Student Code: _____

22nd INTERNATIONAL BIOLOGY OLYMPIAD

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Taipei, Taiwan

PRACTICAL TEST 4　實作四

PLANT ANATOMY, PHYSIOLOGY, AND GENETICS

植物解剖,生理及遺傳學

Total Points:100

Duration: 90 minutes

Dear Participants,

- In this test, you have been given the following 2 tasks:
  Task I: Plant anatomy (**60 points**)
  Task II: Plant physiology and genetics (**40 points**)
- Check your **Student Code** on the **Answer Sheet and Template paper** before starting the test.
- Write down your results and answers in the **Answer Sheet**. **Answers written in the Question Paper will not be evaluated.**
- Make sure that you have received all the materials listed for each task. If any of the listed items is missing, **lift the sign.**
- Ensure that you organize the sequence of your tasks efficiently.
- Stop answering **immediately** after the end bell rings.
- After test, enclose the **Answer sheets**, **Question paper**, **Data printout**, and the **Template paper** (without slides) in the provided envelop. Our lab assistant will collect it promptly.
- No paper or materials should be taken out of the laboratory.

- 在此實作中，包含下面兩個部分：
  實作 I:植物解剖
  實作 II:植物生理與遺傳學
- 請在考前先檢查答案紙及鑑定紙上的編號
- 將答案填寫在答案紙上，**寫在試題上的答案將不計分!**
- 請檢查每個實作上所列的所有器材，如有缺漏者，請舉牌通知監考人員
- 請確切安排操作實作的順序，以提高效率
- 鈴響後，應立刻停止作答
- 實作結束後，把答案紙,試題,列印出來的數據及鑑定紙(不用交製成的玻片標本)放進信封袋中，監試人員會來收卷
- 請勿攜出任何實驗室中的器材

Good Luck!!

Task I (60 points)

Plant Anatomy 植物解剖

Equipments:	**Quantity**
1. Slides (in carrier box)	20
2. Cover slips (in carrier box)	30
3. Compound microscope (with 4X, 10X, and 40X objective lenses)	1
4. Ocular micrometer (installed within the lens)	1
5. Single sided razor blade (in carrier box)	5
6. Petri dish (in carrier box)	1
7. Forceps (in carrier box)	1
8. Marker pen	1
9. Kimwipes	1
10 Paper towel	1
11 Waste basket	1

器材

1. 載玻片(於工具盒中)	20
2. 蓋玻片(於工具盒中)	30
3. 光學顯微鏡(含 4X, 10X, and 40X 物鏡)	1
4. 目鏡測微器(已置入目鏡中)	1
5. 單面刀片(於工具盒中)	5
6. 培養皿(於工具盒中)	1
7. 鑷子(於工具盒中)	1
8. 拭鏡紙	1
9. 擦手紙	1
10. 垃圾桶	1

Materials:	**Quantity**
1. Double distilled water (labeled as "ddH_2O" in carrier box) 二次蒸餾水(工具盒中標示爲"ddH_2O")	20 mL/vial
2. 1 N hydrochloric acid (HCl) (in carrier box) 1 N 鹽酸(HCl)	5-10 mL/vial
3. Transparent nail polish (in carrier box) 透明指甲油(於工具盒中)	1 vial
4. Section slides X, Y, and Z of the root of plant K in slide box K 切片盒 K 中有植物 K 的根部永久切片標本 X, Y, and Z	1 slide each
5. Four-compartment plastic petri dish (Containing tissue samples from plants V, W, M, N, P, Q, R, S in each compartment) 四格培養皿(分別放置植物 V, W, M, N, P, Q, R, S 的組織樣本)	2 petri dishes
6. Template paper (with student code) for placing the slides with sections you made and for documenting 鑑定紙(上有學生編號)用以放置你製作的切片並留作證據	1 sheet

Part A: Structure of Plant Root (１０ points total)

Introduction :

