

Dear Participants!

各位參賽者

In the laboratory “**PLANT PHYSIOLOGY, MORPHOLOGY AND ANATOMY**” you
在「植物生理、形態及解剖」實驗中，你將回答以下三題：
will be given the following three tasks:

Task 1. The study of physical and chemical properties of photosynthetic pigments.

第一題：光合作用色素的物理及化學特性

Task 2. The study of angiosperm flowers structure.

第二題：被子植物花的構造

Task 3. The study of anatomic structure of a plant organ on a cross section.

第三題：植物器官之橫切面的解剖構造

Duration of the lab work is **60 minutes**.

本實驗之時間共有 60 分鐘

Maximum number of points – **68**.

滿分為 68 分

You have to write down your results and answers into the **ANSWER SHEET** which will
你必將結果及答題案寫在答案紙上！助教將在時間結束時將答案紙收回，試題上不
be collected by an assistant when the time elapses. It is not necessary to write anything in the
必寫任何答案。
task sheets.

Result sheets taken away from the laboratory will not be accepted!

答案紙不能私自帶離實驗室！

Please be careful when performing reactions and do not let the reagents and solutions

請小心使用化學藥品，勿讓藥品及溶液碰觸到皮膚及衣服。

come in contact with your skin and clothes! Use gloves when necessary!

必要時可帶手套操作

Contact the assistant in case of any unforeseen situations!

如有任何問題，請通知助教。

Good luck!

Country _____

國家

First name _____ **Family name** _____

名

姓

Code _____

編號

Task 1. (35 points) The study of physical and chemical properties of photosynthetic pigments.
第一題 (35分) 光合作用色素的物理及化學特性

The conversion of the energy of light into chemical energy occurs in plants with the help of pigment-protein complexes of chloroplast membranes. These complexes include photosynthetic pigments which determine the activity of the primary photosynthetic processes. An understanding of photosynthesis is impossible without knowledge of photosynthetic pigment properties. Chlorophyll and other photosynthetic pigments have several specific properties: absorption of different wavelengths of light, ability to participate in redox reactions, solubility in different types of solvents, etc.

植物將光能轉換成化學能的過程發生在葉綠體膜上，且需要有色素－蛋白質複合物之協助。這些複合體包括決定主要光合作用過程的光合色素。

欲了解光合作用則必須知道光合色素的特性。
 葉綠素及其他光合色素有多種特殊性質：
 吸收不同波長的光、具有參與氧化還原反應的能力、
 可溶於不同溶劑中．．．等

You have to study several of these properties of photosynthetic pigments during this task.
 本題中你必須研究出光合色素的特性。

Materials and equipment

材料及器材

1.	A stand with tubes. 試管及試管架	1
2.	Pipettes. 吸管	5
3.	Ethanol extract of photosynthetic pigments (Flask A). 以酒精萃取的光合色素 (燒瓶A)	1
4.	20 % KOH solution (Flask B). 20% KOH 溶液 (燒瓶B)	1
5.	Distilled water (Flask C). 蒸餾水 (燒瓶C)	1
6.	Petrolic (petroleum) ether (Flask D). 石油醚 (燒瓶D)	1
7.	A sheet of white paper. 一張白紙	1
8.	A water bath. 水浴槽	1
9.	A tube holder. 試管夾	1
10.	10 % HCl solution (Flask E). 10% HCl 溶液 (燒瓶E)	1
11.	Saturated $(\text{CH}_3\text{COO})_2\text{Zn}$ solution (Flask F). $(\text{CH}_3\text{COO})_2\text{Zn}$ 的飽和溶液 (燒瓶F)	1
12.	Saturated ascorbic acid solution (Flask H). 抗壞血酸 (維他命C) 飽和溶液 (燒瓶H)	1

1.1. (8 points) Transfer 3 ml of pigment solution from **flask A** into tube № 1 and also 3ml into tube № 2.

從燒瓶 A 吸取 3 ml 的色素溶液分別放入試管 № 1 及 № 2

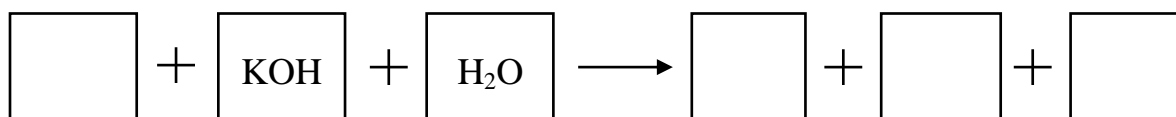
Add five drops of 20% KOH from **flask B** and 1 ml of H₂O (from **flask C**) to the tube № 1 and 從燒瓶 B 中取 20% KOH 5 滴，及從燒瓶 C 中取 1 ml 的水，加入試管 № 1。

to the tube № 2 - only 1 ml of H₂O.

試管 № 2 只加 1 ml 的水。

Using the formulae below, fill in the missing components of the chemical reaction you have just observed in the scheme 1.1 of the answer sheet. Under fulfillment of this scheme please use the number of abbreviation of this compound from the list below.

