統上受到農業以及火的活動所造成，火對生態系的影響是多樣而複雜的，有些科學家強調要評估火對土壤的生物多樣性及土壤的功能性在大火之後土壤退化所扮演的關鍵性角色，排除其他非火造成可能的影響，如植物的移除、土壤變粗劣以及其他火所引起的改變。許多野火事件留下了焚燒與未焚燒的鑲嵌地帶，可以用這些地帶來研究火對土壤的影響。

**Section I -** To assess the effect of fire on soil properties, 10 soil samples were randomly collected from each plot and immediately mixed to obtain a representative and homogeneous sample of each of the 5 burned and 5 unburned plots. Samples (± 1 kg each) were collected at 0 -20 cm depth, after removing the litter layer. Samples were packed in open plastic bags, kept at 4°C, and sieved through a 2 mm sieve to remove the coarse fragments (stones, roots, etc.). Afterwards, each sample was divided into 3 aliquots.

**第一節：**來評估火對土壤性質的影響，從火燒的區域與未被火燒的區域各選五個小區塊（polt），每個小區塊內再隨機選擇 10 個土壤樣本進行混合以產生一個均質且具代表性的樣本。每個土壤樣本係移除地表落葉腐植土（litter layer）後，取地下 0-20 公分深度土壤約 1 公斤重。土壤樣本用開口塑膠袋裝，在 4°C 環境中，用 2 mm 篩子篩選以移除粗粒（如樹根、石頭等），其後把每一個樣本分成三等份。

- The first aliquot was air-dried to constant weight for determination of pH, electrical conductivity (EC), cation exchange capacity (CEC), and total organic carbon ($C_{org}$) content.
  第一等分利用空氣乾燥到等重，用來進行 pH 值、導電度（EC）、陽離子交換能力（容量；CEC），以及總有機碳含量（$C_{org}$）的測定。
- The second aliquot was stored at 4°C for the assessment of water content (to express microbial variables to dry weight), total microbial biomass carbon ($C_{mic}$), and fungal mycelium (FM) content, and microbial respiration.
  第二等分儲存在 4°C 來評估水含量（用乾重來呈現微生物的變異），總微生物生物碳量，及菌類菌絲體的含量，以及微生物的呼吸量。
- The third aliquot was stored at -20°C for DNA extraction and protein analysis.
  第三等份儲存在-20°C 做 DNA 萃取以及蛋白質分析。

**Table 1** - Results obtained for several parameters in unburned and burned soils
從燒過以及未被火燒過土壤內幾項因子測量的結果

| **Variable** | **Soil before fire**<br>**火燒前的土壤**<br>mean (± sd) | **Soil 2 weeks after fire**<br>**火燒後兩周的土壤**<br>mean (± sd) |
|---|---|---|
| pH<br>酸鹼值 | 6.0 (± 0.3) | 6.8 (± 0.2) |
| EC (dS $m^{-1}$)<br>導電度 | 0.30 (± 0.06) | 0.50 (± 0.06) |
| CEC (cmol $kg^{-1}$ dw)<br>陽離子交換能力 | 38.0 (± 3.3) | 26.1 (± 9.6) |
| Corg (g $kg^{-1}$ dw)<br>總有機碳含量 | 98.0 (± 10.2) | 86.0 (± 2.7) |
| Cmic (mg $g^{-1}$ dw)<br>總微生物生物碳量 | 1.2 (± 0.8) | 1.9 (± 1.2) |
| FM (mg $g^{-1}$ dw)<br>菌類菌絲體的含量 | 1.1 (± 0.3) | 2.9 (± 0.3) |
| Respiration (mg $CO_2$-C $g^{-1}$ dw $d^{-1}$)<br>呼吸量 | 0.15 (± 0.01) | 0.15 (± 0.03) |

dw = dry weight 乾重 - sd = standard deviation 標準差

1. Why is it necessary to determine the soil water content of each sample? **Classify each of the following statements as true (T) or false (F). [4 points, 1 point each correct answer]**

   為什麼需要測定每一個土壤樣本的含水量？**分辨出下列敘述的對（T）或錯（F）。**

   a) To express the results in terms of soil dry weight (dw) avoiding the water weight which varies among samples
   用土壤的乾重量表示是為了避免樣本中水重量的變異

   b) Because it is impossible to determine some parameters in wet soil
   因為某些測量因子在濕的土壤中無法測定

   c) To evaluate the percentage of living organisms that died with fire
   來測定活的個體被火燒死所佔的比例

   d) To assess if the fire was very intense
   去評估過去是否有大火

2. After the fire, why does the electrical conductivity of the soil increase? **Classify each of the following statements as true (T) or false (F). [4 points, 1 point each correct answer]**

   在火燒後，為何土壤的導電度會增加？**分辨出下列敘述的對（T）或錯（F）。**

   a) Due to increased content of ions in the soil solution
   由於土壤溶液中離子含量的增加

   b) Due to decreased content of ions in the soil solution
   由於土壤溶液中離子含量的減少

   c) Due to the decrease in the soil cation exchange capacity
   由於土壤陽離子交換能量的減少

   d) Due to the dead of soil organisms including microbes
   由於土壤裡生物的死亡包含微生物

3. Which hypotheses are supported by the results presented in the table? **Classify each of the following statements as true (T) or false (F). [4 points, 1 point each correct answer]**

   在表中的結果支持哪些假說？**分辨出下列敘述的對（T）或錯（F）。**

   a) The microbial community of the soil may increase after a fire
   火後土壤內的微生物群集可能會增加

   b) The soil respiration and soil biotic activity increase after the fire
   火後土壤內的呼吸量以及土壤生物活動增加

   c) The fire contributes to the loss of organic matter in the soil
   火造成土壤中有機物質的損失

   d) The fire is a cause of soil acidification
   火是造成土壤酸化的因素之一

4. The observed increment in fungal mycelium after fire… **Classify each of the following statements as true (T) or false (F). [4 points, 1 point each correct answer]**

   真菌菌絲體在火燒後觀察到的逐漸增加，**分辨出下列敘述的對（T）或錯（F）。**

   a) Cannot justify the observed decrease in soil organic carbon after fire
   不能支持在火燒後觀察到土壤內有機碳的減少

   b) May result from the proliferation of certain fungal species able to grow fast when nutrients are available
   或許是肇因於當有營養鹽可用時，某些能快速增長的真菌物種增生的結果

   c) Contributes to an increase in soil electrical conductivity
   提供土壤導電度的增加

   d) May represent a substantial contribution for the observed increment in the soil microbial carbon
   或許代表了土壤裡微生物碳所觀察到的逐漸增長的具體貢獻

5. What does the soil organic carbon include? **Classify each of the following statements as true (T) or false (F). [4 points, 1 point each correct answer]**

   土壤裡的有機碳包含什麼？**分辨出下列敘述的對（T）或錯（F）。**

   a) The soil organic matter, as well as the living biomass
   土壤裡有機物及活生物的生物量

   b) The bacterial biomass, but not the fungal one
   細菌生物量，但不是真菌的

   c) All the carbon in the soil
   土壤中所有的碳

   d) The carbon fraction that can be used by plants
   可以被植物使用的碳含量

**Section II -** People often realize that after a fire water lines change their path across fields. Several factors contribute to these changes. One of them is soil hydrophobicity, which can be understood as the soil's water repellency. This phenomenon is associated with the covering of soil particles by hydrophobic organic substances, and there are currently numerous reports of water repellency in areas with burnt soils. Fungi such as *Fusarium graminarum* or *Penicillium nigricans* can release hydrophobic organic substances. The hydrophobicity of the mycelium is determined by low molecular weight proteins that are unique to fungi and are excreted in monomora/monomers that acquire their final conformation by self-assembly – the hydrophobins.

**第二節：**人們經常了解到在火後，水在野地的動線會改變。這些改變受到幾個因子的影響，其中之一就是土壤的拒水程度，也就是我所認知土壤對水的排斥性。此現象與土壤的顆粒被拒水性有機物質包覆有關，目前有許多報告顯示被火燒過的地區土壤對水有排斥性。真菌類如 *Fusarium graminarum* 或 *Penicillium nigricans* 能釋放拒水性有機物質。菌絲體的拒水性程度取決於真菌特有的低分子量蛋白質，其分泌的單體分子經由聚合最後所形成的分泌物--拒水素（疏水蛋白 hydrophobins）。

In the following experiment, soil hydrophobicity was determined using the angle between the water drop and the soil surface, as represented in the **Figure1**.

下列實驗，土壤拒水性是根據水珠與土壤表面的角度，如圖一所示。

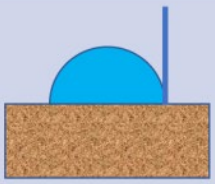
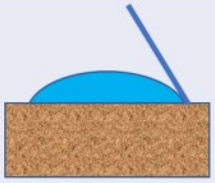
| | 1 | 2 | 3 |
|---|---|---|---|
| A |  | Yes | ≥ 90° |
| B |  | No | 0° ≤ x ≤ 90° |

**Figure 1** - Schematic representation of the angle formed between the water drop and the soil surface. 1 - Schematic representation of the water drop on the soil surface; 2 - Soil water repellent; 3 - Contact between soil and water.

圖 1，圖像顯示水珠與土壤表面形成的角度。1 - 圖像顯示水珠在土壤表面；;2 - 土壤對水排斥性；3 - 土壤與水的接觸。

6. Based on figure 1, answer the following questions **by filling the space** with the letter corresponding to the correct situation (A or B). **[5 points, 1 point each correct answer]**
根據圖 1，回答下列問題，選擇適合的狀態（A 或 B）填入。

a) Which soil is more hydrophobic?
哪種土壤較具排水性？

b) Which soil favours run off?
哪種土壤對水流失有利？

c) Which soil favours water infiltration?
哪種土壤有利於水的浸潤？

d) In which soil do you expect to find a higher hydrophobin concentration?
哪種土壤你預期會發現有較高的拒水素濃度？

e) Which soil may belong to a burned stand?
哪種土壤可能屬於燒過的地段？

**Section III -** After a fire soil water infiltration decreased by 50% and the fungal mycelium increased by 30%.
**第三節：**在火燒後土壤的水浸潤降低 50%，真菌菌絲體增加 30%。

**7.** Based on the statement above, **classify each of the following conclusions as true (T) or false (F). [5 points, 1 point each correct answer]**
根據上述句子，**分辨出下列敘述的對（T）或錯（F）**。

a) the proportion of *Fusarium graminarum* or *Penicillium nigricans* increased among the soil filamentous community and they are producing more hydrophobin than before fire
*Fusarium graminarum* 或 *Penicillium nigricans* 在土壤中菌絲群集的比例增加，比在火燒過之前產生更多的拒水素

b) There is an increased production of hydrophobin, which contributes to an enhancement of water run off
拒水素的產量增加，加強表水流失量

c) There is an increased production of hydrophobin, which contributes to an enhancement of water infiltration
拒水素的產量增加，加強表水的浸潤

d) Fungal mycelium is occupying the free space left by the decrease in water infiltration
真菌菌絲佔了因水浸潤(infiltration)減少而留下來的空間

e) The decrease in water infiltration increases the run off and the risk of soil erosion
水浸潤的減少，增加了水的流失以及土壤沖蝕的風險

# Part 3
# The departure – The Gulf of Cadis III
# 第 3 部分
# 出發 - 卡迪斯灣 III

**Subject:** Animal Physiology
**Theme:** Microplastics in aquatic insect larvae (20 min)
**Time proposed:** 20 min
**科目：**動物生理學
**議題：**水生昆蟲幼蟲中的塑膠微粒（20 分鐘）
**作答時間：**20 分鐘

### Introduction 前言

Five hundred years ago Ferdinand Magellan, commanding a fleet of five vessels, headed south through the Atlantic Ocean to Patagonia. Despite a series of storms and mutinies, they made it through the Strait of Magellan into a "peaceful sea" (Pacific Ocean).
五百年前，費迪南德·麥哲倫指揮著一支由五艘船組成的艦隊，向南穿過大西洋到達巴塔哥尼亞。儘管經歷了一系列風暴和兵變，他們還是通過麥哲倫海峽進入了「和平之海」（太平洋）。

If Ferdinand Magellan left today the likelihood of finding a sea of plastic particles would be enormous. In early times, microplastic contamination was associated to the sea, but nowadays we know that its origin is terrestrial and that our rivers are one of the main vehicles of these particles for our oceans…
如果費迪南德麥哲倫於今日離開，將有很大的機會找到富含塑料顆粒的海洋。在早期，微塑料污染與海洋有關，但現在我們知道它的起源是陸地，我們的河流是這些顆粒進入海洋的主要載體之一…

… Thus, in this stopover, you will have the opportunity to know what microplastics cause in the larva of an insect that lives in contact with the contaminated sediments of a river in the Iberian Peninsula. It is intended that you understand the physiological responses of these organisms when they are forced to ingest inert particles due to microplastic contamination of the sediments they live in.
…因此，在這次中途停留期間，你將有機會了解到微塑料對生活在伊比利亞半島河流接觸受污染沉積物的昆蟲幼蟲引起何種問題。本題目的是讓你了解這些生物體因生活在微塑料污染的沉積物中而被迫攝入惰性顆粒時的生理反應。

**Context 情境**

The non-biting midge larvae *Chironomus riparius* is one of the most abundant macroinvertebrate species in freshwater benthic ecosystems. Its lifecycle presents an adult aerial period of 2-4 days for reproduction and a period for development of 14-16 days, where larvae go through 4 metamorphic stages (from L1 to L4) until reaching a pupal stage and emerge as adults. This lifecycle is represented in figure 1.

