IBO 2018, Tehran, Iran

Practical Exam "Plant Systematics, Anatomy & Physiology"

Student Code:

29th International Biology Olympiad

15-22 July 2018, Tehran, Iran

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Practical Exam

Plant Systematics, Anatomy & Physiology

Total Points: **100**
Duration: **90 minutes**

Please write your student code into the box on the title page.
請將您的學生代碼寫入標題頁的框中。

Use **answer sheet**, which is provided separately to answer all questions.
使用單獨提供的答案紙來回答所有問題。

The answers written in the question paper **will not be evaluated**.
寫在試題上的答案不會給分。

In order to use the flags (the signs on your desk) just put them in the **flag stand** located on the left wall of your desk.
為了使用小旗（桌子上的標誌），將它們放在桌子左牆上的旗架上即可 。

Please ensure that all the materials and equipments are available to you. If anything is missing, put your yellow flag in the flag stand no later that **5 minutes** after beginning of exam. (Any complaints after 5 minutes will not be accepted)
請確保您可以使用所有器材。如果遺漏任何東西，請在考試開始後 **5** 分鐘內將黃旗放在旗架上。（5分鐘後的任何投訴都不會被接受）

In case of emergencies or questions put your **yellow flag** in the flag stand.
如遇緊急情況或問題，請將您的黃旗放在旗架上。

No additional materials will be provided in any case of material loss during experiments.
在實驗過程中，任何材料損失都不會提供額外的材料。

Please be careful to follow the **safety instructions** while using materials on this task as is noted through protocol.
按照操作步驟中的說明，在使用此Task的材料時，請務必遵守安全說明 。

We suggest you to read the entire protocol before starting the experiments which helps you with time management.
我們建議您在開始實驗之前閱讀整個操作步驟，以幫助您進行時間管理。

Stop answering and put down your pen **immediately** at the end of exam. Put the entire protocol with the answer sheet in the envelope. Our assistants will collect the envelopes.
在考試結束時，立即停止接聽並放下筆。將整個操作步驟與答案紙放在信封中。我們的助手將收集信封。

Good luck 祝你好運

Write each indicated number in the cell next to it with your own handwriting.
根據下表所指示的數字，寫下你的手寫法。

1	
7	

Materials and equipment (Number of each object must be noticed)
器材 (檢查每項內容)

1. Microscope 顯微鏡
2. Lab gloves, tissue paper 手套、衛生紙
3. Samplers (100-1000 µL) and blue tips 微量吸管 (100-1000 µL) 及藍色尖頭
4. TLC plates (5 plates) TLC 板 (5片)
5. Pencil (1) 鉛筆 (1支)
6. Ruler (1) 尺 (1把)