在下列反應式中，依你所觀察到的結果，在空格內填入適當的化合物編號（如下），直接填在答案紙之 1.1 題上。



1. **C₅₅H₇₂O₅N₄Mg** – chlorophyll.
葉綠素
2. **C₃₄H₃₀O₅N₄ MgK₂** – potassium salt of the chlorophyllic acid.
葉綠素鉀鹽
3. **C₅₅H₇₄O₅N₄** – pheophytin (phaeophytin).
植物黑質
4. **C₂₀H₃₉OH** – phytol.
葉綠醇
5. **CH₃OH** – methanol.
甲醇
6. **C₂H₅OH** – ethanol.
乙醇
7. **MgCl₂** – magnesium chloride.
氯化鎂
8. **KCl** – potassium chloride.
氯化鉀

1.2. (4 points) Add 1 ml of the petrolic (petroleum) ether (from the **flask D**) to the tubes № 1 and № 2, shake well and leave to stand until the fractions separate completely.

從燒瓶 D 中取 1 ml 的石油醚分別加入試管 № 1 及 № 2 中，搖晃均勻並靜置直到液面出現分層。

Determine the colour of each fraction in the tubes № 1 and № 2. Write down the results in the appropriate cells of the table 1.2 of the answer sheet. Please use single letter colour codes as shown below.

分辨試管 № 1 及 № 2 中各分層的顏色，並在答案紙上適當的空格中寫下其結果。請用以下英文代碼填入答案

- A. violet;紫色
 B. blue;藍
 C. green;綠
 D. yellow;黃
 E. red;紅
 F. olive brown;綠褐色
 G. black;黑
 H. colourless;無色

Tube №	Reagent	Experiment 1.1.	Experiment 1.2.
試管№	試劑	實驗 1.1	實驗 1.2
		ethanol fraction colour	petrolic ether fraction colour
		乙醇分層顏色	石油醚分層顏色
1	KOH		
2	H ₂ O		

1.3. (4 points) Which pigments are responsible for the colour of the petrolic fraction 試管№1 及№2 中石油醚分層的顏色是哪些色素的呈色結果？
 on the tubes № 1 and № 2? Write down in the answer sheet (1.3) single letter codes for the
 在答案紙上寫下化合物的英文代號（如下）
compounds from the list below:

№ 1: _____

№ 2: _____

- A. anthocyanins;花青果
 B. carotenoids;類胡蘿蔔素
 C. phycobilins;藻胆色素
 D. chlorophylls;葉綠素

1.4. (2 points) Add 3 ml of the pigment extract to the tube № 3 (**flask A**) and add 5 drops 從燒瓶A中取3 ml的色素液加入試管№3中，再加5滴的HCl of HCl (**flask E**). Mix the tube contents thoroughly by shaking. Record the new colour. (燒瓶E)，搖晃混合均勻，記錄顏色變化。

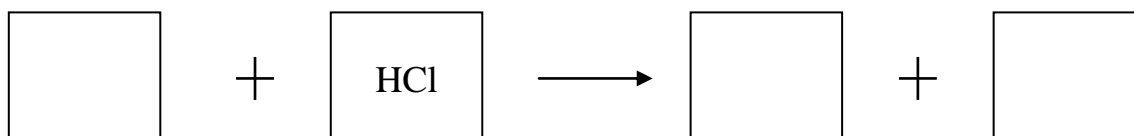
Add 1 ml of the saturated (CH₃COO)₂Zn solution (from the **flask F**) to the same tube. Heat 然後在同一管中再加入1 ml (CH₃COO)₂Zn的飽和溶液（燒瓶F），將試管置於水 the solution on the water bath. Mix by shaking and record the new colour of the solution. 浴槽中加熱，搖晃混合均勻，記錄顏色變化！

Write the results down in the table 1.4 of the answer sheet. Please use single letter colour 將結果填在答案紙的表 1.4 中 請用以下英文字母代號作答 codes as shown below.

- A. violet;紫
 B. blue;藍
 C. green;綠
 D. yellow;黃
 E. red;紅
 F. olive brown;綠褐
 G. black;黑
 H. colourless.無色

Reagent	New colour in the tube
試劑	試管溶液顏色
HCl	
(CH ₃ COO) ₂ Zn	

1.5. (6 points) In the scheme 1.5 of the answer sheet, please write the possible components in 1.5 題的答案紙上代表在試管№ 3 中加入 HCl 之後的反應式，請用以下化學式 of the reaction in the tube № 3 after addition of hydrochloric acid to the pigment 之數字代號填入空格中 extract. Please use the formulae from the list below.



1. C₅₅H₇₂O₅N₄Mg – chlorophyll.
葉綠素
2. C₃₄H₃₀O₅N₄ MgK₂ – potassium salt of the chlorophyllic acid.
葉綠素鉀鹽
3. C₅₅H₇₄O₅N₄ – pheophytin (phaeophytin).
植物黑質
4. C₂₀H₃₉OH – phytol.
葉綠醇
5. CH₃OH – methanol.
甲醇
6. C₂H₅OH – ethanol.
乙醇
7. MgCl₂ – magnesium chloride.
氯化鎂
8. KCl – potassium chloride.
氯化鉀

1.6. (1 point) Add 2 ml of the pigment extract and 2 ml of ascorbic acid (**flask H**) to the tube № 4. Mix by shaking until the colour changes.
在試管№ 4 中加入 2 ml 的色素液及 2 ml 維他命 c (燒瓶 H)