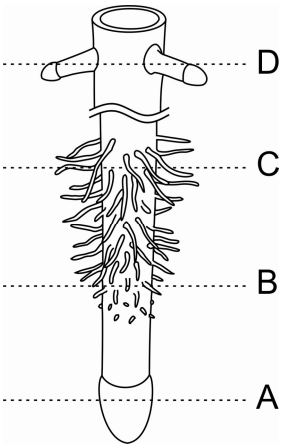


Figure 1 The structure of a typical plant root tip
典型的植物根尖構造

There are three slides (X, Y, and Z) that are the transverse sections (located within the circular label on the slides) from different regions of the root of plant K. You need to determine whether plant K is monocot or dicot to answer questions later. Observe these sections under microscope and answer the following questions.
X, Y, and Z 三個切片標本爲植物 K 根部的三個不同區域之橫切面(在切片標本上以圓圈標示)，你須在後面判斷植物 K 是單子葉或雙子葉，在顯微鏡下觀察這些橫切面並回答下列問題

Q1.A.1.（２ point each, ６ points total）

Section X, Y, and Z each corresponds to which part of the root depicted in Figure 1. Check [X] the correct answers on the answer sheet.
X, Y, and Z 三個切片分別代表上方圖１所示的根部哪三個區域？請在答案紙上適當空格中標示 X

Q.1.A.2. （single answer, ４ points）

What is the direction of maturation of primary xylem in the root (tissues mature earlier → tissues mature later)? Check [X] the correct answers on the answer sheet.
根中的初級木質部的成熟方向爲何？（較早成熟的組織→較晚成熟的組織）請在答案紙上適當空格中標示 X

Part B: Structure of Plant Stem（6 points total）

Introduction :

Carefully prepare transverse sections of proper thickness from the stem segments of plants V and W and place them on separate slides. Add a drop of water onto the sections and cover with cover slips. Observe under the microscope, and answer the following questions. You need to determine whether plants V and W are monocot or dicot to answer questions later. **When you finish this part, place your slides with the sections on the template paper, lift the sign and the lab assistant will mark with stamp in the boxes with slides.**
分別從植物 V 及 W 的莖段切出適當厚度橫切面，放在不同的載玻片上，加一滴水並蓋上蓋玻片，在顯微鏡下觀察並回答下面問題，你須在後面判斷植物 V 及 W 是單子葉或雙子葉，當你完成此部分，將你製作的水埋玻片標本放在鑑定紙對應格上，**舉牌**請監試人員檢查並在鑑定紙上蓋章標記

Q.1.B.（3 points for each plant, points are given when all correct answers are selected; 6 points total）（每種植物３分，全對才給分）

What are the distribution patterns of vascular bundles in the stems of plant V and W? Check [X] the correct answers on the answer sheet.
植物 V 及 W 的莖中維管束的分布類型爲何？請在答案紙上適當空格中標示 X

Part C: Structure of Plant Leaf（14 points total）

Introduction :

First determine the upper and lower epidermis of the leaves of plants M and N. Answer the following questions. You need to determine whether plants M and N are monocot or dicot to answer questions later. **When you finish this part, place your slides with the sections on the template paper, lift the sign and the lab assistant will mark with stamp in the boxes with slides.**

先判斷植物 M 及 N 葉片的上表皮及下表皮，再回答下面問題．你須在後面判斷植物 M 及 N 是單子葉或雙子葉．當你完成此部分，將你製作的水埋玻片標本放在鑑定紙對應格上，**舉牌**請監試人員檢查並在鑑定紙上蓋章標記

Q.1.C.1（8 points）

Observation of stomata of plant M: **觀察植物 M 的氣孔**

Prepare the upper and lower epidermis strips of the leaves, either by peeling them off with bare hands or by scraping off the undesired parts and leaving only the epidermis. Place these epidermal tissues on separate slides, with the epidermal side facing upward. Add a drop of water on each tissue sample and cover with cover slip. Observe under the microscope and use the ocular micrometer for measurements. One smallest unit of scale length of the micrometer is approximately 30 μm when observing under 4X objective lens. Answer the following questions in the answer sheet.