7. Tweezers (1) 鑷子 (1支)
8. TLC tank with lid (1) 有蓋的 TLC 缸 (1組)
9. Capillary tube (1 box) 毛細管 (1盒)
10. Transparent tape (1) 透明膠帶 (1個)
11. Safely-taped razor blades (5) **Caution: Do not cut your finger. Take the blades from their yellow-taped site** 刀片 **(**小心勿切到手**)**
12. Band aids (2) 繃帶 (2個)
13. Alcohol pad (2) 酒精棉片 (2個)
14. Watch glass (5) 觀察用凹玻璃 (5個)
15. Foam (for sectioning) 保麗龍 (切片用)
16. Glass slide and glass slip (5 each) 載玻片/蓋玻片 (5個)
17. Wash bottle 500 mL (1) 洗瓶 500 mL (1個)
18. Beaker 1000, 50 and 25 mL (1 each) 燒杯 1000, 50 and 25 mL (各1 個)
19. Dropper (1) 滴管 (1支)
20. Pipette filler (1) 吸管頭 (1 個)
21. Pipette 10 mL (1) 吸管 10 mL (1支)
22. 1 mL syringe (1) 針筒 1 mL (1支)
23. pH- indicator paper 酸鹼試紙
24. Test tube (5) 試管 (5支)
25. Solution 1 for NO_3 measurement (1) [CAUTION] 量測硝酸鹽的溶液1 (小心) (1個)
26. Solution 2 for NO_3 measurement (1) 量測硝酸鹽的溶液2 (1個)
27. Color reference strip for NO_3 measurement (1) 量測硝酸鹽的顏色對照帶 (1 條)
28. Solution 1 for $CaCO_3$ measurement (1) 量測碳酸鈣的溶液1 (1個)
29. Solution 2 for $CaCO_3$ measurement (1) 量測碳酸鈣的溶液2 (1個)
30- A rack containing: 試管架中有
-One Falcon tube containing TLC solvent (TS: Ethanol: *n*- Propanol; Distilled water, 2:2:1), 1管 TLC 展開液 (酒精:正丙醇:水 2:2:1)
- Extracted petal pigments in microtubes labelled as PA to PE, 內含花瓣色素的小管 (分別標示為PA 至 PE)
- Soils washout in falcons labelled as S1-S5 內含土壤過濾水的管 (分別標示為S1-S5)
-Leaf extracts in microtubes labelled as L1 to L5 內含葉片萃取液的小管 (分別標示為L1 至 L5)
-Sodium hypochlorite solution (cleaning agent) 次氯酸鈉溶液 (清潔劑)
- Staining solution (Toluidine blue O solution) 染劑 (甲苯胺藍 O)
- Leaf samples A-E preserved in microtubes 葉片保存樣本的小管 (分別標示為A-E)
- Microtube containing KOH pellets (1) [CAUTION] 氫氧化鉀顆粒 的小管 (1個) (小心)
31- Answer sheets (two, 1 for writing the answers and the second one which is labelled as Answer sheet 2 for pasting TLC plates) 答案紙 (2張，1張寫答案，另一張標示為"答案紙2" 是用來貼 TLC 板的結果)
32- Green and Yellow flags. 綠色及黃色旗子

Introduction 簡介

Caryophyllales is the carnation order of dicotyledonous flowering plants. It is a diverse order that includes trees, shrubs, lianas, mangroves, stem or leaf succulents, annuals, and even carnivorous plants. Many members of the order are ecologically specialized to tolerate extreme environments. In the following experiment we are going to investigate ecophysiological features of five members of caryophyllales order in response to different habitats.
石竹目 包括像康乃馨之類的雙子葉植物。這個目的成員多樣，包括樹木、灌木、藤本、紅樹林植物、莖或葉呈肉質、一年生植物、甚至食蟲植物。許多成員特化成能夠耐受極端的環境。以下實驗將探討這個目的5個成員在不同棲地下所反應之生理生態的特徵。

Task 1: Betalain and anthocyanin in Caryophyllales
Task 1: 石竹目 的甜菜紅素及花青素

Nearly all flowering plants have coloured petals with red, blue, or purple products of the anthocyanin biosynthetic pathway. Anthocyanin pigments play additional roles in vegetative tissues, providing protection against ultraviolet (UV), herbivores, and pathogens. Moreover, a second group of colourful pigments, the betalains, is found in the plant order Caryophyllales. One of these two types of pigments exists in each family and they are never found together.
幾乎所有開花植物的紅、藍、或紫色的花瓣，都有花青素的生物合成機制。營養組織裡的花青素還有其他功能，例如可抵抗UV、草食者及病原菌。此外，石竹目還有另一群鮮豔色素，甜菜紅素。這兩類的色素存在於石竹目的不同科，且不會重複出現。

The pigments of petals or bracts of five species (plants PA-PE) of Caryophyllales are extracted in microtubes (plants A-E) . Each plant belongs to one family. Determine the kind of pigments present in each plant using the protocol 1.
石竹目的五種植物(plants A-E) 的花瓣或苞片所萃取之色素，分別裝在標示 PA-PE小管中。他們分別屬於不同科。利用操作步驟1 來決定其色素類型。

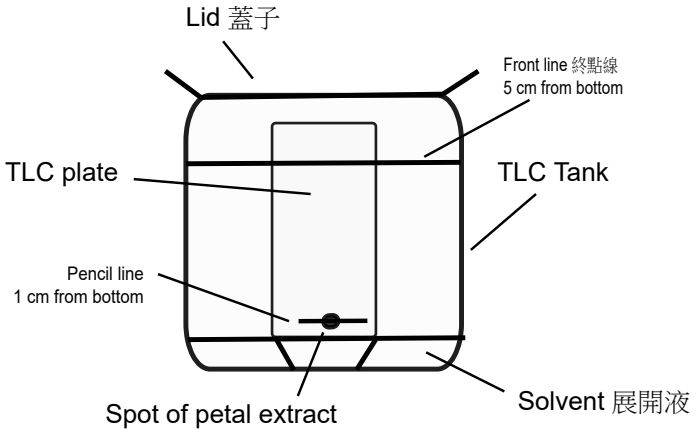
Protocol 1. Anthocyanin and betalain assay:
操作步驟**1.** 花青素及甜菜紅素分析