搖晃混合直到顏色改變。

Please note the colour change. Put the results in the table 1.6 in the answer sheet. Please 請注意顏色變化 將結果填在答案紙的表 1.6 中，

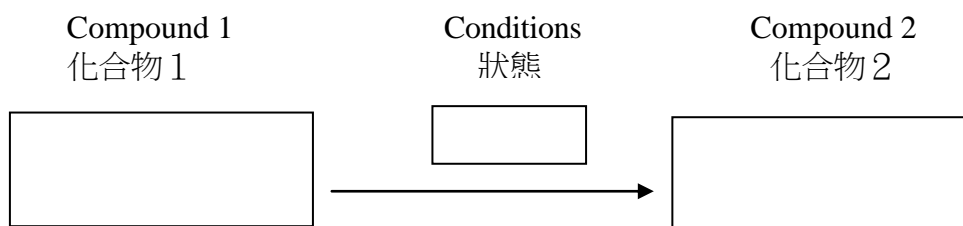
use the single letter colour codes shown below.

請用以下英文字母代號

- | | |
|-------------|-------------------|
| A. violet;紫 | E. red;紅 |
| B. blue;藍 | F. olive brown;綠褐 |
| C. green;綠 | G. black;黑 |
| D. yellow;黃 | H. colourless.無色 |

Extract colour before reaction	Solution colour after reaction
反應前的顏色	反應後的顏色
C	

1.7. (6 points) Complete the scheme of this reaction (1.7 in the answer sheet)
 從下列的化合物及狀態代號中，選擇適當代號填入反應式內
 using compound and condition numbers from the two lists below:



Compounds:

化合物

1. chlorophyll; 葉綠素
2. pheophytin (phaeophytin); 植物黑質
3. ascorbic acid; 抗壞血素 (維他命 C)

Conditions:

狀態

4. electrons involved; 電子
5. protons involved; 質子
6. light involved. 光

1.8. (4 points)

Write the results down in the table 1.8 of the answer sheet. Please use single letter colour
 將結果填在答案紙的表 1.8 中，直接用英文字母代號
 codes shown below.

A. violet;紫
B. blue;藍
C. green;綠
D. yellow;黃

E. red;紅
F. olive brown;綠褐
G. black;黑
H. colourless.無色

Compound №	Colour before reaction	Colour after reaction
化合物編號	反應前的顏色	反應後的顏色
1		
2		

Task 2. (12 points) The study of angiosperm flowers structure.**第二題（12分）被子植物花的構造****Materials and equipment****材料及器材**

- | | | |
|----|---|-----|
| 1. | Fixed flower preparations (A, B, C).
已經固定的花朵 | x 3 |
| 2. | Forceps.
鑷子 | x 1 |
| 3. | Dissecting needles.
解剖針 | x 2 |
| 4. | A magnifying glass.
放大鏡 | x 1 |

2.1. (6 points) Study the morphology of flowers A, B, C. Using formula numbers (1-14)

2.1(6分)檢視 A、B、C 三朵花的形態。依據下方花的公式(1-14)，選擇每一朵花正 from the list below, indicate the correct formula for each flower in the answer sheet. 確的公式，將其數字填入答案卷中。





1. * $K_5 C_5 A_\infty G_{\infty}$ 花萼片 5 花瓣片 5 雄蕊 ∞ 雌蕊 ∞ * = polysymmetrical 對稱
2. * $P_5 A_\infty G_{\infty}$ 花被片 5 雄蕊 ∞ 雌蕊 ∞ ↑ = monosymmetrical 不對稱
3. * $K_5 C_5 A_{5+5} G_{(3)}$
4. * $K_{(5)} C_5 A_{5+5} G_{(5)}$
5. * $K_5 C_5 A_\infty G_{1-}$
6. * $K_{(5)} C_5 A_\infty G_{(5)}$
7. ↑ $K_{(5)} C_{1,2,2} A_{(5+5)} G_{\underline{1}}$
8. ↑ $K_{(5)} C_{1,2,2} A_{(9)1} G_{\underline{1}}$
9. * $K_0 C_5 A_5 G_{(\bar{2})}$
10. * $K_{2+2} C_4 A_{2+4} G_{(2)}$
11. ↑ $K_{(5)} C_{(2,3)} A_{2,2} G_{(2)}$
12. * $K_{(5)} C_{(5)} A_5 G_{(2)}$
13. ↑ $K_0 C_{(5)} A_{(5)} G_{(\bar{2})}$
14. * $P_{3+3} A_{3+3} G_{(3)}$

A	B	C

2.2. (3 points) The diagrams show the types of ovaries characteristic of angiosperm flowers.

2.2 (3分) 下圖表示開花植物子房的形式。

Using the numbers (1-4) from the table below, record the types of ovaries for the flowers A, B and C in the answer sheet.
使用下表中的數字(1-4)，將A、B、C三朵花的子房形態以數字填入答案紙中

			
1.	2.	3.	4.
Superior ovary (Hypogynous flower)	Middle ovary (Perigynous flower)	Half-inferior ovary (Half-epigynous flower)	Inferior ovary (Epigynous flower)
子房上位 (花下位)	子房周位 (花周位)	子房半下位 (花半上位)	子房下位 (花上位)

A	B	C

2.3. (3 points) Please indicate in the answer sheet to which family the plants with flowers

2.3(3分) 在答案卷中，指明A、B、C三朵花所屬的科。

A, B and C belong. Use the numbers (1-10) from the list below.