製作葉片上,下表皮的玻片標本，你可以直接撕下所需的表皮，或用刮去不需要的部分只留下所需的表皮．把上,下表皮分別放在不同玻片上，並將表皮面朝上，加一滴水並蓋上蓋玻片．在顯微鏡下觀察並使用目鏡測微器來測量，測微器的最小格在 4X 物鏡下大約爲 30 μm，在答案紙上回答下列問題

(a) Measurement of stomatal size on upper epidermis:
測量上表皮的氣孔大小

i) Under the 40X objective lens, what is the length of each smallest scale unit of the ocular micrometer? (1 point)
在 40X 物鏡下，測微器的最小格長度爲？μm

ii) Measure the lengths of 3 guard cells, then average their lengths. (3 points)
量測 3 個保衛細胞長度，求其平均值

(b) Measurement of stomatal density on lower epidermis:
測量下表皮的氣孔密度

i) Under 40X objective lens , what is the approximate area of the field of view ? (1 point)
在 40X 物鏡下，視野下的面積大約爲？

ii) Observe 3 fields of view, and calculate the number of stomata in each. Then work out the average stomatal density. (3 points)
觀察 3 個視野並計算每個視野的氣孔數目，求其平均值

Q.1.C.2 （6 points, points are given when all correct answers are selected）（6分，全對才給分）

Observation of leaf tissue of plant N:
植物 **N** 的葉片組織觀察

Use the provided transparent nail polish to paint the upper and lower epidermis of leaves. When the nail polish has dried, carefully peel off the layers and place on separate slides, with the epidermal side facing upward. Add a drop of water on each sample, cover with cover slips. Use the appropriate objective lens to observe. Determine the stomatal distribution of the upper and lower epidermis, and deduce the habitat of plant N. Check [X] the correct answers on the answer sheet.

將透明指甲油分別塗抹在葉片的把上,下表皮上面，待乾燥後，小心撕下指甲油印模，分別放在不同玻片上，並將表皮面朝上，加一滴水並蓋上蓋玻片．在顯微鏡下用適當物鏡來觀察，判斷上,下表皮的氣孔分布，並據以判斷植物 **N** 的生長棲地，請在答案紙上適當空格中標示 X

Part D : Monocot or Dicot of Plants (5 points)

Q.1.D (1 point each, 5 points total)

Determine whether plants K, V**,** W, M, and N are monocot or dicot. Check [X] the correct answers on the answer sheet.
判斷植物 K, V**,** W, M, and N 分別爲單子葉或雙子葉植物?在答案紙適當位置上作記[X]

Part E: Calcium Crystals in Plant Cells（20 points）

植物細胞內的含鈣結晶

Introduction :

Some plants have idioblasts that can form polygonal calcium oxalate crystals or calcium carbonate crystals. Use the four plant materials (P, Q, R, S), carefully prepare transverse sections of appropriate thickness with a clean razor blade, and place the sections on separate slides. Add a drop of water on each section, and cover with cover slips. Observe under the microscope and check for the presence of crystals. If the crystals are present, locate the region of crystal distribution in the tissue (most crystals present in or absent from the cells of vascular bundles), carefully open the cover slip, remove the excess water around the sections, and add a few drops of HCl. Add cover slips again and observe the samples under the microscope and deduce the types of crystals that are present. **When you finish this part, place your slides with sections on the template paper, lift the sign and the lab assistant will mark with stamp in the boxes with slides.**

某些植物具有可形成多邊形草酸鈣或碳酸鈣結晶的液胞，請用四種植物(P, Q, R, S)的材料小心切出適當厚度的橫切切片，分別置於不同載玻片上，加一滴水並蓋上蓋玻片．在顯微鏡下觀察並檢查是否有結晶，若有，判斷結晶在組織中的分布（大部分結晶存在或缺乏於維管束細胞中），並仔細打開蓋玻片，擦掉切片旁邊多餘的水分，加數滴的鹽酸，再蓋上蓋玻片並在顯微鏡下觀察，據以判斷其結晶的類型．當你完成此部分，將你製作的水埋玻片標本放在鑑定紙對應格上，**舉牌**請監試人員檢查並在鑑定紙上蓋章標記

Q.1.E （6 points for each plant with the presence of crystals, points are given when all correct answers are selected ; 2 points for the plant with the absence of crystals; 20 points total）（答對一種具結晶的植物６分，全對才給分；沒有結晶的植物２分；共２０分）

According to your observation, fill in the corresponding letters in the table in the answer sheet.
Plants: P, Q, R, S
Location of crystals: **A** (most crystals present in cells of vascular bundles)
B (crystals absent from the cells of vascular bundles)
Crystal type: **C** (polygonal calcium oxalate crystal) ; **D** (calcium carbonate crystal)
根據你的觀察，在答案紙的表格中填入對應的英文字母
植物：P, Q, R, S
結晶位置：**A** (大部分結晶在維管束細胞中)
B (維管束細胞中沒有結晶)
結晶類型：**C** (多邊形草酸鈣結晶) ; **D** (碳酸鈣結晶)

Documentation

When you finish all the parts (A to E) of Task I, double check whether you have collected all the stamps for this Task. If not, lift the sign and the lab assistant will check your template sheet. (0.5 point for each slide present, 5 points total).