1.Mark the TLC plates. Draw a straight horizontal line by pencil about 1 cm from the bottom of each plate. (trapez shape. Draw another line 4 cm above the the former one and consider it as the solvent front line).
1.在**TLC** 板上畫線**.** 在每片板得離底部1公分處，以鉛筆畫1條橫線為起點；然後在往上離起點線4公分處畫線，當作展開液要跑到的終點線。

2. label the TLC plates. Label all the 5 plates from A to E on the top with a pencil (in English alphabet).
2. 標示**TLC** 板**.** 以鉛筆在每片**TLC**板上端分別依序標上A - E。

3.Take a small amount of solution. Shake the tube before using. Pick an appropriate amount of the pigment extract by using a capillary tube, to spot on the plate.
3. 取少量萃取液**.** 使用前先搖均勻，用毛細管取適量色素萃取液，點在板上。

4.Spotting on plates. As shown in figure 1, gently spot each extract on a separate TLC plate on the horizontal line (Spot radius should be about 0.2 cm). Repeat spotting for each extract to concentrate pigments on TLC plate (about 3 times). It is better to let the TLC plate dry before each spotting.
4. 在板上點色素**.** 如圖1所示，分別在不同**TLC**板上的起點線上輕輕點上萃取液，點的半徑約為0.2 cm。每次點乾後再點一次，至少重複3次，萃取色素才夠濃。



5. Preparing the tank. Pour the solvent (Falcon TS) to the tank (notice that when you place the plates in the tank, the solvent level should be below the spots). Cover the tank with the lid and wait about **5 minutes** to solvent phase equilibrate with gas phase.
5. **裝置展開缸.** 將展開液倒入缸中 (注意，當你把TLC板放入缸中，展開液必須在色素點下方)。蓋上蓋子，靜置**5分鐘**，讓展開液揮發至整個缸中。

6. Chromatography. When the spots on the TLC plates are dry, gently and immediately (solvent/gas equilibrium must be maintained) place the TLC plates into the solvent tank by tweezers, just in the furrows, with the spotted end of each plate at the bottom.
Note: Put all plates simultaneously in the furrows inside the TLC tank.
Submerge the bottom edge into the solvent. Cover the tank with the lid again. Let the tank be undisturbed. Wait about until the solvent reaches the solvent front line.
6. **跑色層分析.** 當在TLC板上的色素點乾了，使用鑷子，立即把TLC板小心置入缸中溝槽，並維持缸內展開液/氣相平衡。 **注意: 同時讓 5片板在缸中跑色層展開**。板子底端須浸到展開液，蓋好蓋子，等大約**15分鐘**，直到展開液跑到終點線。

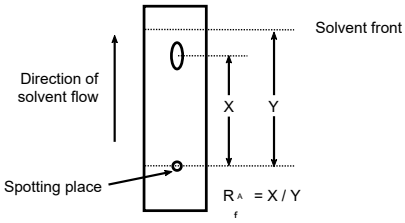
7. Remove the plate. Using tweezers, carefully remove the plate from the tank.
7. **取出板子.** 使用鑷子，小心取出板子。

8. Wait for the solvent to evaporate off the plate.
8. 等板子上的展開液完全揮發

9. Stabilization. Paste transparent tape on your plates to prevent pigment loss and **attach your TLC plates to the answer sheet 2.** Solvent front should be upward.
Note: Once you finished it, put the green flag in the flag stand.
9. **固定.** 用透明膠帶貼住色素條帶以免掉色，然後**把TLC板，黏在答案紙2上** (終點線向上)。
注意：實驗一旦完成，立即將綠色旗子插在旗架上