使用下方所列的數字(1-10)，將正確的數字填入。

1. Ranunculaceae.
毛茛科
2. Oleaceae
木犀科
3. Rosaceae.

薔薇科

4. Leguminosae (Fabaceae), Papilionaceae.

豆科 (蝶形花科)

5. Fagaceae

殼斗科

6. Cruciferae (Brassicaceae).

十字花科

7. Labiatae (Lamiaceae).

唇形科

8. Solanaceae.

茄科

9. Compositae (Asteraceae).

菊科

10. Liliaceae.

百合科

A	B	C

Task 3. (21 points) The study of anatomic structure of a plant organ on a cross section.
第三題 (21分) 植物器官之橫切面的解剖構造

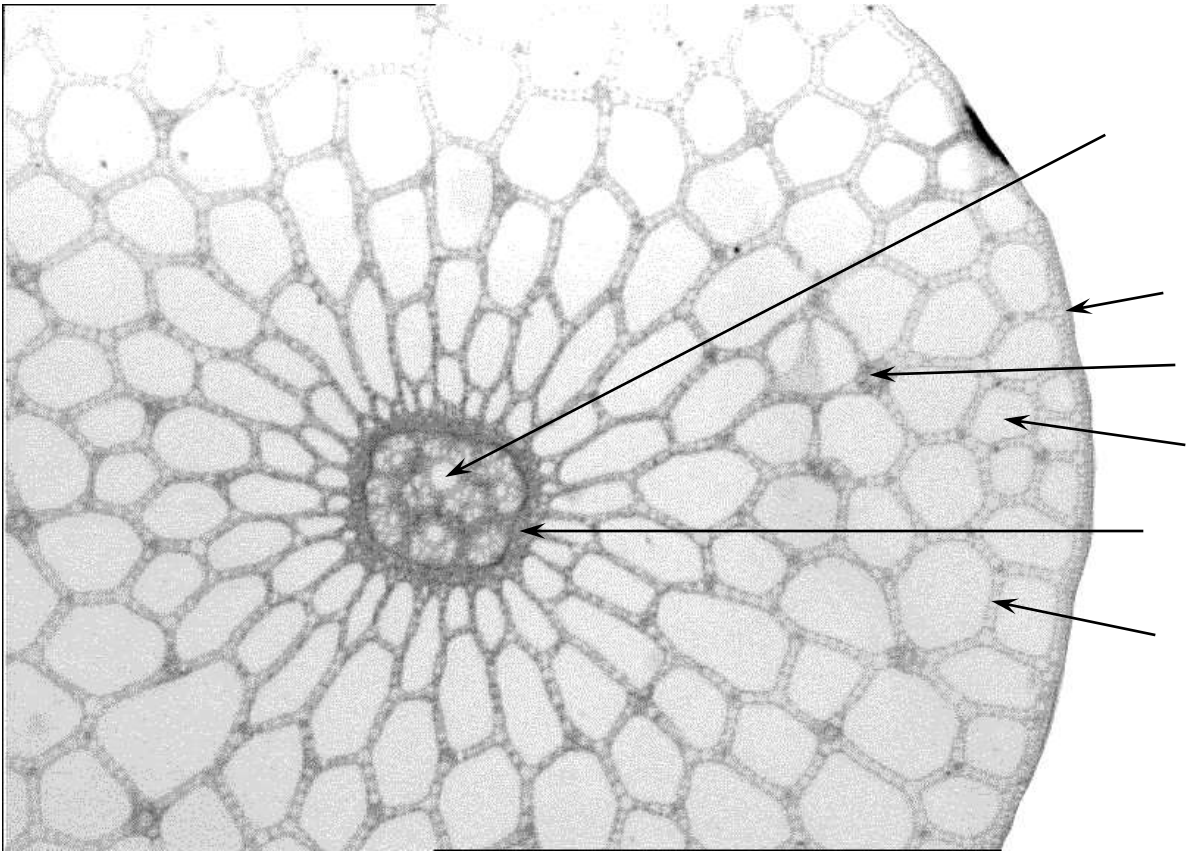
Materials and equipment
材料及器材

1. Fixed parts of a plant organ. 一植物器官的固定部分	1
2. Microscope «AxioStar». 顯微鏡	1
3. Forceps. 鑷子	1
4. Dissecting needles. 解剖針	2
5. Blade. 刀片	1
6. Glass slides. 載玻片	2
7. Cover slips. 蓋玻片	4
8. Dropping bottle with phloroglucine solution. 內有間苯三酚 (phloroglucine) 溶液的滴瓶	1
9. Pipette. 吸管	1
10. 10 % HCl solution (Flask E). 10 % HCl 溶液(燒瓶 E)	1
11. Distilled water (Flask C). 蒸餾水 (燒瓶 C)	1