不叮咬的搖蚊（*Chironomus riparius*）幼蟲是淡水底棲生態系統中最豐富的大型無脊椎動物的物種之一。其生命週期包括成蟲繁殖期為 2-4 天、發育期為 14-16 天，其中幼蟲經歷 4 個變態階段（從 L1 到 L4），直到達到蛹期，並以成蟲出現。這個生命週期如圖 1 所示。

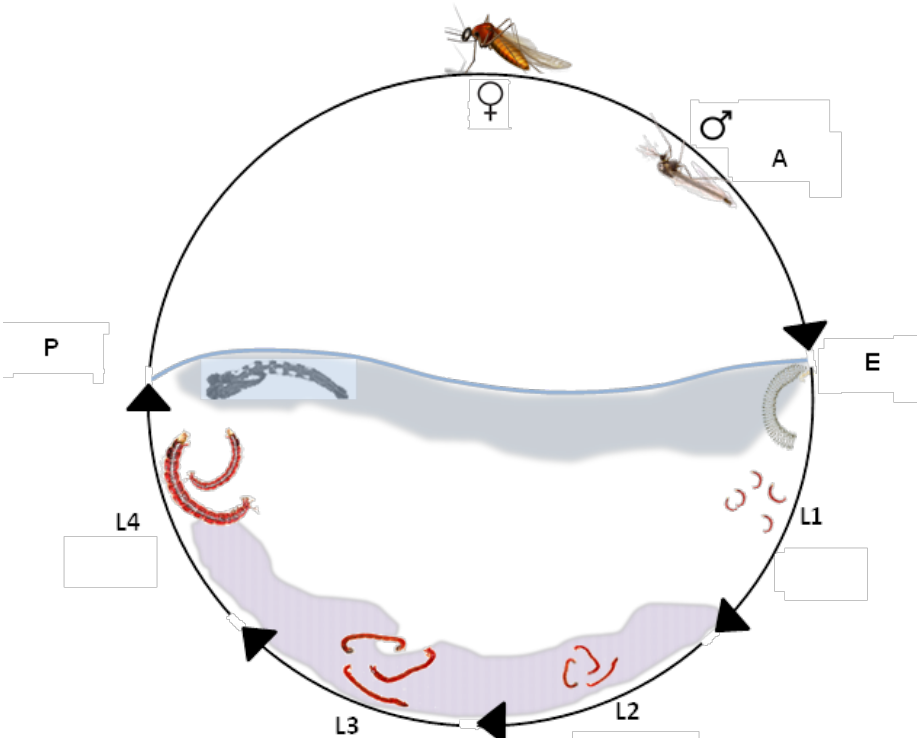



**Figure 1** - Life cycle of *Chironomus riparius*. A, adult; E, egg rope; L1-L4, 1st to 4th instar larvae; P, pupa.

圖 1 - *Chironomus riparius* 搖蚊的生活史。A, 成蟲；E. 卵塊；L1-L4，第一到第四齡幼蟲；P, 蛹。

1. One characteristic of the life cycle of *Chironomus riparius* that allows scientists to use this species in freshwater studies concerning the effects of contaminants is: [**choose the correct option**] **[1 point]**

   *Chironomus riparius* 生活史的特徵可以讓科學家能夠在淡水研究中探討汙染物效應之特質是什麼？[選出一個正確的選項] **[1 分]**

   a) a relatively short period developing in sediments
      在沉積物中的發育時間相對短
   b) a relatively long period of its aerial phase
      在空中階段生存的時間相對長
   c) a relatively long period developing in sediments
      在沉積物中的發育時間相對長
   d) a relatively long-life cycle
      生活史相對長

**Context 情境**

Inhabiting the uppermost layers of sediment, the larvae of *Chironomus riparius* act as deposit-feeders, feeding on sediments and particulate organic matter (detritus). Their feeding behavior is mostly non-selective determined by bioavailability. Typically, first instar (L1) larvae of *Chironomus riparius* ingest sediment particles up to 20 µm as part of their regular feeding activity. Conversely, final instars (3rd–4th instar; L3-L4, figure 2) can ingest particles up to almost 200 µm.

棲息在沉積物的最上層的搖蚊（*Chironomus riparius*）幼蟲為沉積物攝取生物取食沉積物顆粒與有機物（碎屑）。它們的攝食行為大多為非主動選擇而是取決於該地可獲得性的生物資源來決定。一般來說搖蚊的一齡 (L1) 幼蟲攝取高達 20 µm 的沉積物顆粒，作為其日常攝食活動的一部分。然而終齡（第 3-4 齡；L3-L4，圖 2）可攝取高達近 200 µm 的顆粒。

**Figure 2** – Schematic representation of L4 larvae of *Chironomus riparius* in freshwater sediments. (This figure was kindly provided by the project comPET).

圖 2. – 搖蚊 4 齡(L4)幼蟲在淡水沉積物中的示意圖

2. Due to the feeding behaviour of L4 larvae of *Chironomus riparius*, it can be hypothesized that: [**choose the correct option**] **[1 point]**
根據搖蚊 4 齡幼蟲的攝食行為，以下哪一個假說正確？[1 分]

a) The mouth apparatus of L1 enables the larvae to ingest particles up to 200 µm
1 齡幼蟲的口器使其能攝入 200 µm 的顆粒

b) The mouth apparatus of L4 enables the larvae to ingest particles up to 200 µm
4 齡幼蟲的口器使其能攝入 200 µm 的顆粒

c) L1 larvae can be a good model to determine the ingestion of particles of the size range 32-63 µm
1 齡幼蟲可拿來測定 32-63 µm 顆粒的攝入情形

d) L4 larvae is not a good model to determine the ingestion of particles of the size range 32-63 µm
4 齡幼蟲不適合拿來測定 32-63 µm 顆粒的攝入情形

**Context 情境**

Continuous release and long-term deposition of microplastics (MPs) are the main causes of their presence and persistence in freshwater sediments, especially near highly industrialized or densely populated areas where they can reach levels up to 9 g $kg^{-1}$ of sediment (Hurley *et al.*, 2018). Therefore, riverine sediments might be major sinks of MPs imposing a potential threat to freshwater benthic invertebrates.

塑膠微粒(MPs)的持續釋放和長期沉積是它們在淡水沉積物中存在和持久存在的主要原因，尤其是在高度工業化或鄰近人口稠密的地區，它們的沉積物含量可達 9 g $kg^{-1}$（Hurley 等人，2018）。因此，河流沉積物可能是 MPs 的主要匯聚處並對淡水底棲無脊椎動物構成潛在威脅。

**Figure 3** – Photographs of L4 larvae of *Chironomus riparius* exposed 48 h to sediments containing polyethylene microplastics (PE-MPs) of the size range 32-63 µm (left photograph) and sediments without microplastics (right photograph). (The photographs were kindly provided by the project comPET).

圖 3. -搖蚊 4 齡幼蟲暴露 48 小時於含有 32-63 µm 聚乙烯塑膠微粒 (PE-MP) 的沉積物（左圖）和不含塑膠微粒的沉積物（右圖）。

3. The observation and comparison of larvae on both photographs is a good method to: **[choose the correct option]** **[1 point]**

觀察與比較這兩張照片中的搖蚊幼蟲是個好方法可以拿來(選擇正確選項)(1 分)：

a) quantify the number of PE-MPs of the size range 32–63 µm inside the gut of L1 larvae
量化 1 齡幼蟲腸道內 32–63 µm 的 PE-MPs

b) quantify the number of PE-MPs of the size range 32–63 µm inside the gut of L4 larvae
量化 4 齡幼蟲腸道內 32–63 µm 的 PE-MPs

c) show that L1 larvae ingested PE-MPs of the size range 32–63 µm
顯示 1 齡幼蟲攝入了32–63 µm 的 PE-MPs

d) show that L4 larvae ingested PE-MPs of the size range 32–63 µm
顯示 4 齡幼蟲攝入了32–63 µm 的 PE-MPs

**Context 情境**

Three replicates (of 15 organisms each) per condition were used to estimate the number of MPs inside the gut of the larvae of *Chironomus riparius* exposed for 48 hours to concentrations of 0.00, 1.25, 5.00, and 20.00 g $kg^{-1}$ dry sediment of PE-MPs of the 32-63 μm size class. Table 1 presents the results of such experiment.

每個條件三個重複（每個重複 15 個體）用於估計暴露於 32-63 μm 尺寸等級的 PE-MPs 沉積物，濃度分別為 0.00、1.25、5.00 和 20.00 g $kg^{-1}$ 中 48 小時的搖蚊幼蟲腸道內的塑膠微粒數量。表 1 羅列出這個實驗的結果。

**Table 1** - Number of polyethylene microplastics (PE-MPs) of size-class 32-63 μm inside the gut of L4 of *Chironomus riparius* after 48 h of exposure to different concentrations of PE-MPs in the sediment.
表 1. 在沉積物中暴露於不同濃度的 PE-MPs 48 小時後，4 齡搖蚊幼蟲腸道內 32-63 μm 尺寸等級的聚乙烯塑膠微粒 (PE-MPs) 的數量。

| Concentration of PE-MPs in the sediment 沉積物中 PE-MPs 的濃度 (g $Kg^{-1}$ sediment) | Number of ingested PE-MPs ± standard error of the mean 攝取的 PE-MP 數量 ± 平均值的標準誤差 (number/organism) |
|---|---|
| 0.00 | 0,00 ± 00.0 |
| 1.25 | 525 ± 51.1 |
| 5.00 | 2047 ± 54.1 |
| 20.00 | 2389 ± 31.0 |

**4.** 本題刪除

5. The observed proportions between the number of PE-MPs inside the gut of L4 as a function of its concentration in sediments might mean that: [**choose the correct option**] **[1 point]**
在 4 齡搖蚊幼蟲腸道內觀察到的 PE-MPs 數量比例與其在沉積物中的濃度可能意味著：[選擇正確的選項] [1 分]

a) The volume of the gut of L4 is not finite
4 齡搖蚊幼蟲腸道的容量並不是有限的

b) The expected number of PE-MPs of L4 for the highest concentration in sediments could be lower
在高濃度沉積物中的 4 齡幼蟲體內 PE-MPs 的期望數值可能較低

c) The number of ingested PE-MPs is near its maximum value
被攝入的 PE-MPs 數量近乎其最大值

d) None of the above
以上皆非

6. The number of PE-MPs inside the gut of L4 was 0 for the control condition. This is because: [**choose the correct option**] **[1 point]**
   4 齡幼蟲腸道內 PE-MPs 的數量在對照條件下為 0。這是因為：【選擇正確的選項】【1 分】
   a) L4 did not ingested PE-MPs despite their presence in sediments
      儘管 PE-MPs 存在於沉積物中，4 齡幼蟲並未攝取 PE-MPs
   b) L4 ingested PE-MPs in control sediments, but the egestion was faster than ingestion
      4 齡幼蟲在對照組沉積物中攝入 PE-MPs，但排出比攝入速度快
   c) L4 did not ingested PE-MPs since sediments of control do not have them
      因為對照組沉積物沒有 PE-MPs，所以 4 齡幼蟲沒有攝入
   d) none of the above
      以上皆非

**Context 情境**

Seven replicates (of 15 organisms each) per condition were used to estimate oxygen consumption rate of larvae of *Chironomus riparius* exposed for 48 hours to concentrations of 0.00, 1.25, 5.00, and 20.00 g $kg^{-1}$ dry sediment of PE-MPs of the 32-63 µm size class. Briefly, samples were homogenised for 30 seconds at 4 °C. From each homogenized sample, 300 µL were collected, mixed with a detergent, centrifuged (1000 g X 10 min, 4ºC), and the resulting supernatant used for the analysis of the electron transport system (ETS) activity. The oxygen consumption was estimated by following the increased absorbance at 490 nm throughout a 3 min period and expressed as KJ $hour^{-1}$ $mg^{-1}$ organism. The results of such experiment are presented in figure 4.
每種條件使用 7 個重複（每個重複具有 15 個體）來估計搖蚊幼蟲暴露於等級 32-63 µm 的 PE-MPs ，濃度分別為 0.00、1.25、5.00 和 20.00 g kg-1 的 PE-MPs 乾沉積物 48 小時後，估計其耗氧率。簡而言之，樣品在 4ºC 下均質化 30 秒。從每個均質樣品中，收集 300 µL，與清潔劑混合，離心（1000g X 10 分鐘，4ºC），所得上清液用於分析電子傳遞系統 (ETS)的活性。透過在 3 分鐘內在 490 nm 處所增加的吸光度來估計耗氧量，並表示為 KJ $hour^{-1}$ $mg^{-1}$ organism。實驗結果如圖 4 所示。

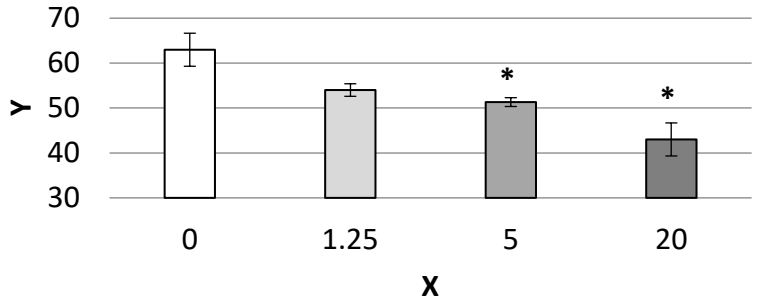



Figure 4 – Oxygen consumption rate(mJ $h^{-1}mg^{-1}$ organism) in isolated samples of larvae of *Chironomus riparius* exposed for 48 hours to concentrations of 0.00, 1.25, 5.00, and 20.00 g $kg^{-1}$ dry sediment of PE-MPs of the size class 32-63 µm. Axes: **X** - concentration of polyethylene microplastics (g PE-MPs/Kg sediment); **Y** - oxygen consumption rate (kJ/h/mg organism). Values are presented as mean ± standard error of the mean (n=7). *denotes a significant ($p < 0.05$) difference when compared with the control (0) treatment after one-way ANOVA followed by the post-hoc Dunnett's tests.