10. Calculate the retardation factor (Rf). Rf is the ratio of the distance a band has moved to the distance the solvent has moved. Use the middle of each band to measure travelled distance. (Figure 2)
10. **計算Rf值**. Rf值是條帶距離相對於展開液移動距離之比值，以條帶的中間點來測量。(Figure 2)

Note: Rfs ≤ 0.70 stand for anthocyanin and Rfs > 0.70 for betalain.
注意: 若 Rfs ≤ 0.70 ，屬於花青素；Rfs > 0.70 則屬於甜菜紅素。



Question 1. Indicate presence of anthocyanins or betalians in plants A-E with a "✓" in answer sheet. Also write related Rf-values (Display only two digits of the decimal point and ignore other digits).
Question 1. 在答案紙上，分別以 "✓" 標出植物含有花青素或甜菜紅素。並記錄其相對Rf值至小數點後二位。

To deliver answer sheet 2, put the green flag in the flag stand.
若要繳交答案紙**2**，請把綠旗插在旗架上

Task 2: Ecophysiological features of plants in order Caryophyllales
Task 2: 石竹目 植物的生理生態特徵

There are five soil washouts indicated as Falcons S1-S5. There are also five leaf extracts (microtubes L1-L5).
S1-S5管中分別是五種土壤過濾液。另外還有葉片萃取液 (L1-L5小管中)。

Note::The 5 soil washouts (S1-S5) correspond to the 5 leaf extracts but(L1-L5), one by one (S1 belongs to L1). But we do not yet know which of these soil washout and leaf extract pairs belong to which plant (Plants A-E).
注意: 五種土壤過濾液對應至五種葉片萃取液，但是不知這些土壤過濾液及葉片萃取液是來自甚麼植物 **(Plants A-E)**。

By performing protocols 2.1 to 2.3, measure the $CaCO_3$ and Nitrate concentration of soil washout samples and the pH of both soils washouts and plant leaf extracts.
利用操作步驟2.1 to 2.3，分別測量土壤過濾液的碳酸鈣及硝酸鹽濃度；測量土壤過濾液以及葉片萃取液的pH值。

Note: The leaf extracts were prepared at dawn.
注意: 葉片萃取液是在清晨收集的

Protocol 2.1. Measuring the soil $CaCO_3$ content
操作步驟**2.1** 測量土壤的碳酸鈣含量

To investigate the total concentration of all salts in soil, we measure $CaCO_3$ content of soil washouts by conducting volumetric assay. "Solution 1 for $CaCO_3$ measurement" contains an indicator that turns blue when there is no free Ca^{2+} in the mixture. "Solution 2 for $CaCO_3$ measurement" contains compound X (4 mM) that forms 1:1 complex with Ca^{2+} ions.
為探討土壤中所有鹽類的總濃度，以體積分析來測量土壤過濾液的碳酸鈣含量。"量測碳酸鈣的溶液1" 含有指示劑會讓不含有游離Ca^{2+}的混合液變成藍色。"量測碳酸鈣的溶液2" 則含有化合物 X (4 mM) ，其會和鈣離子形成 1:1 複合體。

1. Add 10 mL of the soil washout to the beaker. (Wash the beaker with distilled water before this step, if necessary).
1. 取 10 mL 的土壤過濾液至燒杯中 (必要時，先以蒸餾水洗燒杯)

2. Add 2 drops of the “Solution 1 for $CaCO_3$ measurement” and mix. If the solution is blue, the $CaCO_3$ concentration is ≤1mg/L. If the solution is red, then proceed to next step
2. 加入2滴 "量測碳酸鈣的溶液1"並混合均勻。若溶液是藍色，則碳酸鈣濃度為 ≤1 mg/L；若是紅色，則繼續下面步驟。

3. Using syringe, add “$CaCO_3$ solution 2” to the mixture until the colour turns blue. Shake the beaker while adding the solution. Write the volume of “Solution 2 for $CaCO_3$ measurement”” consumed and Ca^{2+} concentration of soil washouts in **Question 2: Table 1 of the answer sheet** (Ca molar mass = 40 g/mole).
3. 使用針筒漸漸滴入"量測碳酸鈣的溶液2" 直到溶液變藍色。邊滴加、邊搖晃燒杯。在答案紙 **Question 2:Table 1**中，寫下消耗掉的溶液 2之體積，以及土壤過濾液的鈣離子濃度 (鈣的莫耳重= 40 g/mole)