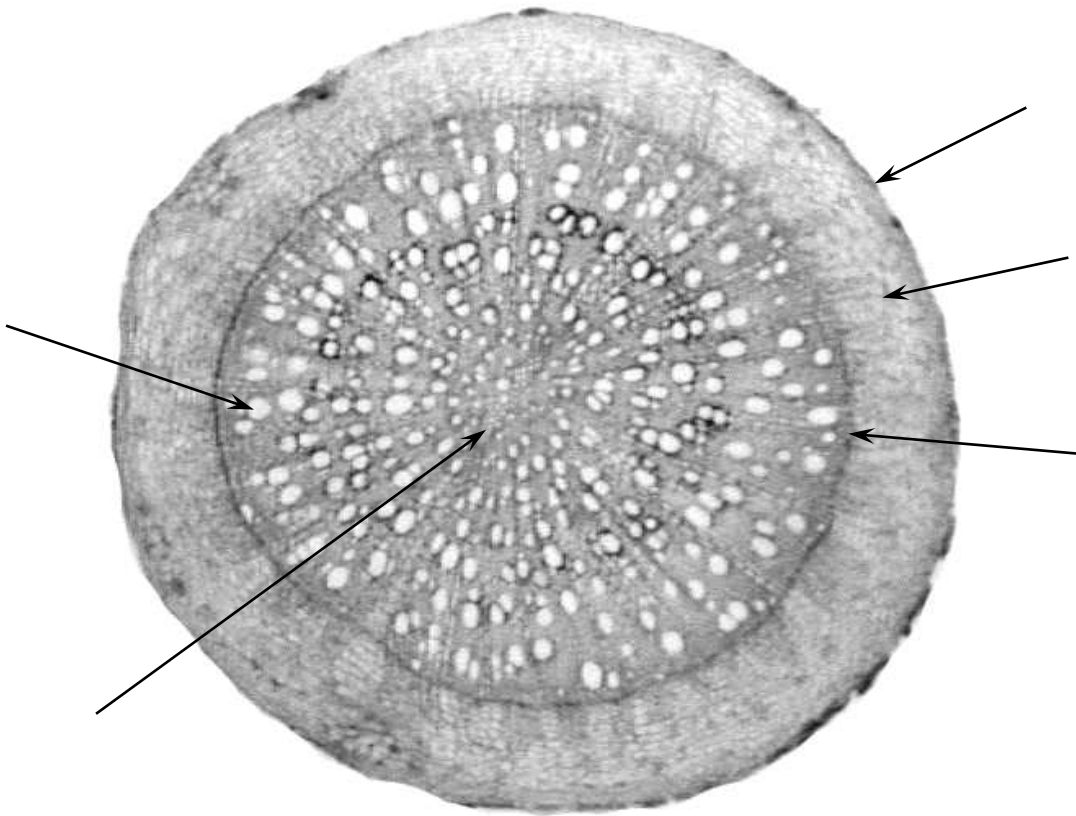
Prepare a cross section of the object you are given. Stain this cross section with phloroglucin

作植物器官固定部分的橫切面製片。用間苯三酚加以染色，並加數滴 HCl。and add several drops of HCl. Wash the preparation thoroughly with water for 2-5 minutes and 二至五分鐘後用水加以清洗後，蓋上蓋玻片。在顯微鏡下觀察切片。then cover it with a cover slip. Observe the preparation under the microscope.

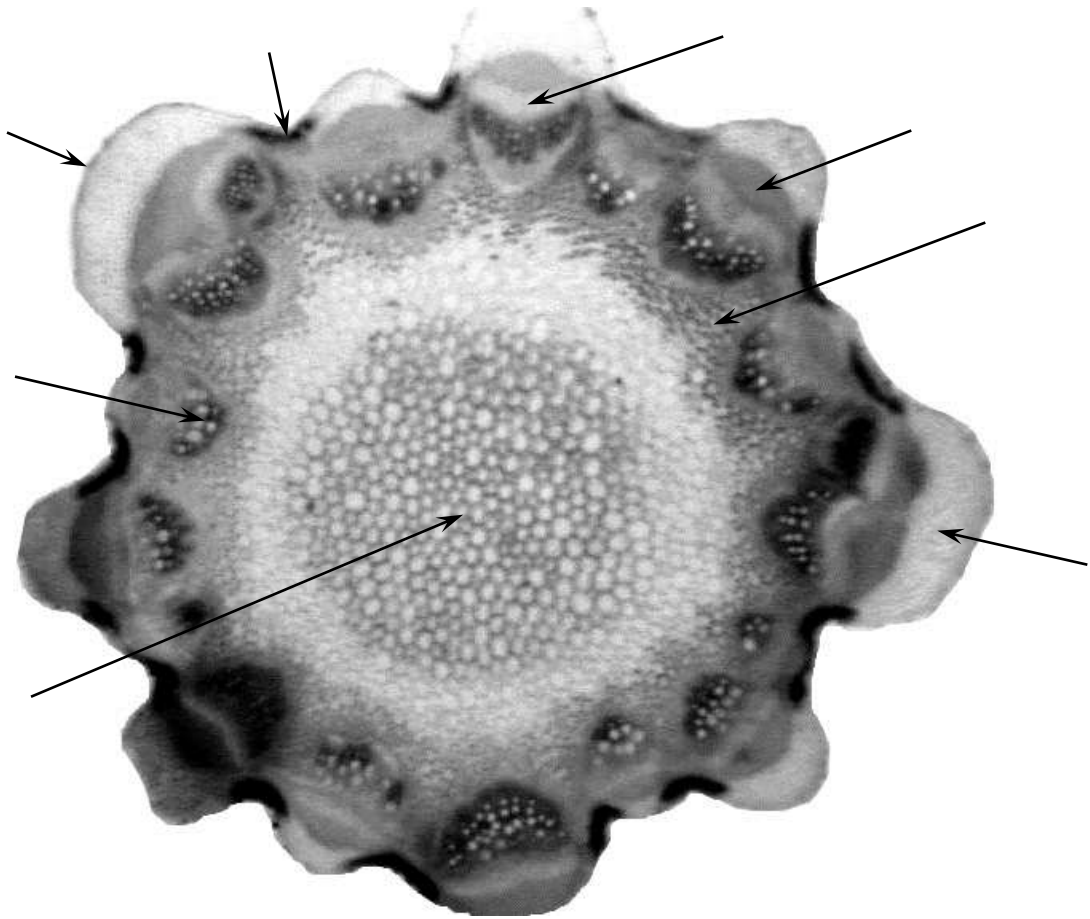
Compare the cross section you have just prepared to the schemes 1-6 below and determine 比較你做的橫切片和下方 1 至 6 的圖片，然後決定你的橫切片跟哪一圖片是一樣的。which scheme it corresponds to.