圖 4 –分別暴露於尺寸級別為 32-63 µm 且濃度分別為 0.00、1.25、5.00 和 20.00 g kg-1 的 PE-MPs 乾沉積物 48 小時的搖蚊分離樣本之耗氧率（mJ $h^{-1}$ $mg^{-1}$ organism）。 X 軸—聚乙烯塑膠微粒的濃度（g PE-MPs/Kg 沉積物）； Y—耗氧率（kJ/h/mg 生物個體）。數值為平均值 ± 平均值的標準誤差 (n=7)。 * 表示與對照 (0) 處理相比，經過 ANOVA 分析和事後 Dunnett 檢測後的顯著 ($p < 0.05$) 差異。

7. The oxygen consumption rate (Figure 4) of larvae of *Chironomus riparius*: [**choose the correct option**] **[1 point]**
搖蚊幼蟲的耗氧率（圖 4）：【選擇正確選項】【1 分】

a) Was not significantly affected by the ingestion of PE-MPs
並未顯著受到攝入 PE-MPs 的影響

b) Was significantly increased due to ingestion of PE-MPs
因攝入 PE-MPs 而有顯著增加

c) Was significantly decreased due to ingestion of PE-MPs
因攝入 PE-MPs 而有顯著下降

d) Is not shown in figure 4
在圖 4 中沒有顯示

8. The results obtained with larvae of *Chironomus riparius* indicate that: [**choose the correct option**] [**1 point]**

   由搖蚊幼蟲所獲得的結果指出：【選擇正確選項】【1 分】

   a) The ingested PE-MPs are inert and consequently aerobic energy production might be compromised due to lack of nutrients
   由於攝入的 PE-MPs 是惰性的，導致有氧能量的產量可能會因缺乏營養而受到影響

   b) A decreased ETS activity enables larvae to ingest less PE-MPs due to an excess of nutrients
   因營養過剩，電子傳遞系統活性的降低促使幼蟲攝入較少的 PE-MP3

   c) All the above options are correct
   以上皆對

   d) All the above options are incorrect
   以上皆非

9. The electron transport system occurs inside: [**chose the correct option**] [**1 point**]
   電子傳遞系統發生在：【選擇正確選項】【1 分】

   a) Lysosomes 溶小體

   b) The nuclei 細胞核

   c) The Golgi apparatus 高基氏體

   d) The mitochondria 粒線體

10. What stage of aerobic respiration does the protocol focus on to determine oxygen consumption? [**choose the correct option**] **[1 point]**
    本題中實驗程序主要檢測的耗氧量發生在有氧呼吸的那一階段？【選擇正確選項】【1 分】

    a) Oxidative phosphorylation 氧化磷酸化

    b) Krebs cycle 克氏循環

    c) Glycolysis 糖解作用

    d) Gluconeogenesis 糖質新生作用

# Part 4

# The first stopover – The Canary Islands

# 第一中繼站 - 卡納利群島

**Subject:** Ecology
**學科：**生態學
**Theme:** Cory's shearwaters: mighty travellers of the Atlantic seas
**主題：**柯氏鰹鳥：大西洋上強悍的旅者
**Time proposed:** 20 min
**建議時間：**20 分鐘

**Introduction**

Although poorly known, Cory's shearwaters, *Calonectris borealis* (Cory, 1881), are the most emblematic seabirds in the Portuguese coastal and oceanic waters. They nest exclusively on islands, occurring in the archipelagos of the Azores, Madeira, and also in Berlengas, off the Portuguese coast.

雖然對柯氏鰹鳥（*Calonectris borealis* (Cory, 1881)）所知不多，但是他是在葡萄牙海岸及海域最具有代表性的海鳥。他們只有在葡萄牙外海的亞速爾群島(Azores)、Madeira 及 Berlengas 這些群島築巢。

Cory's shearwaters are formidable oceanic migrants. They are present in their breeding areas from mid-February to mid-October. They nest in burrows and rock crevices where they lay just one egg, and are unable to replace it in the same year, in case of loss. In late October, the vast majority of birds departs to the southern hemisphere, heading towards Uruguay and Brazil, and then crossing to South Africa, where they spend most of the non-breeding season in the rich waters of the Benguela current. In February, they return to the colonies for the next breeding season.

柯氏鰹鳥是一個可敬的大洋遷移者，他們只有在二月中到十月中會出現在繁殖地，他們在地穴及岩隙築巢，每巢只產一蛋，如果遭受破壞則當年無法再產卵，在十月末，絕大多數鳥離開後往南半球，飛向烏拉圭和巴西，然後再橫跨至南非，他們在非繁殖期留在豐腴的 Benguela 洋流環境度過，二月他們再回到原來聚落進行繁殖。

According to the International Union for Conservation of Nature (IUCN), the conservation status of Cory's shearwaters is "Least Concern", due to the relatively large populations, some of which are actually growing.

根據國際鳥盟（the International Union for Conservation of Nature (IUCN)）的資訊，柯氏鰹鳥由於有較大的族群，而且有些族群仍成長中，所以被歸為最不需要顧慮的鳥種。

The largest known colony of Cory's shearwaters is located in the Selvagens Islands, ca. 300 km south of the island of Madeira, Portugal. In this island, with about 270 ha, there was a breeding population of shearwater that some researchers speculated to have reached 130,000 breeding pairs! However, the continued exploitation of birds for human consumption, and especially two slaughter episodes of adult birds, in 1978 and 1979 (coinciding with the creation of a Nature Reserve) decimated the population, drastically reducing the number of breeding pairs. From 1980 onwards, a biological station was set on the island, ensuring a permanent presence of nature

wardens, which has allowed the recovery of the shearwater population. Since then, several studies have been undertaken on the demography and migratory ecology of this species.
其中最大的柯氏鼱鳥族群是在 Selvagens Islands 島上，離葡萄牙 Madeira 島嶼南邊 300 公里處。在這個島嶼約 270 公頃，根據研究員人員的估計有 13 萬對在島上繁殖。然而人類對鳥類資源的利用，尤其是在 1978 與 1979 年兩次大規模的屠殺成鳥（同時該島成立自然保留區），造成繁殖族群大量減少。從 1980 年開始，在島上設立生物站，希望能夠永久執行對這地方的保護，使得該地的柯氏鼱鳥族群能恢復，其後幾項研究針對本種族群動態及遷移生態進行研究。

**Context 情境**

In 1980, the population of Cory's shearwaters was estimated at only 7000 breeding pairs (Mougin and Stahl 1982). In 2005, the population was estimated again suggesting the presence of 29,540 breeding pairs (Granadeiro *et al*. 2016).

在 1980 年，柯氏鰹鳥族群估計大約有 7000 對（Mougin and Stahl 1982）。在 2005 年估計大約有 29540 對（Granadeiro *et al*. 2016）。

1. Assuming that the rate of population increase has remained constant throughout the entire period; determine the annual growth rate of the population. **Perform the necessary calculations, starting from the function**:
   假設族群增長速率在上述時期是恆定的，估算每年族群生長速率。根據以下公式，進行必要的計算：

$$N_{(t+1)} = R \times N_{(t)} \quad \Leftrightarrow \quad N_{(t)} = R^t \times N_0$$

   Where:
   *N* = Number of individuals 個體數量
   *R* = Growth rate of the population 族群成長速率
   *t* = time 時間

   and **choose the correct option**. **[1 point]**
   **選擇正確選項。**
   a) 5.93% per year
   b) 3.22% per year
   c) 4.22% per year
   d) 3.05% per year

2. Considering that the population growth rate has remained unchanged since 2005, and assuming a hypothetical growth rate of 4.6% per year, determine how many years it will take this colony to reach 130 000 breeding pairs. Perform the necessary calculations using the function above and **choose the correct option**. **[1 point]**
   假設從 2005 年之後族群成長速率維持不變，族群成長速率每年為 4.6%，估算多少年後族群會達到 130000 對。使用上面的公式執行必要的計算，並選擇正確選項。
   a) around 26 years (25.7 years)
   b) around 33 years (32.9 years)
   c) around 48 years (48.2 years)
   d) around 51 years (51.4 years)

**Context 情境**

During the breeding period, Cory's shearwaters feed in a vast area around the Selvagens, including the pelagic waters around the island, the seamounts and also the African coast, i.e., in very different oceanographic domains. Figure 1 portraits 3 real shearwater tracks collected when birds were foraging during the chick-rearing period, as well as the variation of temperature and bathymetric conditions during each trip.

在繁殖時期，柯氏鰹鳥圍繞在 Selvagens 島附近很大一個區域覓食，包括島嶼外的開闊水域，海底山脈和非洲海岸，是非常不同的海洋地理區塊。圖 1 顯示三筆柯氏鰹鳥在育雛期間覓食時的活動軌跡，以及每次活動時溫度與海洋深度的變化。

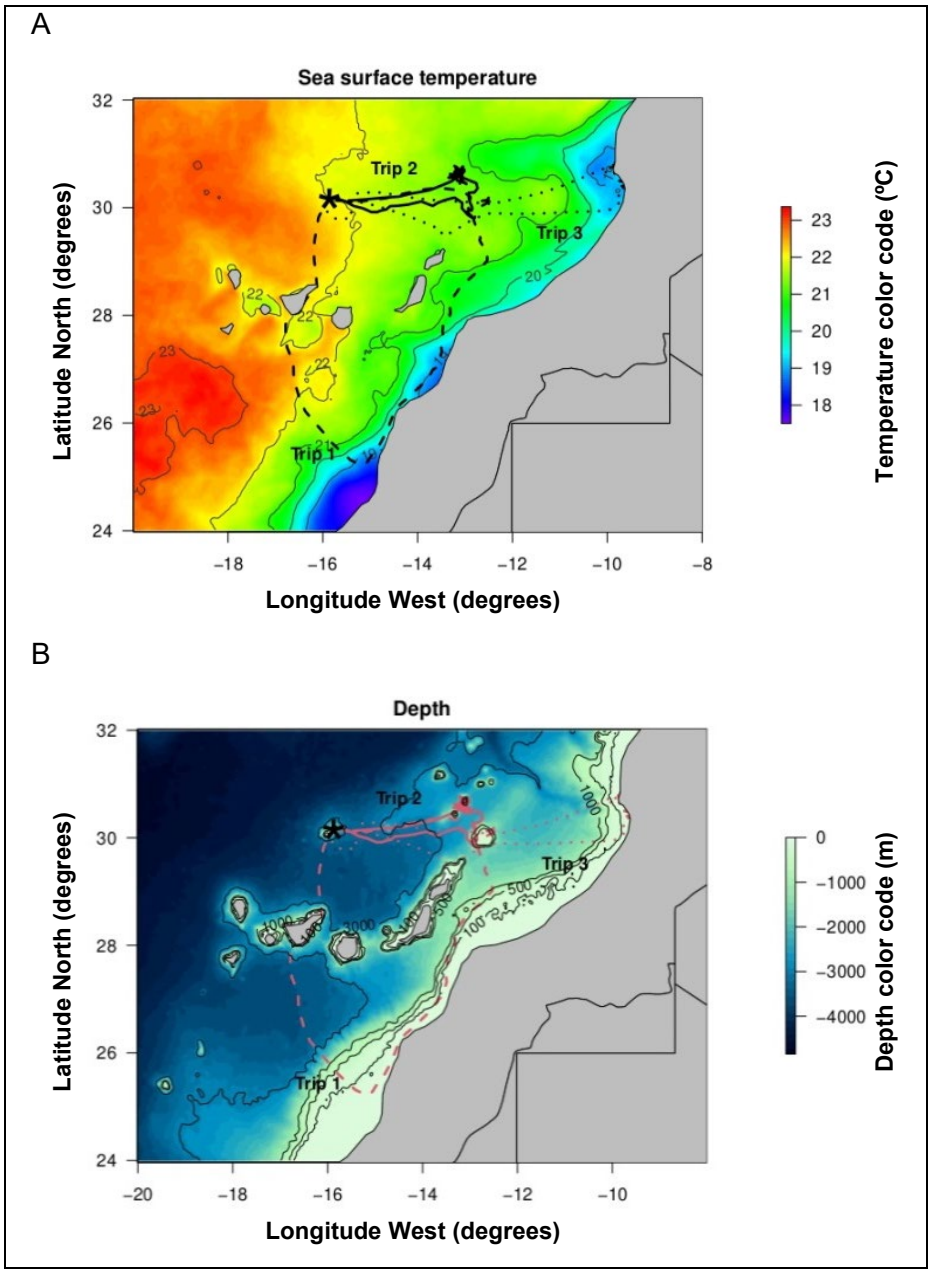



**Figure 1** – Three real shearwater tracks obtained (with GPS loggers) in Selvagem Grande (the island is marked by a black asterisk), plotted over maps of sea surface temperature (A) and of depth (B), showing the variation in temperature and bathymetry experienced by shearwaters during the course of each trip. Trip 1 - dashed line, trip 2 - solid line, trip 3 - dotted line.

圖 1、由衛星定位收集三筆柯氏鰹鳥在 Selvagem Grande 島嶼（島嶼以黑星號標示）活動軌跡，圖中顯示海洋表面溫度（A）與深度（B），在每一次旅途上所經歷的溫度與深度。第一次旅途用長條虛線，第二次旅途用實線，第三次旅途行用點狀虛線。

3. **Figure 2** shows three profiles of temperature and depth variation related with the trips displayed in **Figure 1**. Associate each of the trips (1, 2 and 3) to the respective profile of variation in temperature and depth conditions shown in figure 2 (A, B and C). [**Fill the spaces with the letters A, B or C, as appropriate**] **[3 points, 1 point each correct answer]**

圖 2 顯示圖 1 中三次旅途的溫度與深度相關變化。三次旅途(1、2 及 3)的溫度與深度變化以圖 2 的 A、B、C 表示。根據以下問題選擇適合的字母填入。

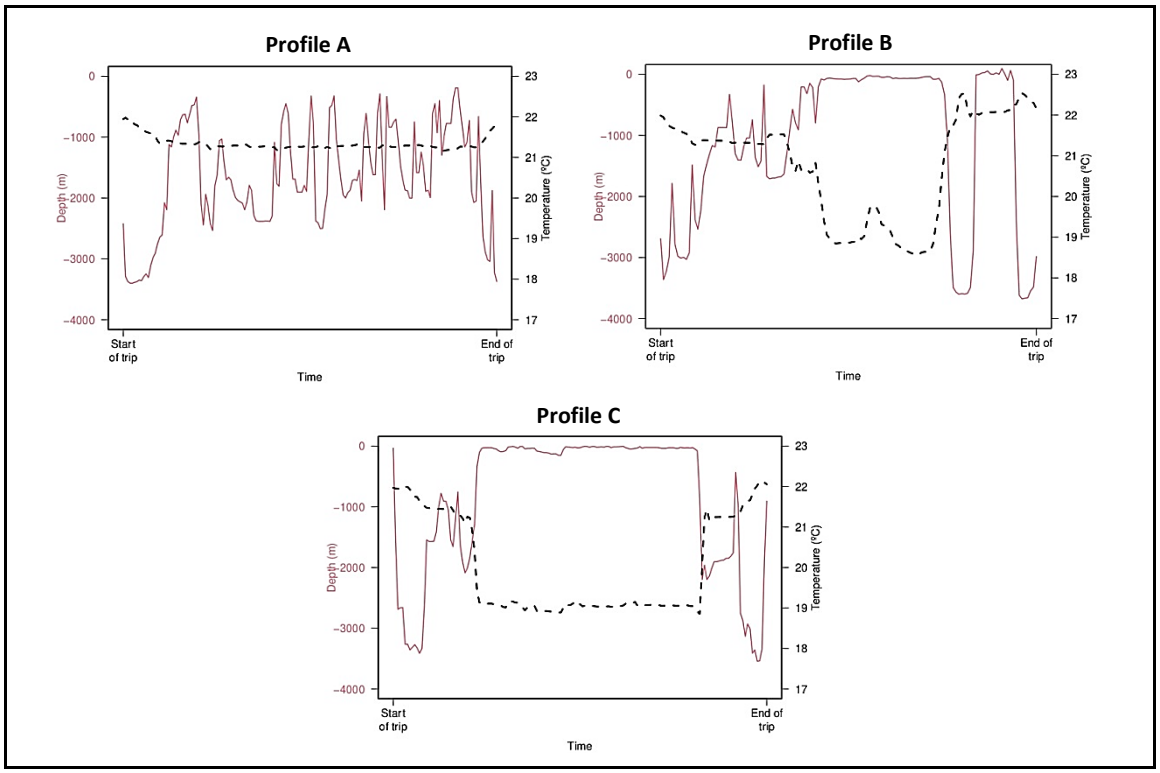



Figure 2 – Profiles of variation in temperature and bathymetry experienced by shearwaters along each of the three trips represented in figure 1.

圖 2、每一隻柯氏鰹鳥在旅途中所經歷的溫度及深度影像變化

**Context**

During the breeding period, Cory's shearwaters feed in different areas, and therefore prey on distinct marine communities. Table 1 shows the results of diet studies of birds foraging in three areas.

在繁殖期，柯氏鼱鳥在不同區域覓食，所以他們在不同的海洋群集捕食，表 1 顯示鳥類在三個不同區域的食性。

**Table 1** - Prey consumption by Cory's Shearwaters in three different oceanic domains (the figures in the table represent number of prey)

表 1、柯氏鼱鳥在三個不同海洋區塊捕食的獵物（表中數字代表獵物數量）

| **Prey species**<br>**獵物物種** | **Coastal zones**<br>**海岸區域** | **Seamounts**<br>**海底山脈** | **Pelagic areas**<br>**開闊水域** |
|---|---|---|---|
| *Sardina pilchardus* | 280 | 70 | 21 |
| *Scomber colias* | 28 | 140 | 28 |
| *Macroramphosus scolopax* | 20 | 140 | 70 |
| *Engraulis encrassicolus* | 20 | 84 | 42 |
| *Trachurus sp.* | 16 | 210 | 161 |
| *Diretmus argenteus* | 12 | | 28 |
| *Naucrates ductor* | 12 | | 350 |
| *Ommastrephes bartramii* | 8 | | |
| *Histioteuthis arcturi* | 4 | | |

4. Using the Shannon-Wiener index (H') rank the studied areas by ascending order of diversity. [**choose the correct option**] **[1 point]**
使用 Shannon-Wiener index (H')由低到高排序三個區域的生物多樣性。選擇正確選項

$$H' = -1 \times \sum_{i=1}^{\cdot} (p_i \times \ln p_i)$$

Where:
*pi* = relative proportion of each prey species 每個獵物物種的相對比例

a) Seamounts < African Coast < Pelagic areas
b) African Coast < Seamounts < Pelagic areas
c) African coast < Pelagic areas < Seamounts
d) Pelagic areas < African coast < Seamounts

~~**5.** The Cory's shearwater colony in Selvagem Grande depends to a large extent on the Canary Current Large Marine Ecosystem region, where one of the most important upwelling systems in the Atlantic Ocean is located. Complete the following statements concerning this oceanographic phenomenon. [**choose one option from the appropriate key in each case to fill the blanks in each of the sentences**] **[7 points, 1 point each correct answer]**~~
~~柯氏鼱鳥族群在 Selvagem Grande 主要依賴 Canary 洋流大海洋生態區，其內有大西洋裡最重要的上升流之一。根據海洋地理現象完成下列敘述。（請選擇適當的關鍵字填入下列句子的空格）~~

a) Coastal upwelling is an oceanographic process in which _____ water, _____ nutrients _____ deeper areas to the surface water.
海岸上升流是一種海洋地理的作用過程，此洋流是_____水，_____營養鹽_____深水區至淺水區。

| a) | Key | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | | | 2 | | | 3 | |
| A | warm | 暖的 | A | rich in | 富含 | A | rise from | 上升自 |
| B | cold | 冷的 | B | poor in | 缺乏 | B | descend to | 沉降至 |
| C | cleaner | 較乾淨的 | C | contaminated with | 被汙染 | C | dilutes into | 稀釋到 |
| D | saltier | 較鹹的 | D | with rare | 稀有 | D | | |

b) In this region, the upwelling(上升流) is more intense(強勁) when the winds blow from _____, which causes the surface water to move _____ the coast.
在此區域，當風由_____方向吹，使上升流更強勁，造成表面水_____海岸。

| b) | Key | | | | |
|---|---|---|---|---|---|
| | 1 | | | 2 | |
| A | North | 北 | A | toward | 朝向 |
| B | South | 南 | B | away from | 遠離 |
| C | East | 東 | C | along (to the North) | 沿著（往北） |
| D | West | 西 | D | along (to the South) | 沿著（往南） |

c) Across the globe, coastal upwelling occurs mainly in areas close to the _____ coasts of the continents.
綜觀全球，海岸上升主要發生的地區是接近_____的大陸海岸。

| c) | Key | |
|---|---|---|
| | 1 | |
| A | North | 北 |
| B | South | 南 |
| C | East | 東 |
| D | West | 西 |

d) The availability of nutrients in ocean water is mostly essential for the growth of _____.
海洋中營養鹽的可利用程度對_____的生長是最重要的。

| d) | Key |
|---|---|

| | 1 | |
|---|---|---|
| A | phytoplankton | 浮游植物 |
| B | zooplankton | 浮游動物 |
| C | fish and squids | 魚和烏賊 |
| D | marine mammals | 海洋哺乳類 |

**Context 情境**

Cory's shearwaters are trans-equatorial migrants, heading to the southern hemisphere in mid-October and only returning to the breeding grounds in mid-February. A group of researchers tried to understand whether the date of departure from the colony influenced their migratory strategies, and particularly the decision to carry out (or not) temporary stops during the migration, commonly known as stopovers. To address this issue, researchers deployed tracking devices (geolocators) to 97 individuals in September, before they left the colony to migrate. The data obtained in the following breeding season allowed for the construction of Figure 3.

柯氏鰹鳥是跨越赤道的遷移者，在十月中往南半球，只有在二月中回到繁殖地。一群研究人員嘗試了解離開繁殖地的日期是否影響其遷移策略，特別是遷移過程中決定在中途暫時停留或不停留。為了解這個議題，研究人員選了 97 個個體，在九月牠們離開前裝上追蹤器（定位器）。圖 3 為下一繁殖季所收集到的資料。

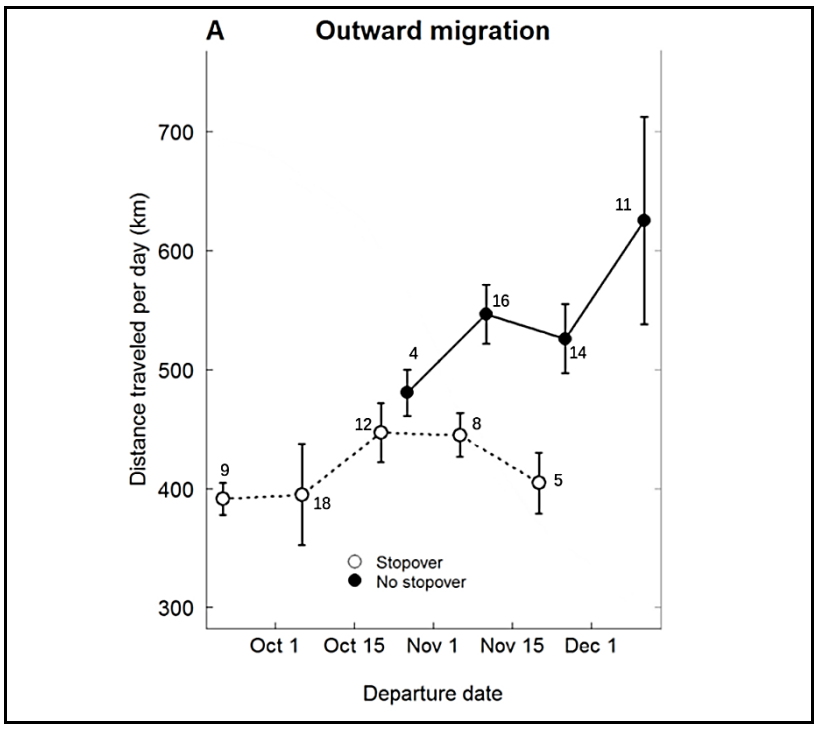



**Figure 3** – Relation between the date of departure of Cory's shearwaters for their migration and the mean distance travelled per day (± standard deviation) in birds that made stopovers (open symbols) and in birds that did not (solid symbols); the numbers next to each dot represent the number of individuals tracked in each situation.

圖 3、兩類（有在中途停留或不停留）柯氏鰹離開繁殖地的日期與平均每天飛行距離（± 標準差）的關係，白圈為有在中途停留，黑點是不停留。白圈與黑點旁的數字為收集資料的鳥個體數。

6. Based on the interpretation of the Figure, **classify each of the following statements as true (T) or false (F)**. **[4 points, 1 point each correct answer]**
   根據圖的解說，**分辨出下列敘述的對（T）或錯（F）**。
   a) The decision to make migratory stopovers does not depend on the date of departure from the colony
      對於遷移過程中，選擇是否中途停留與開始遷移日期無關
   b) When birds choose to stopover, it is because they can travel faster
      當鳥選擇中途停留是因為他們能夠飛得更快
   c) The distance travelled per day increases throughout the migratory period, regardless of stopovers
      無論有無在中途停留，在遷移過程中每天飛行距離增加
   d) The probability of carrying out a stopover tends to decrease with the increase in the departure date
      開始遷移日越晚，傾向在中途停留的機率越低

# Part 5
# The second stopover – Rio de Janeiro, Brazil
# 第二站 巴西里約熱內盧

**Subject:** Cellular Biology and Biotechnology

科目：細胞生物學和生物技術

**Theme:** Natural products in plants

主題：植物中的天然物

**Time proposed:** 20 min

建議時間：20 分鐘

### Introduction

There is growing interest in the use of herbal medicinal products (HMP). Among the most sought-after HMP are those containing *Hypericum perforatum* L., prescribed, essentially, for the relief of moderate depressive states and of anxiety. These products are available on the market in various forms, such as, for example, capsules, tablets, alcoholic extracts, plant for infusions and food supplements. Antidepressant activity has been attributed to hypericin and hyperforin. These compounds, however, do not exist in all *Hypericum* species. In *H. perforatum*, hypericin, with a characteristic dark red color, occurs in black glands present in the leaves and petals.

現在人們對草藥產品（HMP）的使用越來越感興趣。其中最受歡迎的是含有貫葉連翹（*Hypericum perforatum* L.）的草藥產品，主要用於緩解中度憂鬱狀態和焦慮。此類產品以各種形式在市場上販售，例如膠囊、藥錠、酒精萃取物、用於點浸漬液和食品補充劑的植物。金絲桃素和貫葉金絲桃素具有抗憂鬱的活性作用。然而，這些化合物並不是存在於所有金絲桃屬植物物種。在貫葉連翹中，具有特有深紅色的金絲桃素存在於葉子和花瓣中的黑色腺體中。

**Section I -** To evaluate the presence of hypericin in two sachets of HMP, marketed for infusions, and in capsules, marketed as food supplements, the morphological and chemical characteristics were evaluated. For this, the material was observed under an optical microscope, and extracted with methanol. In this way it was possible to differentiate which HMP were from *H. perforatum*, or from another species, frequent in Portugal.

為了評估草藥產品是否含有金絲桃素的存在，此產品包含二包市售浸漬液用的材料和作為食品補充劑的膠囊，檢視其形態和化學特徵。為此，在光學顯微鏡下觀察植物材料，並用甲醇萃取。經由這種方式，可以區分哪種草藥產品是來自貫葉連翹或來自葡萄牙常見的其他物種。

The images in **Figure 1** show, randomly, phases of the process.

圖 1 中的影像隨機顯示此過程的各個階段。

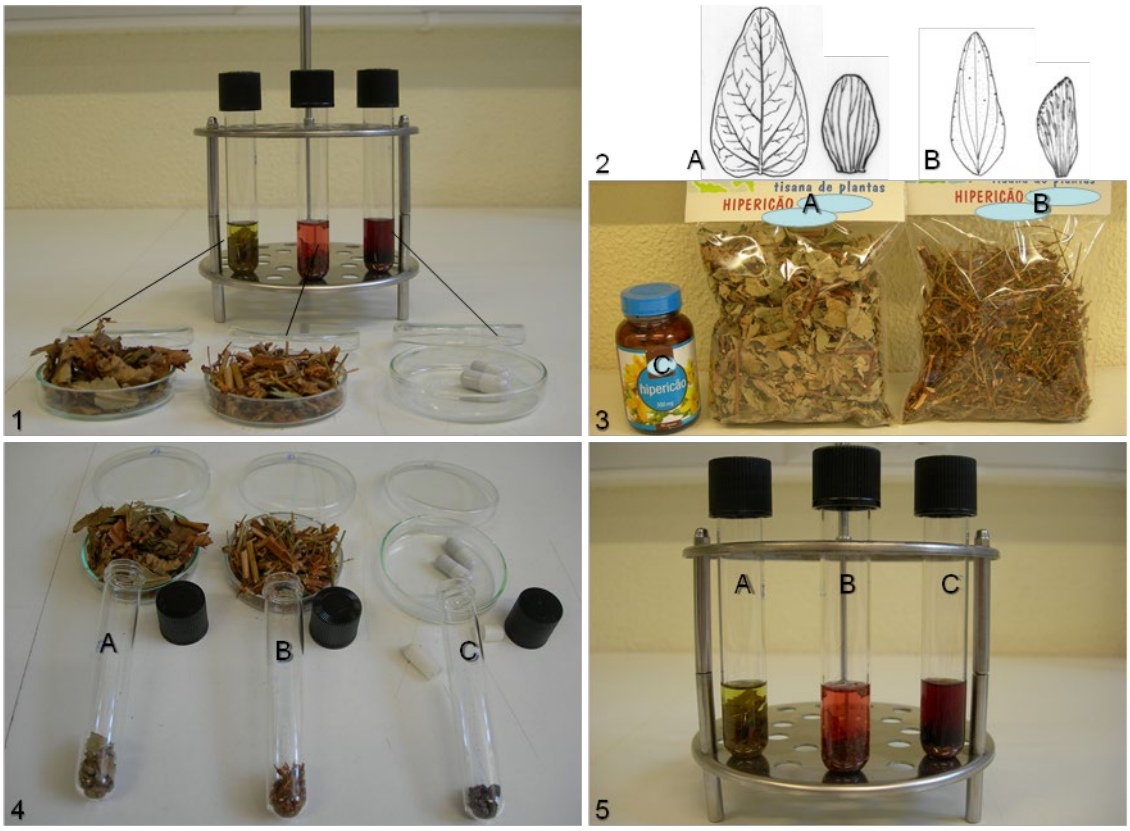



**Figure1**–Different phases of the determination of the presence of hypericin and of the extraction process, based on the method of methanol extraction.

圖 1 – 使用甲醇萃取方法，以確定金絲桃素存在和其萃取過程的不同階段。

1. To present correctly and sequentially the observations of the morphological and chemical characteristics of the samples, the ordering of the figures should be: [**choose the correct option**] **[1 point]**
   為了正確、且依序地呈現樣品的形態和化學特徵之觀察結果，圖 1 中的影像排列順序應該是：[選擇正確的選項][1 分]
   a) 2, 4, 3, 1, 5
   b) 3, 2, 4, 1, 5
   c) 1, 2, 3, 4, 5
   d) 4, 2, 3, 1, 5

2. **Classify as true (T) or false (F) each of the sentences below**. **[6 points, 1 point each correct answer]**
   區分下列每一個句子為正確(T)或錯誤(F)。【6 分，每個正確答案 1 分】
   a) Image 5 shows the maceration of the plant material in methanol
      影像 5 顯示了植物材料浸漬在甲醇中
   b) Image 2.B represents schematically the observation of sample 4.C under the microscope
      影像 2 的 B 繪圖代表在顯微鏡下觀察樣品影像 4 之 C 的情形
   c) Image 2.A schematically represents leaves and petals from sample A, which has no black glands
      影像 2 的 A 繪圖代表樣品 A 的葉子和花瓣，其沒有黑色腺體存在
   d) Chlorophyll is the dominant pigment in sample C
      葉綠素是樣品 C 中的主要色素
   e) Based on the observed reaction, we can conclude that sample A is from *Hypericum perforatum*
      根據觀察到的反應，我們可以得出結論是樣品 A 來自貫葉連翹
   f) Only two samples show the presence of hypericin
      只有兩個樣品顯示有金絲桃素的存在

**Section II -** Allelopathy is a natural phenomenon of biological interaction. Mediated by substances (allelochemicals) produced by an organism, the interaction can affect the surrounding community positively (to be beneficial) or negatively (to be harmful). Many allelochemicals produced by a plant affect germination, growth, survival, and reproduction of other plants. Some aquatic plants (e.g. *Nymphaea odorata*) release allelopathic substances that suppress the growth of duckweed *(Lemna minor*). Man often uses this type of allelochemicals to obtain formulations that act as natural herbicides. For this purpose, it is necessary to test the allelopathic potential of plant extracts, such as, for example, essential oils.

相生相剋作用是生物交互作用的自然現象。在生物體所產生的物質（相生相剋物質）仲介之下，這種交互作用可以對周圍群落產生正向（有益）或負向（有害）的影響。植物產生的眾多相生相剋物質會影響其他植物的發芽、生長、存活和繁殖。一些水生植物（例如北美香睡蓮 *Nymphae aodorata*)會釋放相生相剋物質來抑制浮萍（*Lemna minor*）的生長。人類常使用此類型的相生相剋物質來做為天然除草劑的製劑使用。因此，測試植物萃取物（例如精油）的相生相剋潛力是有必要的。

In the present experiment, Figure 2, the allelopathic effect of *Eucalyptus globulus* (eucalyptus) essential oils was tested on *Lemna minor* (duckweed). The multiwell plate A served as a control (without the addition of essential oil). In each well of the multiwell plate B, 100 µl of essential oil were added. The allelochemical effect of the essential oil was evaluated, among others, by determining leaf chlorosis (a condition characterized by a decrease in the content, or absence of chlorophyll, visible by the pale green or yellowish aspect).

在本實驗中，圖 2，藍桉（*Eucalyptus globulus*）　（桉樹）精油對浮萍的相生相剋作用進行了試驗。多孔盤 A 作為對照（不添加精油）。在多孔盤 B 的每孔加入 100µl 精油。精油的相生相剋作用是藉由葉片萎黃症（一種以葉綠素含量減少或缺乏為特徵的症狀，呈現淡綠色或淡黃色）來評估的。

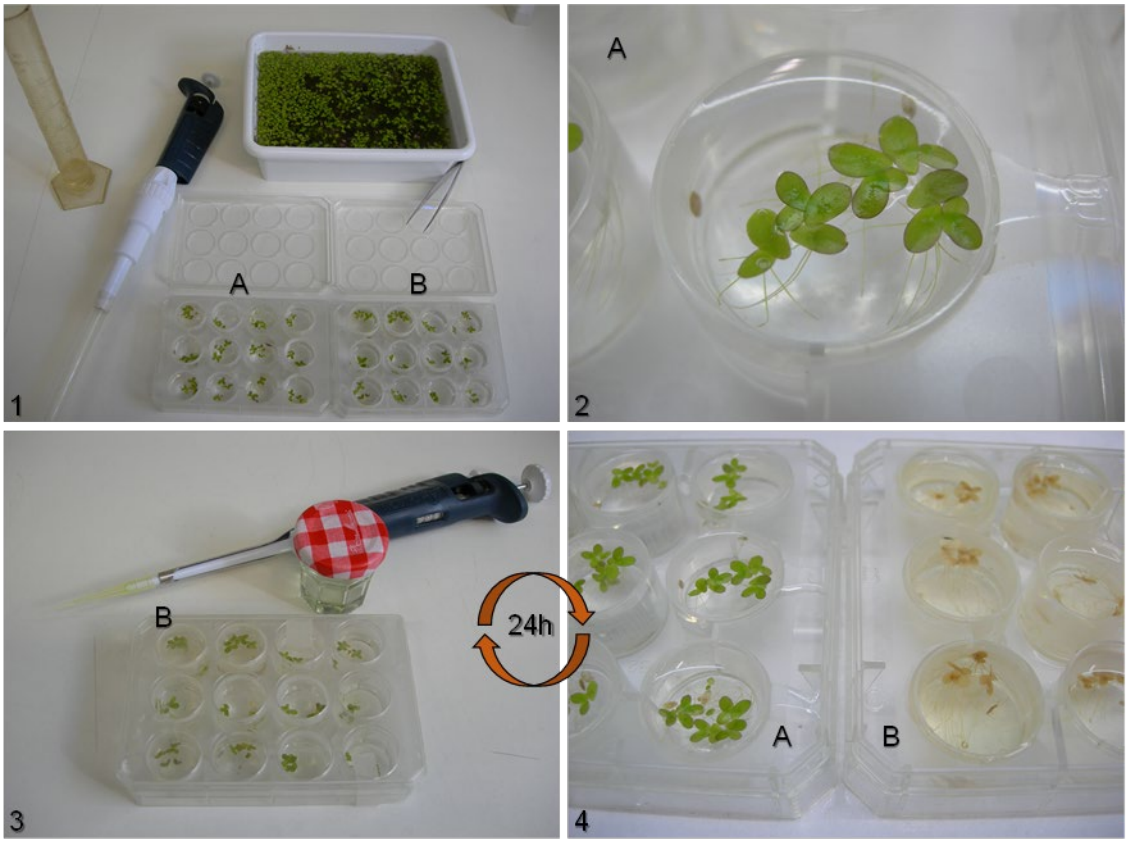



**Figure2**– Different steps of an experiment performed to test the allelopathic effect of *Eucalyptus globulus* essential oils on *Lemna minor*.

圖 2、為測試藍桉精油對浮萍的相生相剋作用所進行實驗的不同步驟。

**3. Classify as true (T) or false (F) each of the sentences below.[6 points, 1 point each correct answer]**

區分下列每一個句子為正確(T)或錯誤(F)。【6 分，每個正確答案 1 分】

a) An allelopathic potential of 100% means that 2 out of 4 leaves of *Lemna minor* did not show leaf chlorosis
100%的相生相剋潛力意思是指 4 片浮萍小葉中有 2 片沒有表現出葉片萎黃症

b) The whole experiment could be carried out in the same multiwell plate
整個實驗可以在同一個多孔盤中進行

c) Leaf vigor was assessed by the absence of leaf chlorosis
葉片活力可藉經由沒有葉片萎黃症來評估

d) The experiment should be carried out under conditions of natural light and humidity, like the natural growth conditions of *Lemna minor*
實驗應在自然光照和濕度條件下進行，類似浮萍的自然生長條件

e) Based on the observed reaction, we can conclude that the essential oil of *Eucalyptus globulus* has no allelopathic effect, under these conditions
依據所觀察的反應，我們可以得出結論，在這些條件下，藍桉精油沒有相生相剋作用

f) The physiological state of *Lemna minor* can condition the result of the experiment
浮萍的生理狀態會影響實驗的結果

# Part 6
# The third stopover – The Strait of Magellan
# 第 6 部分
# 第三站 – 麥哲倫海峽

**Subject:** Ecology

**Theme:** Demography of penguin populations

**Time proposed:** 20 min

**科目: 生態學**

**議題: 企鵝族群統計學**

**時間:** 20 min

**Introduction 前言**

The Magellanic penguin (*Spheniscus magellanicus* Forster, 1781) is an aquatic bird, native to the southern region of the South American continent, particularly to the coasts of Patagonia, Argentina, and the Falkland/Malvinas Islands, in the Atlantic Ocean, and of Chile, in the Pacific Ocean, where the species forms densely populated breeding colonies. After the breeding season the Magellanic penguins migrate North in search for food, in both oceans, reaching the coasts of Brazil, in the Atlantic, or of Peru, in the Pacific.
麥哲倫企鵝 (*Spheniscus magellanicus* Forster, 1781) 是一種水鳥，原生於南美大陸南部地區，特別是巴塔哥尼亞、阿根廷和福克蘭/馬爾維納斯群島的大西洋沿岸和智利的太平洋沿岸，該物種形成族群稠密的繁殖群體。繁殖季節過後，麥哲倫企鵝在兩個大洋向北遷移來尋找食物，到達巴西海岸的大西洋沿岸、或秘魯的太平洋沿岸。
The common name of the species is associated to that of Ferdinand Magellan (Fernão de Magalhães), as its existence was noted for the first time in 1520, during the circumnavigation voyage lead by the Portuguese sailor while passing by the Tierra del Fuego.
該物種的通用名稱與費迪南德·麥哲倫 (Fernãode Magalhães)的名字有關，因為牠的存在是在 1520 年由葡萄牙水手率領的環球航行途中經過火地島時首次被注意到的。

According to the *International Union for Conservation of Nature* (IUCN), the Magellan penguins' populations are estimated as composed by 1.3 million reproducing couples and the species is classified as "*Least Concern*", although following a decreasing tendency (globally) during the

last decades. This decrease is essentially due to the reduction in prey abundance, caused by fishing, to climatic changes and to pollution.
根據國際自然保護聯盟 (IUCN)，麥哲倫企鵝的族群估計由 130 萬繁殖對組成，儘管在過去幾十年中（全球）呈下降趨勢，該物種被歸類為“無危”。這種減少主要是由於捕撈、氣候變遷和污染所導致的獵物數量減少。
The adults may attain 70 cm in height, and weight up to 4-6 kg, the females being a little less robust than males.
成鳥身高可達 70 公分，體重可達 4-6 公斤，雌性比雄性而言較沒有那麼粗壯。
The Magellan penguins are monogamous and reproduce between September and February. They build nests on the floor or in small burrows or lairs, normally protected by low vegetation and, in the most populated colonies, which may have up to 200 000 individuals, the nests may be as close as 1.2-2.5 m. The female lays up to four eggs per year, in two broods of two eggs, laid with an interval of 4 days. The eggs are incubated for about 40 days. The mortality is rather high, both *in ovo*, as in the juvenile phase, before leaving the nest, and especially during the first migration. From then on, the mortality stabilizes, and the adults may live up to an age of 10-20 years.
麥哲倫企鵝是一夫一妻制，在九月至二月之間繁殖。牠們在地面或小洞穴或巢穴築巢，通常由低矮的植被保護，在個體最多的群體中，可能有多達 200000 隻，巢穴間的距離可能短至 1.2-2.5 m。雌性每年最多產四個卵，兩窩兩個卵，產卵間隔 4 天。卵孵化期約 40 天。在離開巢穴之前，尤其是在離巢前的尚未孵化的卵和雛鳥階段與第一次遷徙期間的死亡率都相當高。至此之後，死亡率會趨於穩定，成鳥可能活到 10-20 歲。

**Note:** the experience upon which the exercise is built, is fictitious, as well as the figures that were obtained from it. Nevertheless, all the elements produced for the purpose of this test, are realistic and possible.
註：這個實作題所依據的經驗以及從中獲得的數字都是虛構的。儘管如此，為此實作題目而製作的所有元素在現實中都是可能出現的。

**Context 情境**

Since several decades, the population dynamics of two Magellan penguins' breeding colonies, in two natural reserves dedicated to the conservation of the species – Cape Vígenes, Argentina and Isla Magdalena, Chile – have been regularly monitored.

幾十年來，在兩個致力於保護該物種的自然保護區—阿根廷維吉內斯角和智利馬格達萊納島—兩個麥哲倫企鵝繁殖群的族群動態一直受到定期監測。

Recently, a study on the abundance and population structure of these two colonies, which involved a mark-recapture experiment, was conducted.

最近，對這兩個群體豐富度和族群結構進行了研究，其中涉及標記再捕法實驗。

One week before the beginning of the experiment, in each of the reserves, a 3.0 ha (hectares) study area was selected and three funnel shaped rails were placed by the beach, just as represented in **Figure 1.**

實驗開始前一周，在每個保護區，選擇一個 3.0 公頃的研究區域，並在海灘邊放置三個漏斗形欄杆，如圖 1 所示。

Such devices are intended to guide and concentrate the penguins, making it easier to count them and mark them in their return from the sea towards the respective nests.

這種裝置旨在引導和集中企鵝，使其更容易計數並在它們從大海返回各自的巢穴時進行標記。

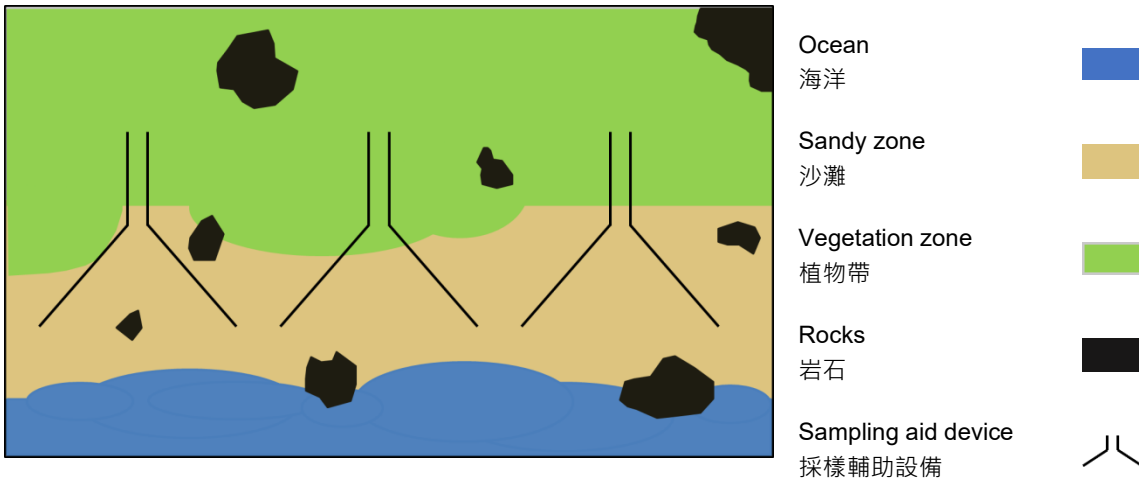



**Figure 1** – View of the sampling aid device installed in each of the studied reserves in order to sample the Magellanic penguins (the image is merely illustrative, as the various components it portrays are not represented in the same scale).

圖 1 -為了對麥哲倫企鵝進行採樣而安裝在每個研究保護區中的採樣輔助設備的示意圖（該圖像僅示意圖，因為它描繪的各種組件未以相同的比例表示）。

In the first session of the experiment an observer, positioned in the narrow extreme of each rail device, counted and marked all penguins that passed by him in their way from the sea to the nest. The marks were small circular spots, made with a harmless colour paint spray on the external face of the left wing of each animal.
在實驗的第一期間，一名觀察員位於每個導道裝置的狹窄末端，計算並標記從大海到巢穴途中經過觀察員的所有企鵝。標記是小的圓形斑點，用無害的彩色油漆噴塗在每隻動物左翼的外側表面上。

In the second session of the experiment, the same observer counted again all penguins that march in their way from the sea to the nest and, among them, all those which were marked in the previous session.
在第二期間中，同一個觀察者再次計算了從大海到巢穴的所有企鵝，其中包括前一次被標記的所有企鵝。

The conditions of the study were those displayed in **Table 1**.
這個研究的所有條件就如同表 1 所示。

**Table 1** – General conditions of the experiment performed on the population dynamics of the reproductive colonies of the Magellan penguin, *Spheniscus magellanicus*, living at Cape Vírgenes and Isla Magdalena
表 1 -對生活在維吉內斯角(Cape Vírgenes)和馬格達萊納島(Isla Magdalena)的麥哲倫企鵝 繁殖群的族群動態進行實驗的一般條件設定

| | Cape Vírgenes (Argentina) | Isla Magdalena (Chile) |
|---|---|---|
| Study area<br>研究範圍 | 3 ha | 3 ha |
| Sessions<br>期間 | 2 days | 2 days |
| Sampling effort<br>採樣工作 | 5 hours | 5 hours |

The results of the experiment, related to the two 3 ha areas under study, are presented in **Table 2**.
表 2 顯示的是與研究中的兩個 3 公頃區域相關的實驗結果。

**Table 2** – Results obtained from the experiment performed on the population dynamics of the reproductive colonies of the Magellan penguin, *Spheniscus magellanicus*, living at Cape Vírgenes and Isla Magdalena
表 2 -對生活在維吉內斯角(Cape Vírgenes)和馬格達萊納島(Isla Magdalena)的麥哲倫企鵝繁殖群體的族群動態進行的實驗獲得的結果

| | | Cape Vírgenes (Argentina) | Isla Magdalena (Chile) |
|---|---|---|---|
| 1st Session 第一期間 | Counted 計數 | 1 068 inds. | 1 077 inds. |
| | Previously Marked 先前被標記的 | 0 inds. | 0 inds. |
| 2nd Session 第二期間 | Counted 計數 | 1 239 inds. | 1 245 inds. |
| | Previously Marked 先前被標記的 | 36 inds. | 34 inds. |

Other information on both populations has been collected for some years and part of it, namely that related with reproduction and mortality, is reproduced in **Table 3**, while the population structure is presented in **Figure 2.**

關於這兩個族群的其他資訊已經收集了一些年，其中一部分，即與繁殖和死亡率相關的資訊，在表 3 中呈現，而族群結構則在圖 2 中呈現。

**Table 3** – Information relative to sex ratio, number of eggs per female and mortality rates estimated for the populations of the Magellan penguin, *Spheniscus magellanicus*, living at Cape Vírgenes and Isla Magdalena.

**表 3** -與生活在維吉內斯角(Cape Vírgenes)和馬格達萊納島(Isla Magdalena)的麥哲倫企鵝族群的性別比例、每隻雌性的產卵數和死亡率有關的資訊。

| | | Cape Vírgenes (Argentina) | Isla Magdalena (Chile) |
|---|---|---|---|
| Sex ratio<br>性別比例 | M/F<br>F/M | 1,0145<br>0,9857 | 0,9231<br>1,0833 |
| Number of eggs per female<br>每隻雌性的卵數 | | 4 | 4 |
| Mortality rate<br>死亡率 | *In ovo*<br>卵內 | 53% | 53% |
| | Juvenile<br>幼鳥 | 65% | 59% |
| | 1st migration<br>1st 遷移 | 71% | 65% |

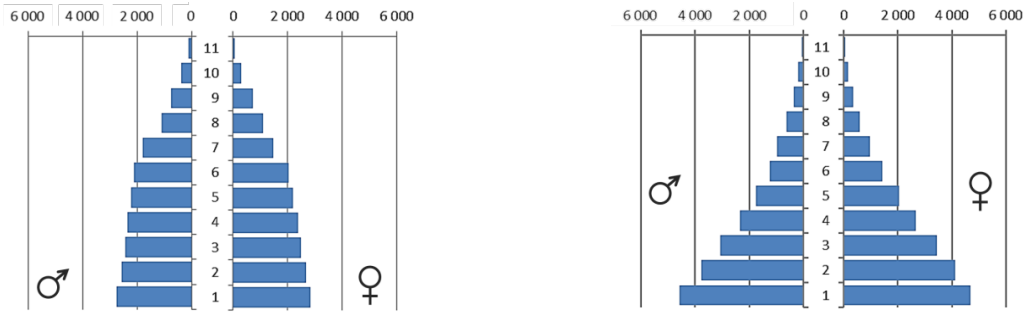



**Figure 2** – Population structure of the populations of the Magellan penguin, *Spheniscus magellanicus*, living at Cape Vírgenes and Isla Magdalena. Vertical axis represents age in years, and horizontal axis represents number of individuals.

圖 2. 生活在維吉內斯角和馬格達萊納島的麥哲倫企鵝 的族群結構。縱軸代表年齡，橫軸代表個體數。

Based on the data provided, help the researchers in the characterization of the studied populations by finding the solution for the problems below, assuming that in both colonies the juveniles have not left the nest yet.