Protocol 2.2: Measuring the Nitrate content
操作步驟2.2: 測量硝酸鹽含量

To measure Nitrate content of soil washouts, we use a kit. Instructions of the kit are as follow:
土壤過濾液的硝酸鹽含量是用試劑套組來操作。說明如下

1. Pour 1 mL of the soil washout sample in the 25 mL or 50 mL beaker.
1. 倒 1 mL 的土壤過濾液於25 mL 或 50 mL燒杯中

2. Add 20 drops of the “Solution 1 for NO_3 measurement” c**arefully** and then add distilled water until the total volume reaches 10 mL.
2. 小心加入 20 滴的 "量測硝酸鹽溶液 1"，然後加蒸餾水，直至總體積為 10 mL

3. **Carefully** and using gloves and tweezers, pick 2 KOH pellets and dissolve them in the above mixture.
3. 戴手套、使用鑷子小心夾 2 顆 氫氧化鉀顆粒於混合液中，並使之溶解

4. By adding drops of “Solution 2 for NO_3 measurement”, a yellow colour will appear.
4. 漸漸滴入 "量測硝酸鹽溶液 2"，直到出現黃色。

5. Continue to add “Solution 2 for NO_3 measurement” drop-wise and shake until the yellow colour is stable.
5. 繼續滴入 "量測硝酸鹽溶液 2"，並混合均勻，直到黃色穩定。

6. Transfer about 5 mL of the mixture to a test tube and compare its color with the color reference strip for NO_3 measurement. Record the result in **Question 2: Table 1 of the answer sheet.**
6. 將約 5 mL混合液`轉倒入試管中，並以量測硝酸之顏色對照帶來比對顏色，然後在答案紙 **Question 2 :Table 1**中，記錄結果。

Protocol 2.3: Measuring pH
操作步驟2.3: 測量 pH值

To measure pH of soil washouts and leaf extracts:
測量土壤過濾液及葉片萃取液的pH值

Put one strip of the pH paper into the sample and pull it out after a few seconds. And shake off the paper to remove extra solution.

把酸鹼試紙放入樣本液中，數秒鐘之後取出。甩去紙上多餘的溶液。

Determine which colour matches the reference strip and record the corresponding pH in **Question 2: Table 1** in the answer sheet.
以顏色對照帶來比對顏色，然後在答案紙 **Question 2 :Table 1** 中，記錄結果。

According to obtained results answer **Question 2: Table 2 in the answer sheet.**
根據所得結果，在答案紙上的**Question 2: Table 2** 回答

Task 3: Identification of C3, C4 and CAM photosynthetic pathway
Task 3: C3, C4 and CAM光合作用機制的判斷

All three types of photosynthetic mechanisms are known among different families of Caryophyllales. In this task you should determine the photosynthetic pathway of each plant.
在石竹目植物的不同科中，可有三種類型的光合作用機制。在此，判斷每種植物的光合作用機制類型。

You can prepare cross sections with protocol 3.
參考操作步驟 3 備製橫切徒手切片 。

Notice that **no point** is considered for preparation of cross sections**, but** you may also need your cross sections to answer task 4.
注意：切片的備製不計分，但你還需要這些切片來回答Task 4。

Protocol 3. Preparation of cross sections.
操作步驟3 **.** 橫切切片的備製。

1**. Carefully** prepare free-hand cross-sections from pre-fixed leaves (microtubes A-E) using razor blade and foam pieces. Store the sections in water in the watch glass or on the glass slide.
1. 使用刀片和保麗龍將已固定的葉子（小管A-E） 小心地準備徒手切片 。將切片存放在凹玻璃 或載玻片 的水中。

2. Put hypochlorite (clearing agent) on the sections.
2.加“次氯酸鈉”（清除劑）在切片上。

3. Remove the clearing agent after at least **3 minutes**.
3.至少**3**分鐘後，移除清潔劑。

4. Wash the sections with water (three times) to get rid of clearing agent.
4.用水清洗切片（三次）以除去清潔劑。

5. Stain the sections with “Toluidine Blue O” solution. (Dilute the “Toluidine blue O” solution 20 times before using)
5.用“甲苯胺藍O” 染劑來染切片 。使用此染劑前，先稀釋20倍。

6. After **1 minute,** wash the stain away using water.
6. **1**分鐘後，用水清洗染劑。

7. Put the sections on a glass slide. Cover each with a drop of water and then with a glass slip and observe them under light microscope.
7.將切片放在載玻片上。加一滴水、蓋上蓋玻片 ，然後在光學顯微鏡下觀察。

8. Based on combined results of task 2 and task 3, indicate the photosynthetic type of each plant with a "✓" **Question 3: Table 1 of the answer sheet.**
8.根據task 2 及 task 3的綜合結果，在 答案紙的**Question 3：Table 1** 用"✓"表示每種植物的光合作用類型。

Task 4: Crystal types in Caryophyllales
Task 4：石竹目中的結晶類型

Calcium oxalate crystals are distributed among many members of Caryophyllales. Accumulation of crystals by these plants can be substantial. Major functions of calcium oxalate crystal formation in plants include high-capacity calcium regulation and protection against herbivory. Crystals are formed in specific shapes and sizes. The crystal morphology is species specific and is used traditionally for determination of species and genera in Caryophyllales.
草酸鈣結晶分佈在石竹目的許多成員中。這些植物對結晶的累積量可能會很大。植物中草酸鈣結晶形成的主要功能包括鈣調節的能力高、以及避免被食草動物攝食。結晶有特定的形狀和大小。結晶形態是物種專一，並且傳統上可用於決定石竹目中的物種和屬。

Use the cross-sections of leaves you prepared in the last task in order to identify the crystal type in the plants A-E. The following figure shows the shape of common crystal types.
使用上一個Task中所備製的葉片橫切切片，以識別植物A-E中的結晶類型。下圖顯示了常見結晶類型的形狀。

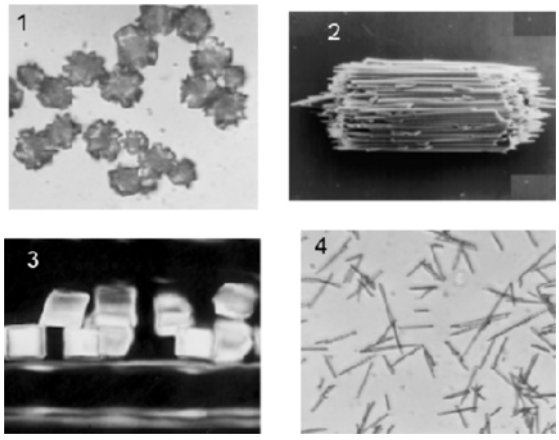


Figure 3. Different types of calcium oxalate crystals, (1) prismatic druse, (2) raphide bundles, (3) tetragonal druse, (4) single raphides.
不同類型的草酸鈣結晶，（1）晶簇，（2）針晶束，（3）菱形結晶，（4）單個針晶。

Question 4:

A: Indicate the presence or absence of each crystal form in plants A-E with "✓" and "×", respectively. **In the answer sheet.**
A：在答題紙上，用"✓"和"×" 分別表示植物A-E中每種結晶類型的存在與否。

B: Given that prismatic druse crystals are abundant in halophytes, soil washout 3 belongs to plant D, identify which soil (S1-S5) belongs to which plant (A-E) and fill **the Question 4: Table 2 in the answer sheet.**

B：已知在鹽生植物中有很多晶簇，而土壤過濾液 3是植物D的棲地，判斷哪個土壤（S1-S5）是哪個植物（A-E）的棲地。並填寫在答案紙上的 **Question 4: Table 2**中。

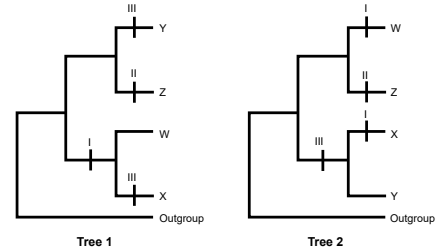
Task 5: Drawing a maximum parsimony tree
Task 5：繪製最大簡約樹

Maximum parsimony is a phylogenetic approach to reconstruct phylogenetic relationships. In this approach, each tree will be evaluated with the number of changes and their weights. The best tree is the one with minimum evolutionary change. Two trees based on the table below for putative taxa W-Z are shown in Figure 4. In this example, 'Tree 2' is better than 'Tree 1' due to its lower score.
最大簡約法是一種重建系統發生關係的方法。在這種方法中，將使用變化的次數及其權重來評估每個樹狀圖。最佳的樹狀圖是具有最少的演化改變次數者。根據下表之分類群W-Z的數據所得之兩個樹狀圖，如圖4所示。在這個例子中，由於改變次數 (score) 較低，故"樹狀圖 2"優於"樹狀圖 1"。

taxon \ trait	I	II	III
W	1	0	0
X	1	0	1
Y	0	0	1
Z	0	1	0
weight	1	2	3

$$\text{score} = \sum N \cdot w$$

Ni is number of changes in trait *i* in tree and *Wi* is weight of trait *i*
*N i*是樹狀圖中特徵 *i* 的改變次數， *W i*是特徵 *i* 的權重



The table below shows phylogenetically important traits of putative taxa P-T.
下表顯示出分類群P-T的系統發生之重要性狀。

Notice the data in the table does not match with the data you obtained in the previous sections.
請注意，表中的數據與在先前部分所得的數據不相符。

trait / Plant	I (Pigments)	II (druses)	III (raphides)	IV (pollen grain)	V (corolla fusion)	VI (perianth whorls	VII (leaf arrangement
P	0	1	1	1	0	1	0
Q	1	1	0	1	1	0	1
R	0	0	1	1	1	0	1
S	0	0	0	1	0	0	1
T	0	1	1	1	1	1	0
Outgroup	0	0	0	0	0	0	0
Weight	2	2	4	3	2	2	1

The table below lists the states of the traits.
下表列出了特徵的狀態。

Trait 特徵	State狀態 0	State狀態 1
I（pigment色素）	anthocyanin 花青素	betalain甜菜紅素
II（druses晶簇）	absent	present
III（raphides針晶）	absent	present
IV（pollen grains花粉粒）	光滑的表面	顆粒狀表面
V（corolla fusion花冠癒合）	petals free花瓣分離	petals connate花瓣合生
VI（perianth whorls花被輪數）	1	2 or more
VII（leaf arrangement葉序）	alternate or rosette互生或輪生	opposite對生

Question 5: Based on the traits in the table above and their weights, draw the maximum parsimonious tree and calculate its score **in the answer sheet**.
Question 5：根據上表中的特徵及其權重，**在答案紙中**繪製最大簡約樹並計算其改變次數。

Note: Placement of apomorphies on the tree is not necessary and no point is considered for that.
注意：樹狀圖上的衍徵之位置不是必要的，故無須考慮之。

Viewing exam as superuser/admin

Student Code:

ANSWER SHEET - PLANT SYSTEMATICS, ANATOMY & PHYSIOLOGY

Please check your student code in the box on the title page.
請在標題頁的框中查看您的學生代碼。

Use **answer sheet**, which is provided separately to answer all questions.
使用單獨提供的答案紙來回答所有問題。

The answers written in the question paper **will not be evaluated**.
寫在試題上的答案不會給分。

In order to use the flags (the signs on your desk) just put them in the **flag stand** located on the left wall of your desk.
為了使用旗幟（桌子上的標誌），只需將它們放在桌子左牆上的旗架上即可 。

Please ensure that all the materials and equipments are available to you. If anything is missing, put your yellow flag in the flag stand no later that **5 minutes** after the beginning of the exam. (Any complaints after 5 minutes will not be accepted)
請確保您可以使用所有材料和設備。如果遺失任何內容，請在考試開始後**5** 分鐘內將黃旗放在旗架上。（5分鐘後的任何投訴都不會被接受）

In case of emergencies or questions put your **yellow flag** in the flag stand.
如遇緊急情況或問題，請將您的黃旗放在旗架上。

No additional materials will be provided in any case of material loss during experiments.
在實驗過程中，任何材料損失都不會提供額外的材料。

Please be careful to follow the **safety instructions** while using materials on this task as is noted through protocol.
按照操作步驟中的說明，在使用此任務的材料時，請務必遵守安全說明 。

We suggest you to read the entire protocol before starting the experiments which helps you with time management.
我們建議您在開始實驗之前閱讀整個操作步驟，以幫助您進行時間管理。

Stop answering and put down your pen **immediately** at the end of exam. Put the entire protocol with the answer sheet in the envelope. Our assistants will collect the envelopes.
在考試結束時，立即停止作答並放下筆。將整個操作步驟與答案紙放在信封中。我們的助手將收集信封。

祝你好運

Write each indicated number in the cell next to it with your own handwriting.
在每個指定的數字旁邊的空格中，寫下您自己的筆跡。

1	
7	

Question 1.

Table 1. 0.5 points for determination of pigment type in each sample, 2 points for each Rf and 0.35 points for correct measurement of Rf of each band, based on the answer sheet 2.). (26 points)

Table 1. 每個樣本的色素判斷0.5分，每個Rf值 2分，根據答案紙 2 之每條帶的Rf值正確計算0.35分（小數點後兩位）。

Plant extract	**Rf1 (The highest)**	**Rf2**	**Rf3**	Anthocyanins 花青素	Betalians 甜菜紅素
PA		======	======		
PB					
PC		======	======		
PD			======		
PE					

Question 2: Table 1(25 points)

Soil washout	**Volume of solution 2 for $CaCO_3$ measurement (two decimal) (mL)** (2.5 points for each)	**(mg/L of Ca) (correct to two decimals) (0.5 points for each)**	**Nitrate content (mg/L)** (1.5 points for each)	**pH** (0.25 points for each)	=====	**Leaf extract**
S1					=====	**L1**
S2					=====	**L2**

S3					**=====**	**L3**	
S4					**=====**	**L4**	
S5					**=====**	**L5**	

Question 2: Table 2

According to results, indicate which soil washout-leaf extract pair (1-5) is related to a halophytic plant and which is related to a carnivorous plant with a tick "✓". (2 points for each column). (4 points)

根據結果，指出哪種土壤過濾液 - 葉萃取液對應組（1-5）與鹽生植物有關，而哪一個與食蟲植物有關，以"✓"標示。(每欄 2分；共4分)

Soil washout and leaf extract 土壤過濾液 及 葉萃取液	**Carnivorous** 食蟲植物	**Halophyte** 鹽生植物
1		
2		
3		
4		
5		

Question 3: Table 1

Indicate photosynthetic type of each plant with a "✓". (1.5 points for each row)(7.5 points)
指出每種植物的光合作用類型，用"✓"表示。(每列 1.5 分，共7.5分)

***Photosynthetic type** 光合作用類型*

Plants	**C3**	**C4**	**CAM**
A			
B			
C			
D			
E			

Question 4:

Table1: Indicate the presence or absence of each crystal form in plants A-E with "✓" and "×", respectively. (for each row, 3.5 points completely correct and 1.75 points if there is one incorrect box. 0 points is considered if there are more than one incorrect boxes.). (17.5 points)
Table 1：分別用"✓" and "×"表示植物A-E中每種結晶的存在或不存在。(每列全對得3.5分，若答錯一個，則得1.75分，若答錯兩個以上，則得0分) (共1.75分）。

Crystal types (in figure 4) / Plants	1	2	3	4
A				
B				
C				
D				
E				

Question 4:

Table 2: Based on results obtained from tasks 2, 3 and 4 identify which soil (S1-S5) belongs to which plant (A-E) and fill the Table 2. (8 points)
Table 2：根據tasks 2, 3 and 4 的結果，判斷每種土壤（S1-S5）為哪種植物（A-E）的棲地，並填入**Table** 2 中。(8分)

plant	Soil
A	
B	
C	
D	**S3**
E	

Question 5: Based on traits in the table above and their weights, draw the maximum parsimonious tree (tree with least score) and calculate its score.
Question 5：根據表格中的特徵及其權重，繪製最大簡約樹並計算其改變次數 (score)。

Note: Replacement of apomorphies on the tree is not necessary and no point is considered for that. ((8 points for clustering and 4 points for calculating the score)(12 points).

注意：更換樹狀圖上的衍徵並非必要，無須考慮。**(**歸群正確得**8**分；計算次數得**4**分；共**12**分**)**。