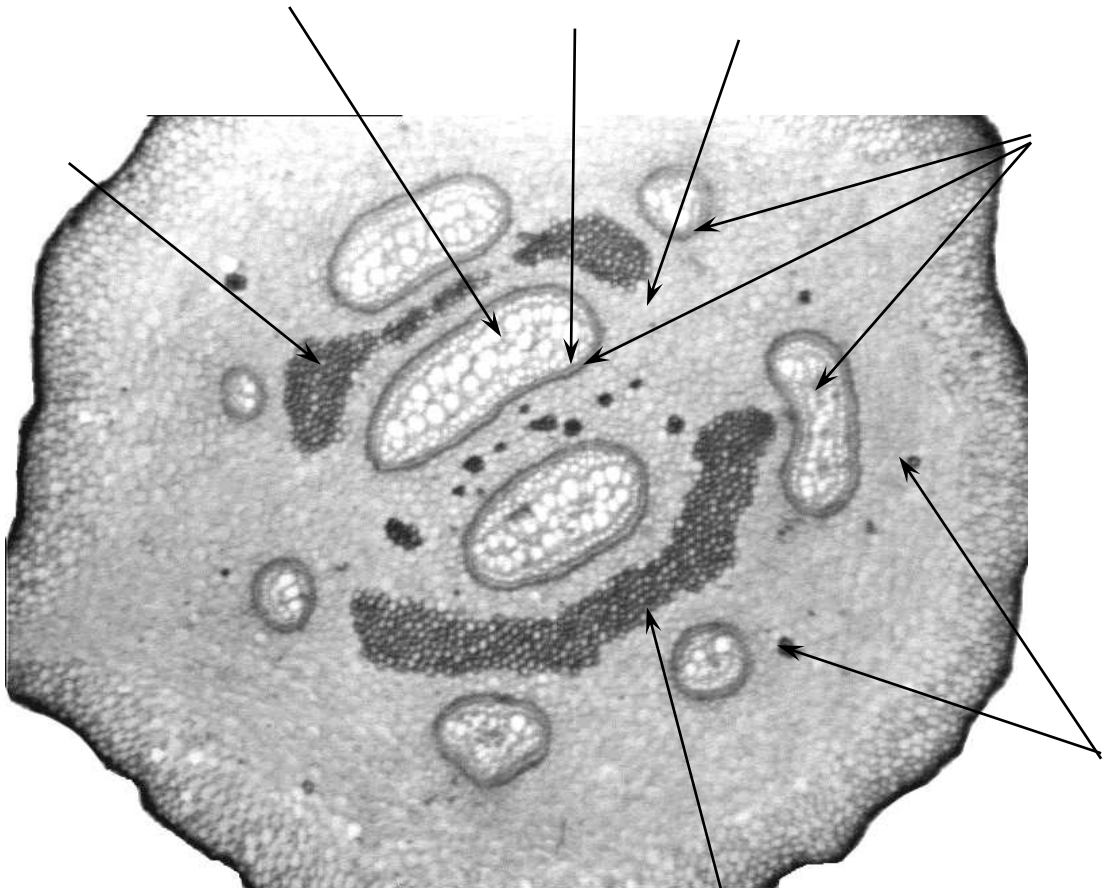
1



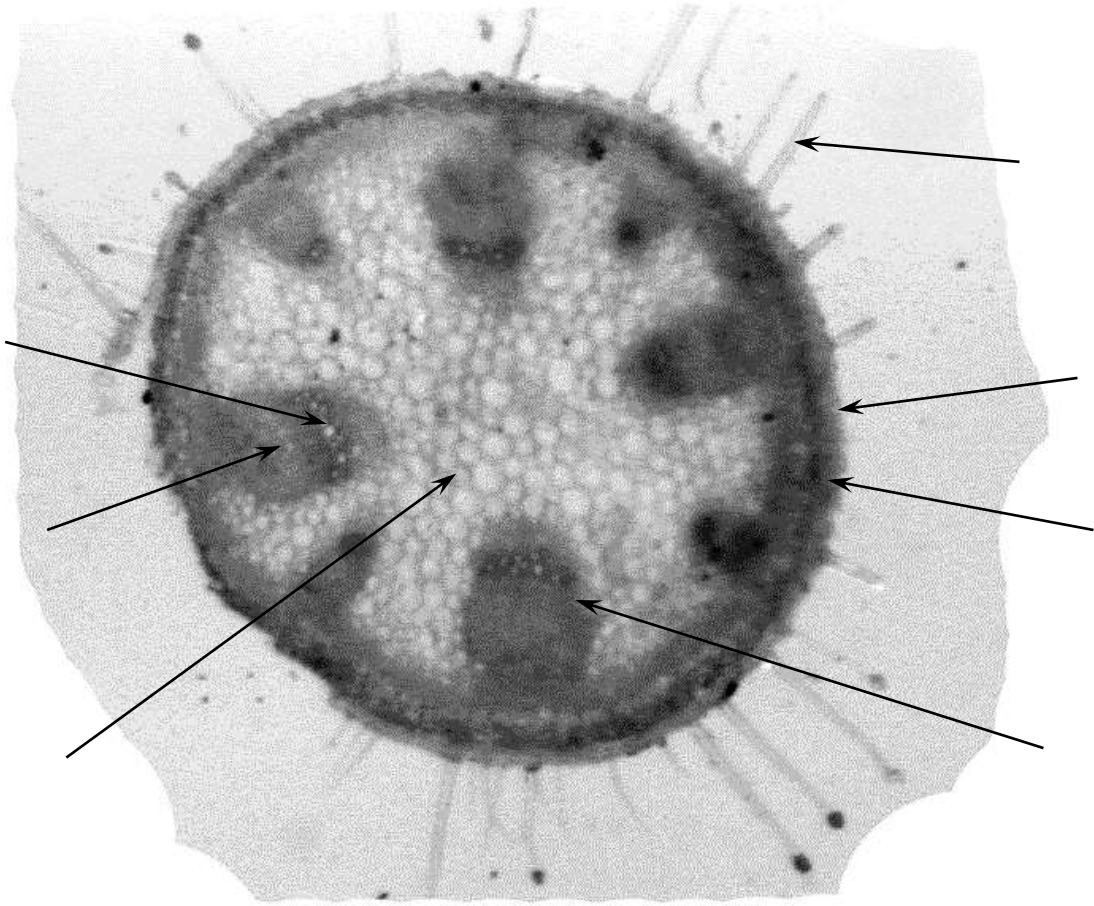
2



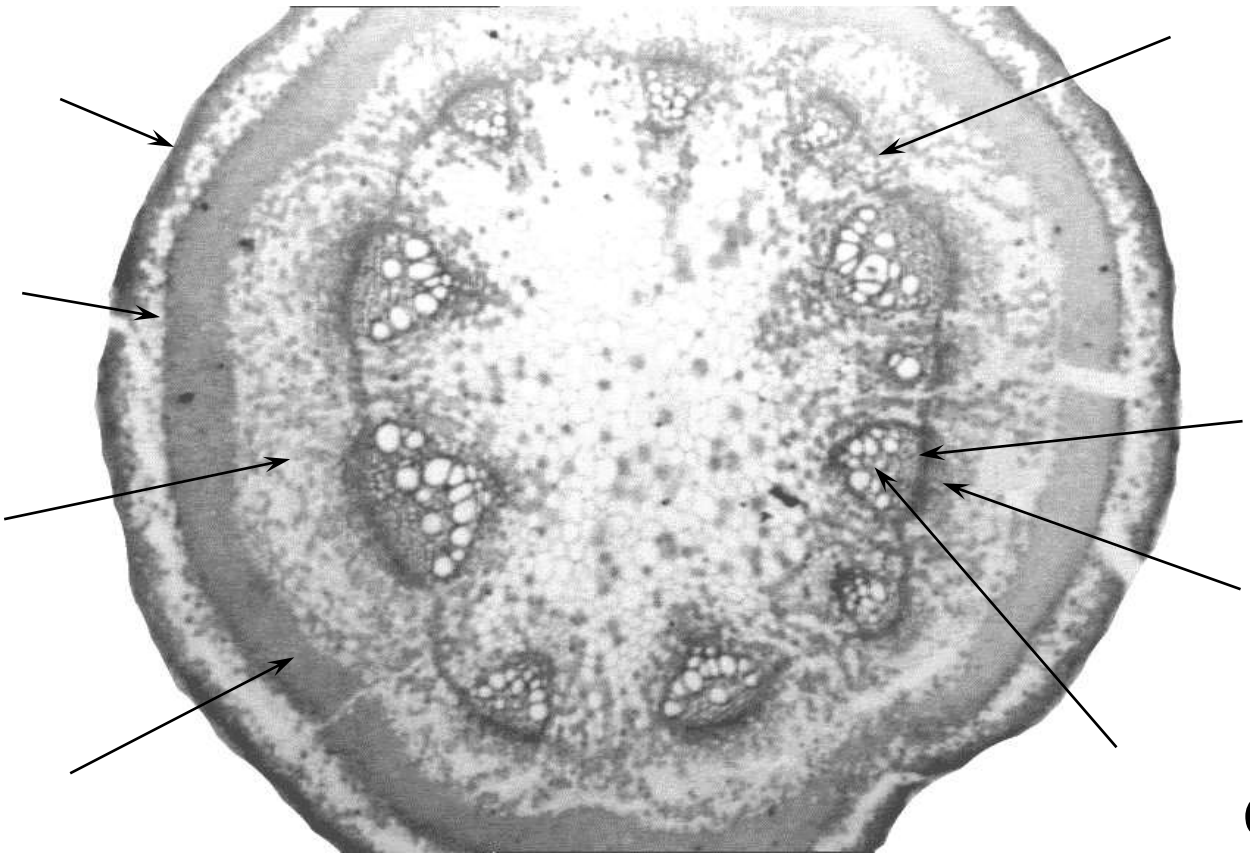
3



4



5



6

3.1. (8 points) Please label (using the numbers from the list below) the tissue elements pointed to by arrows on the scheme corresponding to your cross section in the answer sheet.