當你完成第一部分的所有題目**(A to E)**，請在確定你是否已在每個部分被蓋過章，若無，**舉牌**請監試人員來檢查你的鑑定紙並蓋章標記　（每個蓋章的玻片０．５分，共５分）

Task II (40 points)

第二部分(40 分)

Plant Physiology and Genetics

植物生理學和遺傳學

Shared Equipment

共用儀器

ELISA reader
ELISA 光度計

Equipments: **實驗器材：**	**Quantity** **數量**
1. Micropipettes P200 and P1000 P200 及 P1000 微量吸管	1 each 各 1 支
2. Micropipettes tips for P200 and P1000 P200 及 P1000 微量吸管尖	1 box each 各 1 盒
3. 96-well microplate 96 孔微量呈色盤	1
4. 1.5 mL microcentrifuge tubes (for preparation of standard solutions, use those labeled 0 μM, 25 μM 50 μM, 100 μM, 200 μM, 400 μM) 1.5 毫升微量離心管 (用於配製標準濃度溶液，使用已標示 0 μM, 25μM, 50μM, 100μM, 200μM, 400μM 的離心管)	12 (6 extra unlabeled) 12 (6 支備用無標記)
5. 80-well microcentrifuge tube rack / 4-way test tube rack 80 孔微量離心管架 / 4 面試管架	1 each 各 1 個
6. Vortex mixer 震盪器	1
7. Marker pen 奇異筆	1

Materials: 實驗材料：	**Quantity** **數量**
1. Phosphate detection solution (labeled as "Solution A") 磷酸基偵測溶液(標記爲 Solution A)	10 mL/tube 10 毫升/管
2. 400 μM KH_2PO_4 solution (labeled as "Solution B") 400μM KH_2PO_4 溶液(標記爲 Solution B)	10 mL/tube 10 毫升/管
3. Double distilled water (labeled as "ddH_2O") 二次蒸餾水(標示 ddH_2O)	50 mL/vial 50 毫升/瓶
4. 6 samples to be tested (allotted in microcentrifuge tubes, labeled as sample #1, #2, #3, #4, #5, & #6) 6 個待測樣品 (裝在微量離心管中，標示爲 sample #1, #2,#3, #4, #5 和 #6)	

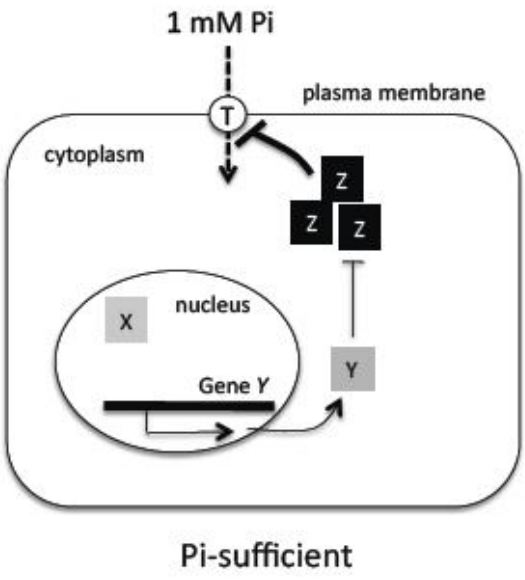
Introduction:

背景介紹：

Phosphate is an important plant nutrient that constitutes substances such as cell membranes, nucleic acids, and energy compounds like ATP. When lacking phosphates, plants' growth and development can be dramatically affected. Plants can sense changes in phosphate concentration in the environment and accordingly regulate their gene expressions, changing the activity of phosphate transport proteins on the cell membranes to maintain the homeostasis of phosphate concentration within. Using the model plant *Arabidopsis*, scientists discovered that root cells respond to phosphate-sufficient (Pi-sufficient; e.g. 1mM) or phosphate-deficient (Pi-deficient; e.g. 10μM) condition as depicted below in Figures 2 and 3, respectively:

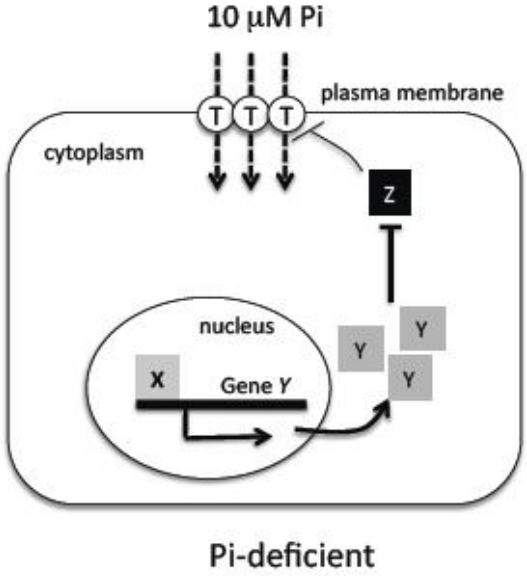
磷酸基是植物重要營養素之一，它構成細胞膜、核酸和能量分子(如 ATP)。當植物缺乏磷酸基時，其生長和發育會受到嚴重影響。植物能依據環境中磷酸基的濃度變化而調控相關基因的表現，進而改變細胞膜上磷酸基輸送蛋白的活性，藉此維持植物體內磷酸基濃度的恆定。科學家以阿拉伯芥爲模式系統，發現根部細胞在磷酸基充足時(Pi-sufficient; 例如 1mM)或磷酸基缺乏時(Pi-deficient; 例如 10μM)的調控反應分別如 Figure 2 和 Figure 3 所示：

Figure 2



Pi-sufficient

Figure 3



Pi-deficient

When *Arabidopsis* is in Pi-sufficient condition (Figure 2), the protein Z negatively regulates the level of the protein T on plasma membrane, which is responsible for the transport of phosphate into the cell, to avoid excessive phosphate absorption that leads to toxicity. On the other hand, when plant is in Pi-deficient condition (Figure 3), the transcription factor X will enhance the expression of gene *Y* and thus increase the level of protein Y. Protein Y can promote the degradation of protein Z, leading to the increase of protein T level, and consequently a higher absorption of phosphate. In general, the phosphate level in the shoot of a plant is proportional to the uptake efficiency of phosphate in the root.

當阿拉伯芥在磷酸基充足時 Pi-sufficient (Figure 2)，Z 蛋白會負向調控降低細胞膜上負責磷酸基輸入的 T 蛋白的量，以避免過量吸收磷酸基吸收而導致毒害。反之，當植物處於磷酸基缺乏時 Pi-deficient (Figure 3)，轉錄因子 X 會強增基因 *Y* 的表現，Y 蛋白的量因而增加。Y 蛋白能促進 Z 蛋白的降解，導致 T 蛋白的增加，造成更高的磷酸基吸收效率。一般而言，植物地上部莖葉的磷酸基含量與其根部的磷酸基吸收效率成正比。

The phosphate level in plants will be considerably affected when the expression of genes encoding T, X, Y, and Z is perturbed by mutation or transgene. Therefore, plant biologists can utilize such mutant or transgenic plants to determine the role and relationship of these genes in the regulatory mechanism of phosphate homeostasis.

當植物中對應 T, X, Y, 和 Z 蛋白的基因之表現量因爲突變或轉殖效應而發生改變時，其磷酸基的含量會受到明顯的影響。因之，植物學家可以利用這些突變體或轉殖植物去探討這些參與磷酸基恆定機制的基因其功用和彼此之間的關係。

There are 6 samples in microcentrifuge tubes, which are extracts from the shoots of five *Arabidopsis* lines (A to E) grown under either Pi-sufficient (1 mM) or Pi-deficient (10 μM) condition (as listed in Table 1). *Arabidopsis* A is wild type and B to E are either knockout (KO; null mutant with complete loss of function of the gene) mutant line or over-expression line corresponding to gene *T, X, Y,* or *Z*. You will be measuring the phosphate level in each sample and determine the identities of the samples based on the principles shown in Fig. 2 and 3. Each sample is derived from 20 seedlings of fresh weight shown in Table 1 and brought to final volume of 10 mL with ddH_2O .

5 個不同品系的阿拉伯芥(A-E)，分別生長於 Pi-sufficient (1 mM)或 Pi-deficient (10 μM) 條件下(如 Table 1 所示)，其中阿拉伯芥 A 是正常型，B ~ E 是將特定基因剔除的突變體(*T, X, Y,* 或 *Z*，基因功能完全喪失)或是會過量表現特定基因(*T, X, Y,* 或 *Z*)。它們的地上部抽出物樣品分別置於 6 個微量離心管中。你將測量各樣品中磷酸基的量，並依據 Fig.2 和 Fig.3 所示調控機制去推定它們分別是屬於何種基因突變體或過量表現。每一個樣品皆來自 20 個幼苗，其總鮮重分別列於 Table 1 中，各樣品均已用 ddH_2O 調整總體積至 10 毫升。

Table 1

Sample No.	Plant	[Pi] in medium 培養基中磷酸基的濃度	Fresh weight of seedlings (mg) 幼苗總鮮重
1	A	1 mM	40.4
2	A	10 μM	17.3
3	B	1 mM	28.0
4	C	1 mM	39.2
5	D	1 mM	30.6
6	E	1 mM	33.8

Use the provided equipments and solutions to measure the phosphate concentration in each sample according to the experimental procedures.
按照實驗步驟，使用提供的器材和溶液去測量各樣品中磷酸基的濃度。

Experimental Procedures:

實驗步驟：

1. Use the 400 μM KH_2PO_4 solution (Solution B), ddH_2O, and pre-labeled 1.5 mL microcentrifuge tubes to prepare the following concentrations of phosphate solutions for standard curve: 0, 25, 50, 100, 200, 400 μM. Use vortex mixer to mix solutions thoroughly. For each concentration, there should be at least 0.5 mL. Use the P200 micropipette with fresh tips to transfer 0.1 mL of each standard solution into the 96-well microplate at specified positions (as in Figure 4, make 2 replicates for each standard).
   用 400 μM KH_2PO_4 溶液(Solution B), ddH_2O 和已標示的 1.5 mL 微量離心管去準備下列濃度之磷酸基溶液，用以繪製標準濃度曲線：0, 25, 50, 100, 200, 400 μM。用震盪器充分混合各製備溶液，每一標準濃度溶液至少要有 0.5 mL。使用 P200 微量吸管以新吸管尖分別取 0.1 mL 的標準濃度溶液，依照 Figure 4 所指示(各標準濃度溶液均做重複)，將各標準濃度溶液置於 96 孔微量呈色盤。

Figure 4 Positions of standards and samples in 96-well microplate

	Standards				Samples			Standards				
A			0		#1	#1		0				
B			25		#2	#2		25				
C			50		#3	#3		50				
D			100		#4	#4		100				
E			200		#5	#5		200				
F			400		#6	#6		400				
G												
H												
	1	2	3	4	5	6	7	8	9	10	11	12

2. Transfer 0.1 mL of each sample into the 96-well microplate at specified positions (as in Figure 4, make 2 replicates for each sample).
   依照 Figure 4 所指示，分別重複取 0.1 mL 的各樣品，置於 96 孔微量呈色盤。
3. Add 0.1 mL of the phosphate detection solution (Solution A) into the wells that contain the standards and the samples. Mix by gently tapping the side of the plate.
   在微量呈色盤上含有標準濃度溶液或樣品溶液的孔位分別加入 0.1 mL 的磷酸基偵測溶液(Solution A)。輕觸敲微量呈色盤邊緣以混和。
4. **Lift the sign** after you finish Step 3, and wait for lab assistants to guide and help you with measuring the absorbance of the reaction mixtures with ELISA reader at 820 nm.
   當你完成步驟 3 後，請舉牌，等候實驗室助教的引導和協助去使用 ELISA 光度計量測反應產物在 820 nm 的吸光度。

5. The lab assistant will print out the data for you. **Put your student code sticker on the print-out**.
   實驗室助教會印出你的測量數據，**請將你的學生代碼貼在印出之數據紙上**。
6. Answer the following questions:
   回答以下問題：

Q.2.1. (18 points total)
Q.2.1. (共 18 分)

Calculate the mean values of the absorbance for each sample and standard. Use the graph paper on the answer sheet to plot a standard curve. **(0.5 point for each standard point correctly plotted)**
分別計算各樣品及標準濃度溶液平均值，使用答案卷上的方格紙畫出標準曲線。**(每個正確的標準濃度點得 0.5 分)**

Determine the phosphate concentrations of the samples in μM and the nmol phosphate per mg of seedling fresh weight for sample # 1 to # 6. Fill in your results in the table of answer sheet. **(2 points for each phosphate concentration measured, 0.5 point for each nmol/mg of phosphate calculated)**
決定樣品 #1 ~ #6 的磷酸基濃度 (以 μM 表示)和幼苗單位鮮重中磷酸基的含量(以 nmole/mg 表示)，將你的答案寫在答案卷上的表中。**(每個磷酸基濃度得 2 分，每個磷酸基含量 nmole/mg 得 0.5 分**

Q.2.2. (Multiple answers, 4 points. Points given when all correct answers are selected)
Q.2.2.(複選題，4 分，所有答案都正確才得分)

For each of the following statements, determine whether they are true or false explanations for those plants having higher phosphate content (nmol/mg) than the wild type. Check [X] the correct answers on the answer sheet.

對於那些磷酸基含量 (nmole/mg) 比正常型高的植物，請判定下列各敘述是正確(true)或錯誤(false)的解釋，用 [X] 在答案卷上標記正確答案。

(A) X cannot be activated in the plant, thus leading to an increase in phosphate uptake.
X 蛋白在此植物中不能被活化，導致磷酸基吸收的增加。

(B) Loss-of- function of Gene *Y* in the plant causing an increase in phosphate uptake.
Y 基因在此植物中失去功能，造成磷酸基吸收的增加。

(C) Loss-of-function of Gene *Z* in the plant causing an increase in phosphate uptake.
Z 基因在此植物中失去功能，造成磷酸基吸收的增加。

(D) The plant harbors a transgene that over-expressed gene *Y*, causing the loss of inhibition of protein T, leading to higher activity in phosphate uptake.
此植物具有一轉殖基因會過量表現 *Y* 基因，使 T 蛋白不能被抑制，導致較高的磷酸基吸收能力。

(E) Protein T of the plant has a defect, and it is unable to transport phosphate efficiently.
此植物的 T 蛋白有缺失，不能有效吸收磷酸基。

(F) The transcription factor X of the plant has a mutation, and is incapable to bind the promoter of gene *Y*.
此植物的轉錄因子 X 有突變，不能結合至 *Y* 基因的啓動子。

Q.2.3. (2.5 points each, 10 points total)
Q.2.3. (每題 2.5 分，共 10 分)

According to the results from the experiment, assign the corresponding plant (B, C, D, or E) to the correct description on the answer sheet.

根據實驗所得結果，將 B, C, D, 或 E 植物分別配合至答案卷上的各正確敘述。

Q.2.4. (Single answer, 4 points)
Q.2.4. (單選題，4 分)

If wild type plant (W), gene *X* knockout mutant (X), and gene *Y* knockout mutant (Y) were all grown in the same Pi-deficient condition, what would be the phosphate level in their shoots (rank from the lowest to highest)? Check [X] the correct answer on the answer sheet.
如果讓正常型植物(W)，*X* 基因剔除突變體(X)，和 *Y* 基因剔除突變體(Y)都種在同一磷酸基缺乏(Pi-deficient)條件下，它們地上部的磷酸基含量的順序爲何 (從低到高排列)？ 用 [X] 在答案卷上標記正確答案。

(A) X < W < Y
(B) Y < W < X
(C) W < X < Y
(D) W < Y < X
(E) X < Y < W
(F) Y < X < W

Q.2.5. (Single answer, 4 points)
Q.2.5. (單選題，4 分)

Western blot is a technique to detect specific protein level with the use of antibody. Which of the following would be the most likely result of the Western blot analysis of protein Y and Z from the total protein extract of samples # 1 and # 2? Check [X] the correct answer on the answer sheet.
西方墨點法是一種利用抗體偵測特定蛋白質含量的技術。以西方墨點法分析樣品 #1 和 #2 的蛋白質抽出物中 Y 蛋白和 Z 蛋白，則可能的結果爲何？用 [X] 在答案卷上標記正確答案。