根據所提供的數據，你可找到以下問題的解決方案來幫助研究人員描述研究族群的特質，假設兩個種群的幼鳥都還沒有離開巢穴。

1. Estimate the number of adult individuals that composes the population of Cape Vírgenes [**choose the correct option**] **[1 point]**.
   估計構成 Cape Vírgenes 族群的成年個體數量 [選擇正確選項] [1 分]。

| | Cape Vírgenes (Argentina) |
|---|---|
| a) | 44 604 inds |
| b) | 38 448 inds |
| c) | 36 757 inds |
| d) | 35 206 inds |

2. The estimate made in the question above was based on a model with the following assumptions [**classify as true (T) or false (F) each of the sentences below**]
   **[8 points, 1 point each correct answer]**
   上面問題中的評估是依據以下假設的模型 [指出下列敘述為正確(T) 或錯誤 (F)] [8 分，每個正確答案 1 分]
   a) The marks and the marking do not affect the survival/behaviour of the animals
      標記與未標記不影響動物的存活與行為
   b) The marked animals are easier to detect than the unmarked
      被標記的動物比未被標記動物容易被偵測
   c) The marked animals must have a recuperation period
      被標記的動物必須有休養期
   d) The probability of capture of marked and unmarked animals is similar
      被標記與不被標記動物的被捕獲機率差不多
   e) The marked animals mix randomly within the population
      被標記動物在族群中的分布為逢機
   f) The marked animals are more abundant than the unmarked ones
      被標記動物比起未被標記動物在族群中的豐富度較高
   g) The marks are not lost between the two sessions of the experiment
      標示牌在實驗進行的兩季之間不會遺失
   h) All marked animals go to the nests after being marked
      所有被標記動物在被標記後都會走去巢位

3. Estimate the average adult individuals' density in the population of Isla Magdalena [**choose the correct option**]. **[1 point]**
   估計馬格達萊納島族群中成年個體的平均密度 [選擇正確的選項]。 [1 分]

| | Isla Magdalena (Chile) |
|---|---|
| a) | 1.41 inds/$m^2$ |
| b) | 1.31 inds/$m^2$ |
| c) | 1.28 inds/$m^2$ |
| d) | 1.22 inds/$m^2$ |

4. Estimate the number of adult males and females in the population of Isla Magdalena [**choose the correct option**] **[1 point]**.
   估計馬格達萊納島族群中成年雄性與雌性在族群中的數量 [選擇正確的選項]。 [1 分]

| | Isla Magdalena (Chile) | |
|---|---|---|
| | Males | Females |
| a) | 18 930 inds | 20 507 inds |
| b) | 18 202 inds | 21 361 inds |
| c) | 21 361 inds | 18 202 inds |
| d) | 19 628 inds | 20 894 inds |

5. Estimate the average density of nests in the population of Cape Vírgenes [**choose the correct option**] **[1 point]**.
   估計 Cape Virgenes 族群中巢的平均密度[選擇正確的選項]。 [1 分]

| | Cape Vírgenes (Argentina) |
|---|---|
| a) | 0.63 nests/$m^2$ |
| b) | 1.63 nests/$m^2$ |
| c) | 0.82 nests/$m^2$ |
| d) | 0.61 nests/$m^2$ |

6. How many new individuals (recruits) can be estimated to enter the population of Cape Vírgenes in the following year [**choose the correct option**]. **[1 point].**
再接下來的一年，估計有多少新個體可加入 Cape Virgenes 的族群？[選擇正確的選項]。[1 分]

| | Cape Vírgenes (Argentina) |
|---|---|
| a) | 3 583 inds |
| b) | 4 463 inds |
| c) | 3 482 inds |
| d) | 4 863 inds |

7. Taking into consideration the graphs of population structure in each reserve, characterize the growth of each of the populations [**choose the correct option**]. **[1 point].**
將兩個保護區的族群結構圖納入考慮時，每個族群的增長的特質為何[選擇正確的選項]。[1 分]

| | Cape Vírgenes (Argentina) | Isla Magdalena (Chile) |
|---|---|---|
| a) | Moderate growth<br>平緩成長 | Stable<br>穩定 |
| b) | Slow growth<br>緩慢成長 | Fast growth<br>快速成長 |
| c) | Stable<br>穩定 | Moderate growth<br>平緩成長 |
| d) | Fast growth<br>快速成長 | Slow growth<br>緩慢成長 |

# Part 7

# The fourth stopover – Ladrones Islands (Marianas)

# 第 7 部分

# 第四站 - 拉德羅內斯群島（馬里亞納）

**Subject:** Ecology and Anatomy

**Theme:** Insect anatomy and ecology

**Time proposed:** 20 min

**科目**：生態與解剖

**議題**：昆蟲解剖與生態

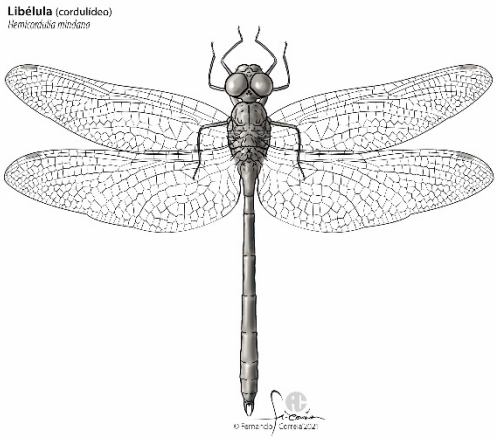
**時間**：20 分鐘

**Introduction**

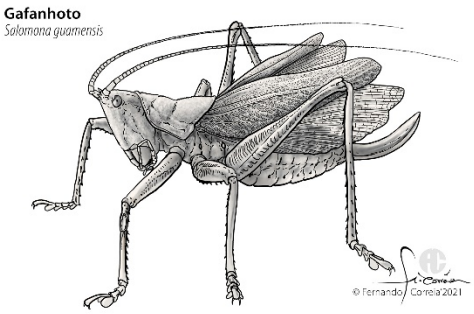
**前言**

The Marianas were the first islands Magellan encountered after crossing the Pacific from the southern tip of South America. They set in an area of about 1000 $km^2$ in the Pacific Ocean and the flora and fauna biodiversity is relatively valuable. The community of insects, although neglected, has been studied and several autochthonous species were found. Among these, there are four endemic species (**Figure 1**) with morphological adaptations to different habitats and diverse behavior.

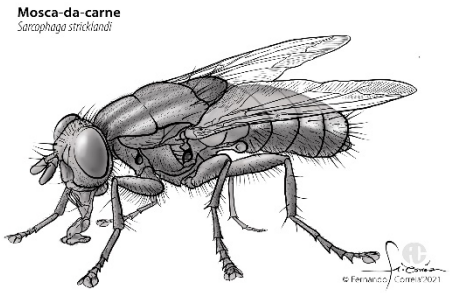
馬里亞納群島是麥哲倫從南美洲南端穿越太平洋後遇到的第一個島群。它們是位於太平洋上約 1000 平方公里的區域，動植物生物多樣性相對寶貴。昆蟲群落雖然被忽視，但已被研究並發現了幾種本土物種。其中，有四種特有物種（ 圖 1）具有對不同棲息地和多樣行為的形態適應。



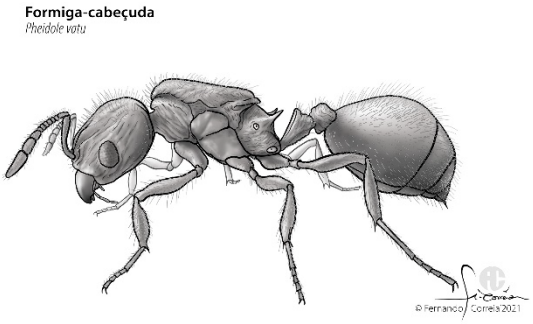

**A** - *Hemicordulia mindana* Needham & Gyger, 1937. [Odonata, Anisoptera]




**B** - *Salomona guamensis* Hebard, 1922. [Orthoptera, Ensifera]




**C** - *Sarcophaga stricklandi* Hall & Bohart, 1948. [Diptera, Sarcophagidae]




**D** - *Pheidole vatu* Mann, 1921. [Hymenoptera, Formicidae]

**Figure 1** - Four Marianas Islands' endemic insect species.
圖 1 - 四種特產於馬里亞納群島的昆蟲

**Section I.** Based on the characteristics of each of the insects present in **Figure 1,** answer the following questions by **selecting the correct option**.
**第一節：**基於圖 1 中所示各種昆蟲的特徵，回答下列問題並選出正確答案。

1. The modified hind wings of *Sarcophaga (= Bezziela) stricklandi* are: **[1 point]**
   *Sarcophaga* (=*Bezziela*) *stricklandi* 的特化後翅是：**【1 分】**
   a) Elytra（翅鞘）
   b) Hamuli（翅鈎）
   c) Haltere（平衡棍）
   d) Tegmina（翅覆）

2. Another name for the walking legs of *Pheidole vatu* is: **[1 point]**
   *Pheidole vatu* 的步行足又可稱為：**【1 分】**
   a) Cursorial（行走足）
   b) Ambulatory（匍行足）
   c) Fossorial（開掘足）
   d) Saltatory（跳躍足）

3. *Salomona guamensis* can detect sounds through an auditory sense structure called: **[1 point]**
   *Salomona quamensis* 使用哪個器官偵測聲音：**【1 分】**
   a) Antenna（觸角）
   b) Sensilla（感覺毛）
   c) Tympanum（鼓膜）
   d) Bristle（刺毛）

4. *Hemicordulia mindana* uses a characteristic mouthpart to eat: **[1 point]**
   *Hemicordulia mindana* 使用何種特定的口器攝食：**【1 分】**
   a) Sucking mouthpart（吸收式口器）
   b) Chewing mouthpart（咀嚼式口器）
   c) Siphoning mouthpart（曲管式口器）
   d) Sponging mouthpart（吮吸式口器）

5. The forewings are attached to which body segment? **[1 point]**
   前翅接在身體哪一個節上？**【1 分】**
   a) First abdominal（第一腹節）
   b) Prothorax（前胸）
   c) Metathorax（前胸）
   d) Mesothorax（中胸）

6. Insects can create vibrations that are transmitted through a substrate… **[1 point]**
   昆蟲可以製造由介質傳遞的聲響…**【1 分】**
   a) And send very specific intraspecific messages, e.g. courtship songs
      並感測特定的種內訊息，例如求偶聲響
   b) And used for efficient intraspecific communication over short distances
      並使用其聲響在短距離內進行有效的種內溝通
   c) And represent a secure means of intraspecific communication
      並代表一種安全的種內溝通方式
   d) All of the above
      以上皆是

7. The chemical trail produced by *Pheidole vatu* would be classified as a(n)… **[1 point]**
Pheidole vatu 所製造的化學蹤跡可以被分類為…**【1 分】**

a) Kairomone（開洛蒙）
b) Pheromone（費洛蒙）
c) Allomone（阿洛蒙）
d) None of the above（以上皆非）

8. *Sarcophaga (= Bezziela) stricklandi* larvae (maggots) move away from a bright source of light. This is an example of a… **[1 point]**
*Sarcophaga (= Bezziela) stricklandi* 的幼蟲(蛆)會忌避有光的地方，這是一個什麼的案例…**【1 分】**

a) Taxis（趨性）
b) Kinesis（運動性）
c) Reflex（反射）
d) Transverse orientation（橫向定向）

9. Like in most insects, *Salomona guamensis* has the sense of smell located in… **[1 point]**
就如同多數昆蟲一樣，*Salomona guamensis* 的嗅覺器官位於…**【1 分】**

a) The tarsi（跗節）
b) The maxillary palps（小顎鬚）
c) The antennae（觸角）
d) The frons（前額）

10. *Hemicordulia mindana* mechanoreceptors would not be receptive to… **[1 point]**
*Hemicordulia mindana* 的機械性受器不會接收什麼刺激…**【1 分】**

a) Body movement（身體移動）
b) Wind speed（風速）
c) Sound vibration（聲音震動）
d) Water vapour（水蒸氣）

**Section II.** Match species with characteristics. Use the key to indicate the characteristics of each of the insect species in the right column. [**Notice that each element of the key may be used once, more than once, or not at all**] **[4 points, 1 point each correct answer]**

**第二節**：匹配特徵與物種。將左邊的檢索碼填在右欄中指出每種昆蟲種類的特徵。【注意，檢索碼中的每個元素都可以使用一次、多次或根本不使用】【4 分，每個正確答案 1 分】

| **KEY（檢索）** | **Species characteristics（物種特徵）** |
|---|---|
| A Apterous（無翅） | *Hemicordulia mindana* |
| B Halteres（平衡棍） | |
| C Hamuli（翅鉤） | |
| D Jumping legs（跳躍足） | *Pheidole vatu* |
| E Sponge-like mouthpart（海綿式口器） | |
| F Furcula（彈器） | |
| G Small hair-like antenna（微小的毛狀觸角） | *Salomona guamensis* |
| H Elytra（翅鞘） | |
| I Tegmina（翅覆） | |
| J Wasp-waist（蜂腰） | *Sarcophaga stricklandi* |
| K Two pairs of wings（兩對翅膀） | |
| L Geniculated antenna（膝狀觸角） | |

**Section III.** Match each behavior listed in the right column with its typical function listed in the left column [**Notice that each element of the key may be used once, more than once, or not at all**] **[5 points, 1 point each correct answer]**

**第三節**：將右欄中列出的每個行為與左欄中列出的典型功能相匹配 **【注意，檢索碼中的每個元素可能使用一次、多次或根本不使用】【5 分，每個正確答案 1 分】**

| **KEY（檢索）** | **Behaviours（行為）** | |
|---|---|---|
| A Light flash in firefly<br>螢火蟲發光 | Courtship<br>求偶 | |
| B Waggle dance in honey-bee<br>蜜蜂跳八字舞 | Dispersal<br>播遷 | |
| C Stridulation in cricket<br>蟋蟀摩擦發音 | Nestmate recognition<br>巢內同伴辨識 | |
| D Trophallaxis in ants<br>螞蟻趨向食物 | Location of food<br>尋找食物 | |
| E Hissing in cockroach<br>蟑螂縮張體節發音 | Alarm<br>警告 | |

# Part 8

# The end of the journey – The Island of Mactan, Philippines

旅程終點 – 菲律賓麥克坦島

**Subject:** Microbiology
科目: 微生物學
**Theme:** Bioremediation
主題: 生物修復
**Time proposed:** 20 min
建議時間: 20 分鐘

**Introduction**
Currently, diverse human activities without respect for the environment make pollution a serious problem. The Earth can only continue to be our home if we adopt sustainable living strategies. **Bioremediation** uses the metabolic potential of microorganisms to reduce pollution in contaminated environments. There are several bioremediation strategies: *in situ*, handling pollution where it exists; *ex situ*, collecting contaminated material and treating it at specific sites; by **biostimulation** of microorganisms indigenous to an environment by adding nutrients or improving environmental conditions to promote the development of that microbiome; by **bioaugmentation**, addition of cultures of exogenous microorganisms to promote degradation of pollutants.

**介紹**
目前，人類不尊重環境的各種活動，使得汙染成為一個嚴重的問題。我們唯有使用永續的生活策略，才能讓地球繼續作為我們的家園。**生物修復 (Bioremediation)** 是利用微生物的代謝能力來降低受汙染環境的汙染。有數種生物修復的策略：*在原位的 (in situ)*，於污染現址進行處理；*離位的 (ex situ)*，收集汙染物質到特殊的場所進行處理；也可採用**生物刺激 (biostimulation)**的策略，就是在環境中添加營養物質或是改進環境條件，來促進一個環境中的微生物群體 (microbiome) 的發育；或是採用**生物增多 (bioaugmentation)**的策略， 是添加外來的微生物菌種來促進汙染物的降解。

**Section I** – An experiment about the purification of mine drainage fluids
第 I 節 – 一個有關純化礦場排放水的實驗

The problem: To study the role of sulphate-reducing bacteria in the bioremediation of acidic mine water.
問題：探討對酸性礦場排放水進行生物修復時，硫酸鹽還原菌所扮演的角色。

The goal of the experiment: To remove metals and sulphate from polluted waters through the use of sulphate-reducing bacteria, reducing those pollutants to levels that allow the waters to be used for irrigation.
本實驗的目標：透過利用硫酸鹽還原菌來移除汙水中的金屬與硫酸鹽，降低汙染物到可供灌溉的程度。

The experiment: A bioremediation system, at laboratory scale, was developed using acidic water from an abandoned copper mine.
實驗：利用一個廢棄銅礦場的酸性水，建立起一個實驗室規模的生物修復系統。

The results: 結果

I. Chemical composition, sulphate concentration and chemical parameters of the original acidic water were analysed (**Table 1**).
分析原始酸性水的化學組成、硫酸鹽濃度、以及化學參數 (**表 1**)

II. Chemical composition, sulphate concentration and chemical parameters of the water after the biologic treatment were analysed (**Table 1**).
分析生物處裡過後水的化學組成、硫酸鹽濃度、以及化學參數 (**表 1**)

III. Electrophoretic profiles of bacterial communities based on the 16S rRNA gene (**Figure 1**).
根據 16S rRNA 基因作出的細菌群落電泳分布圖 (**圖 1**)

**Table 1** - Chemical composition, sulphate concentration and chemical parameters of the water collected in the mine before and after biological treatment

**表 1** – 生物處理前後礦場水的化學組成、硫酸鹽濃度、以及化學參數

| Chemical composition (化學組成) | Concentration (濃度) ($mg\ L^{-1}$) | |
|---|---|---|
| | Before treatment 處理前 | After treatment 處理後 |
| As | 0.10 | < 0.03 |
| Cd | 0.12 | < 0.06 |
| Co | 0.99 | < 0.01 |
| Cr | 0.08 | 0.06 |
| Cu | 28 | < 0.01 |
| Fe | 70 | 0.09 |
| Hg | < 0.01 | < 0.01 |
| K | 0.30 | 3.70 |
| Mn | 7.10 | 3.70 |
| Mo | < 0.01 | < 0.01 |
| Ni | 0.26 | < 0.02 |
| Pb | < 0.04 | < 0.04 |
| Sb | < 0.1 | < 0.1 |
| Se | < 0.007 | < 0.007 |
| Sn | < 0.1 | < 0.1 |
| Sr | 0.14 | 0.47 |
| Zn | 13 | < 0.007 |
| $SO_4^{2-}$ | 1800 | 303 |
| Chemical parameters (Eh = Reduction Potential) 化學參數 (Eh = 還原電位) | | |
| Eh (mV) | 401 | -376 |
| pH | 2.8 | 6.5 |

**1.** Based on the information provided relative to the experiment described above, **classify the statements (a to d) using the key (A to C) [4 points, 1 point each correct answer]**

根據上述實驗所提供的相關訊息，**來分辨下列各敘述 (從 a 到 d)與哪一項 Key (從 A 到 C) 相符合 [共 4 分, 每一正確答案得 1 分]**

| Key | |
|---|---|
| A | The statement is supported by the data<br>實驗數據支持此敘述 |
| B | The statement is contradicted by the data<br>實驗數據與此敘述相矛盾 |
| C | The statement is unrelated to the data<br>實驗數據與此敘述無關 |

a) Before the sulphate-reducing bacteria's activity the redox potential was lower than after bioremediation
在硫酸鹽還原菌活動之前，其氧化還原電位低於生物修復之後。

b) After the treatment, the water´s acidity decreased
在處理之後，水的酸性降低了

c) An efficient removal of the three most abundant metals in the acidic mine water has occurred during the treatment
在處理過程中，酸性礦場水中含量最高的三種金屬被有效移除了

d) The water obtained after the treatment is not suitable for irrigation
處理之後得到的水，不適合灌溉使用

2. Figure 1 shows the electrophoretic profiles of bacterial communities, based on the 16S rRNA gene, present in four bioremediation systems. **Select the key option (A, B or C) that correctly evaluates the whole set of statements** regarding the band that corresponds to sulphate-reducing bacteria. **[1 point]**

   圖 1 是根據 16S rRNA 基因作出的細菌群落電泳分布圖，展現出四種生物修復系統。請根據條帶與硫酸鹽還原菌相對應的各項敘述，**選出能正確評估該敘述的 Key 選項 (A、B、或 C)** **[1 分]**

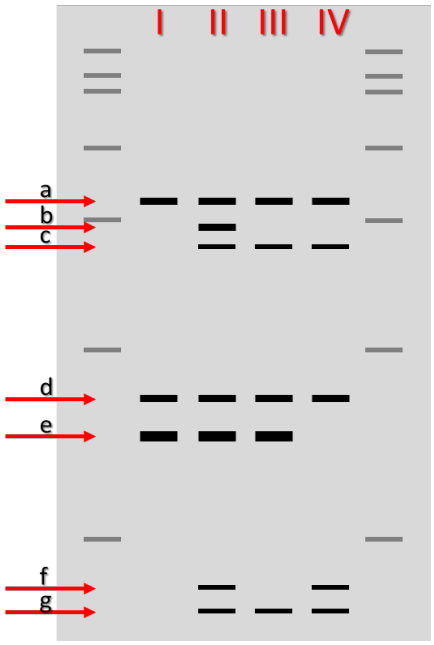



**Figure 1** - Electrophoretic profiles of bacterial communities, based on the 16S rRNA gene, present in four bioremediation systems. Only one system contains sulphate-reducing bacteria. Each band (**a** to **g**) corresponds to a different group of bacteria.

圖 1. 根據 16S rRNA 基因作出的細菌群落電泳分布圖，展現出四種生物修復系統。其中只有一個系統含有硫酸鹽還原菌。每一個條帶 (從 a 到 g) 都與一個不同類群的細菌相對應。

| **Key** | |
|---|---|
| **A** | a) is true, b) is true, but c) is false<br>a) 正確， b) 正確，但是 c) 錯誤 |
| **B** | a) is false, b) is false, and c) is false<br>a) 錯誤，b) 錯誤，c) 錯誤 |
| **C** | a) is false, b) is false, but c) is true<br>a) 錯誤，b) 錯誤，但是 c) 正確 |

a) The band that corresponds to sulphate-reducing bacteria is **e** because it is more intense
對應硫酸鹽還原菌的是 **e** 條帶，因為其顏色最濃

b) The band that corresponds to sulphate-reducing bacteria is **g** because it exists in a profile that does not have **f**
對應硫酸鹽還原菌的是 **g** 條帶，因為其電泳分布圖中不包含 **f**

c) The band that corresponds to sulphate-reducing bacteria is **a** or **d** because it exists in all the profiles
對應硫酸鹽還原菌相對應的是 a 與 d 條帶，因為它們出現在所有的電泳分布圖中

3. Only one of the bacterial community profiles shown in Figure 1 corresponds to the bioremediation system under analysis in Question 1. Which is the profile? [**choose the correct option**] **[1.0 points]**
根據問題 1 的分析，圖 1 中僅有一個細菌群落電泳分布圖能夠與生物修復系統相對應。請問是哪一個電泳分布圖？ [**選出正確選項**] **[1.0 分]**

a) Profile I
分布圖 I
b) Profile II
分布圖 II
c) Profile III
分布圖 III
d) Profile IV
分布圖 IV

**Section II** – An experiment about the purification of food and feed industrial effluents rich in oily products
**第 II 節** – 一個有關食品與飼料工業富含油脂物排放水淨化的實驗

The problem: Food and feed industries produce oily effluents, with high fat, oil and grease (FOG) content.
問題: 食品與飼料工業會產生油性的排放水，具有大量脂肪 (fat)、油 (oil)、與油脂 (grease) 等 (FOG) 成分。
The goal of the experiment: Select bacteria that exist naturally in polluted sites and evaluate them to improve bioaugmentation strategies.

本實驗的目標: 篩選出在污染場址天然存在的細菌，應用它們作生物增多策略改進成效的評估

The experimental steps:
實驗步驟:

1. Bacterial isolation from activated sludge of residues treatment stations.
   從殘留物處理站的活性污泥中分離出細菌
2. DNA extraction from the isolated bacteria.
   從分離出的細菌株中萃取其 DNA
3. Molecular identification of the isolates.
   對分離細菌株進行分子鑑定
4. Evaluation of FOG-biodegradation potential of the isolates.
   評估分離細菌株降解 FOG 的潛力

The results: 結果:

I. In total, 196 isolates were screened for biodegradation potential with pollutants as sole carbon sources for growth.
   以汙染物作為唯一碳源，對全部 196 株分離出之細菌進行生物降解潛力的篩選

II. Best biodegradation results, in 7 days assay of FOG content removal, were 37.9% for oleic acid and 19.1% for triolein by an *Aeromonas* sp. isolate and a *Staphylococcus cohnii* isolate, respectively.
   經 7 天分析 FOG 移除量所得到的最佳降解結果，分別為一株產氣單胞菌 (*Aeromonas* sp.) 的分離株可去除 37.9%的油酸 (oleic acid)，以及一株 科氏葡萄球菌 (*Staphylococcus cohnii* ) 的分離株可去除 19.1%的三油酸甘油脂 (triolein)。

**4.** Based on the experiment described above, **classify as true (T) or false (F) each of the following sentences [4 points, 1 point each correct answer]**
根據上述實驗的敘述，**分辨下列各敘述為對 (T) 或錯 (F) [共 4 分, 每一正確答案得 1 分]**

a) The work described aims to evaluate the biostimulation process in the presence of FOG
所描述的實驗，其目的是在 FOG 存在的情況下來評估生物刺激的程序

b) A biostimulation process will be more successful if point 3. of the experiment is previously applied
如果能先行實施實驗的第 3 點，則生物刺激的程序能夠更成功

c) Biostimulation can only be carried out if the described in points 2. and 3 of the experiment are carried out
只有在實驗所描述的第 2 點與第 3 點執行後，生物刺激才能被執行

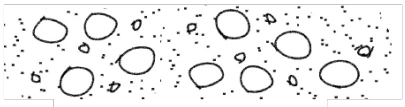
d) The use of bacteria for bioremediation can be a sustainable strategy against pollution
利用細菌進行生物修復，可作為對抗污染的一種永續策略

**Section III** – Bioremediation of oily sludge-contaminated soil
第 III 節 – 油性汙泥汙染土壤之生物修復

5. Consider that you need to create a bioaugmentation system for oily sludge-contaminated soils and you have at your disposal the elements that are presented in **Table 2**. **Select the option that corresponds to an appropriate bioaugmentation system for oily sludge-contaminated soils [3 points, 1 point each correct answer]**
假設你需要設計一個生物增多系統，用來整治被油性汙泥所汙染的土壤，表 2 列出了你擁有的各種處理元素。針對被油性汙泥所汙染的土壤，請選出最合適的生物增多系統的選項 **[共 3 分, 每一正確答案得 1 分]**

**Table 2** – Elements available to build a bioaugmentation system for oily sludge-contaminated soils

**表 2** – 建立一個處理油性汙泥汙染土壤之生物增多系統所提供的各項元素

| | |
|---|---|
| 1. oily sludge-contaminated soil<br>被油性汙泥所汙染的土壤 |  |
| 2. lipolytic bacteria naturally present in the soil<br>土壤中天然存在之可分解油脂的細菌 |  |
| 3. bacteria with enhanced lipolytic activity after some selective growth in lab 經實驗室篩選生長具強化分解油脂能力的細菌 |  |
| 4. nutrients used by lipolytic bacteria<br>油脂分解細菌所需的養分 |  |
| 5. surfactant that breaks down oils into smaller molecules 可將油裂解為小分子的介面活性劑 |  |

a) 1 + 2 + 4

b) 1 + 2 + 3

c) 1 + 2 + 3 + 4

6. Which strategy, among those presented below leads to an effective bioremediation system for fats and oils? **[choose the correct option]** **[1 point]**
下列哪一個策略可導致出一種有效的脂肪與油脂生物修復系統？**[選出正確選項]** **[1 分]**

a) *In situ* promotion of the growth of indigenous lipolytic bacteria
*在原位*促進本土分解油脂細菌的生長

b) Addition of a surfactant to a soil containing lipolytic bacteria
添加介面活性劑到含有油脂分解菌的土壤中

c) *In situ* addition of bacteria with high lipolytic activity
*在原位*添加具有強力油脂分解活性的細菌

d) Confirmation that there is no antagonism between the soil microbiome and the added bacteria
確認土壤微生物群體 (microbiome) 與添加的細菌不會發生拮抗作用

e) All the previous strategies
上述所有的策略

# CONGRATULATIONS!

# YOU MADE IT TO THE END!