3.1(8 分)請用下方的數字，在與你的切片一樣的圖片上，填入箭頭所指部位名稱之數字代號。

- | | |
|---------------------------------------|---------------------------------------|
| 1. Endodermis.
內皮層 | 11. Periderm.
周皮 |
| 2. Phloem elements.
韌皮部 | 12. Sclerenchyma.
厚壁組織 |
| 3. Phellogen (Cork cambium).
木栓形成層 | 13. Pericycle.
周鞘 |
| 4. Collenchyma.
厚角組織 | 14. Xylem elements.
木質部 |
| 5. Phelloderma.
木栓皮層 | 15. Stoma.
氣孔 |
| 6. Chloroplasts.
葉綠體 | 16. Chlorenchyma.
綠色組織 |
| 7. Epidermis.
表皮 | 17. Cambium.
維管束形成層 |
| 8. Exodermis.
外皮層 | 18. Medullary ray (Pith ray).
射髓 |
| 9. Core (Pith, Medulla).
髓 | 19. Interfascicular cambium.
束間形成層 |
| 10. Aerenchyma.
通氣組織 | 20. Fibrovascular bundle.
纖維維管束 |

3.2. (9 points) What elements (1-18) are coloured by phloroglucin in the presence

3.2(9 分)哪一個部分(1-18)在有鹽酸的狀態下會被間苯三酚染色？
of HCl? Please, mark with “+” correct answer in the answer sheet.

請在答案紙上以“+”表示有被染色的部位。

- | | |
|--------------------------------------|---|
| 1. Endoderm cells.
內皮層細胞 | 10. Root hair.
根毛 |
| 2. Elements of phloem.
韌皮部 | 11. Cells of phellogen (Cork cambium).
木栓形成層 |
| 3. Cells of phellem (Cork).
木栓細胞 | 12. Sclerenchyma fibers.
厚壁纖維 |
| 4. Cells of collenchyma.
厚角(組織)細胞 | 13. Pericycle cells.
周鞘細胞 |
| 5. Tracheids.
假導管 | 14. Xylem elements.
木質部 |
| 6. Vessel cells.
導管細胞 | 15. Rhizoids.
假根 |
| 7. Epidermis.
表皮細胞 | 16. Cells of parenchyma.
薄壁組織細胞 |
| 8. Trichomes.
毛 | 17. Cambium cells.
維管束形成層細胞 |
| 9. Stomata guard cells.
氣孔保衛細胞 | 18. Satellite cells.
隨體細胞 |

3.2.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

3.3. (1 point) What compounds are coloured by phloroglucinin the presence of HCl?

3.3(1分)哪一化合物會在有鹽酸的狀況下被間苯三酚所染色？

Write the corresponding number (1-6) from the list below into the answer sheet.

使用下方所列的數字（1 – 6），將正確的數字填入答案卷。

1. Cellulose.

纖維素

2. Pectin.

中膠質

3. Lignin.

木質素

4. Suberin.

木栓質

5. Cutin.

角質

6. Hemicellulose.

半纖維素

3.3.: _____

3.4. (1 point) Determine which organ the cross section was made from. Write the

3.4(1分) 決定你切片所用器官的來源。

corresponding number (1-6) from the list below into the answer sheet.

使用下方所列的數字（1 – 6），將正確的數字填入答案卷

1. Root.

根

2. Stem.

莖

3. Leaf stalk (Petiole).

葉柄

4. Flower stalk.

花梗

5. Runner.

走莖（匍匐莖）

6. Rhizome.

根莖

3.4.: _____

3.5. (1 point) Determine to which division of higher plants the plant you study belong

3.5(1分)你切的植物屬於高等植物的哪一門？

to. Write the corresponding number (1-4) from the list below into the answer sheet.

使用下方所列的數字（1 – 4），將正確的數字填入答案卷

1. Lycopodiophyta.

石松門

2. Equisetophyta.

木賊門

3. Polypodiophyta.

蕨門

4. Pinophyta.

松柏門

5. Magnoliophyta.

被子植物門

3.5.: _____

3.6. (1 point) Using the crosssection you have just prepared, determine to which ecological

3.6(1分)應用你剛完成的切片，決定此植物的生態群（由濕度來看）。將正確的數字 group (relative to water availability) the plant belongs to. Write the corresponding number(1-4) 字（1 – 4）填入答案卷中。

from the ecomorph list below into the answer sheet.

1. Hygrophyte.
濕地植物
2. Hydrophyte.
水生植物

3. Mesophyte.
中生植物
4. Xerophyte.
旱生植物

3.6.:
