Student Code:

# 24th International Biology Olympiad

## 14th-21st July, 2013

## Bern, Switzerland

BERN 2013 International Biology Olympiad

## Practical Exam 2

## Plant Physiology, Morphology and Ecology

Total points: **88**

Duration: **90 minutes**

Dear participants,
親愛的同學，
This test consists of three tasks:
本測驗包括 3 個部分：

Task 1: Determination of glucose content in plant extracts [44 points]

第一部分: 植物萃取液的葡萄糖含量測定

Part 1.1: Calibration curve [13.5 points] 校正曲線
Part 1.2: Glucose content [15 points for measured raw values] 葡萄糖含量
Part 1.3: Data analysis [15.5 points] 數據分析
1.3.1 NADH calibration curve NADH 校正曲線
1.3.2 Glucose concentration in plant extracts 植物萃取液的葡萄糖含量
1.3.3 Interpretation of your results 解釋你的結果

**Task 2: Staining of transitory starch [9 points] 暫存澱粉的染色**

**Task 3: Floral morphology and pollination ecology [35.5 points] 花的形態及授粉生態**

Part 3.1: Floral morphology 花的形態
3.1.1 Type of inflorescence 花序類型
3.1.2 Number of floral parts 花部位的數目
3.1.3 Fusion of floral parts 花部位的癒合
3.1.4 Ovary position 子房位置
3.1.5 Floral symmetry 花的對稱性
Part 3.2: Pollination ecology 授粉生態
3.2.1 Floral shape 花形
3.2.2 Pollinators 授粉者

Please write your student code into the box on the title page.

請在首頁方格中填入你的學生代碼。

**You are strongly advised to start working with Task 1**. During this task, you will have to incubate your probes for 20 minutes and then allow for some time for the lab assistants to perform the necessary measurements. During this waiting time you may work on Tasks 2 and 3.

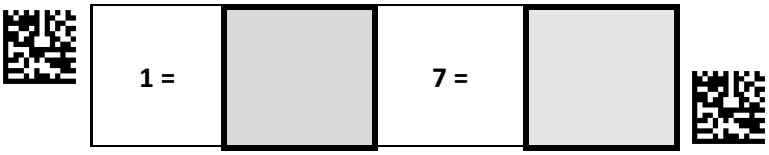
強烈建議先從第一部份開始操作。在第一部份的操作過程中，你將須培養 20 分鐘，然後還須等候監試人員協助操作一些必須的測量。等候時，你可先操作第二及第三部分。

There is no separate answer sheet. Please fill in your answers into the specific answers boxes indicated with a gray background. **Only answers given inside these boxes will be evaluated.**

本測驗不另附答案卷，請將你的答案填入灰色方格中；若在其他地方作答，則不計分。

The answers have to be given either with a tick (√) or with Arabic numbers. The numbers "1" and "7" can look very similar in handwriting. To make sure that those two numbers can be well distinguished by the IBO staff, please write them as you normally would into the following box.

填答時請打勾（V）或填寫數字。手寫的數字「1」及「7」看起來可能很相似，請務必確保計分人員能夠清楚地辨識，不會誤判。請依照你平時寫「1」或「7」的方式填入下列方格中。




Stop answering and **put down your pen IMMEDIATELY** when the bell rings at the end of the exam. Put the entire protocol with all the answers back into the exam envelope.

當測驗結束鈴響時，請停止作答並**立刻放下筆**，並將所有試卷及答案放入試卷袋。

## Material and equipment 材料及器材

Make sure that you have received all the materials and equipment listed for each task. If any of these items are missing, please raise your hand.

請檢查確認各實作所列的所有材料及器材。若有缺少的項目，請舉手通知監試人員。

**Task 1** 第一部分

Plant material: 植物材料:

- 6 x 250 µl plant extracts **[WT light, WT dark, sex1 light, sex1 dark, pgm1 light, pgm1 dark]**
  6 x 250 µl 植物萃取液 **[WT light, WT dark, sex1 light, sex1 dark, pgm1 light, pgm1 dark]**

Solutions and reagents: 溶液及藥品

- 1.5 ml "Master mix" **[MM] 作用混合液**
- 1 ml NADH solution 500 µM **[NADH]**
- 200 µl G6PDH **[G6PDH]**
- 10 ml $H_2O$ **[H2O]**

Technical material: 器材

- 1 micropipette 50 µl-200 µl (can be used down to 20 µl)
  50 µl-200 µl 微量吸管 (可用至 20 µl)
- 1 96-well Microplate (**don't touch the bottom of the plate!**)
  96 孔樣本分析盤 (請勿觸碰盤的底部)
- 1 Timer
  1 個計時器
- Container for used materials
  廢棄物筒
- 2 blank paper sheets for notes
  2 張空白計算紙
- Flag to call the lab assistant
  通知監試人員用的旗子

**Task 2** 第二部分

Plant material: 植物材料

- 8 tubes with de-pigmented plants **[A, B, C, D, E, F, G, H]**
  8 管已去掉色素的植物 **[A, B, C, D, E, F, G, H]**

Solutions and reagents: 溶液及藥品

- 10 ml Lugol's solution **[Lugol]**
  10 ml Lugol's 溶液 **[Lugol]**

Technical material: 器材

- 8 plastic dishes
  8 個培養皿
- Plastic Pasteur pipette
  塑膠滴管
- Waterproof pen for writing on plastic dishes
  可在培養皿上註記的油性筆

**Task 3** 第三部分

Plant material: 植物材料

- 5 tubes with floral specimen in 70% ethanol **[V, W, X, Y, Z]**
  樣本瓶中，浸泡於 70%酒精的 5 種不同的花標本 **[V, W, X, Y, Z]**
- Color print with photos of the flowers V-Z
  花的彩色照片(V-Z)

Technical material: 器材

- 1 dissecting microscope
  1 台解剖顯微鏡
- 1 razor blade
  1 支刀片
- 1 forceps
  1 支鑷子
- 2 toothpick
  2 支牙籤
- 1 plastic dish filled with water
  1 個裝水的塑膠盤

# Task 1: Determination of glucose content in plant extracts [44 points]

第一部分: 植物萃取液的葡萄糖含量測定

Under sufficient light, plants synthesize carbohydrates from atmospheric $CO_2$ by photosynthesis. While a fraction of these photoassimilates is exported to the cytosol and then transformed to soluble glucose, another fraction is retained within the chloroplasts and stored transiently as starch. This starch is subsequently degraded and mobilized to provide a supply of carbon and energy during dark periods.

在足夠的光照下，植物可藉光合作用將空氣中的 $CO_2$ 合成碳水化合物。一部分光合作用產物運送至細胞質液中然後轉形可溶性葡萄糖；另一部分則留在葉綠體內轉為澱粉暫時儲存。此澱粉隨後可被分解或移動，以提供在黑暗期所需的碳及能量。

Several mutants of *Arabidopsis* have been identified that are unable to either synthesize or degrade starch. In this practical, you will work with plant extracts from two of them, along with extract from wild type **[WT]** plants:

阿拉伯芥有多種不能合成或分解澱粉的突變株。本實作中，有兩種突變株以及野生型**[WT]**的萃取液如下。

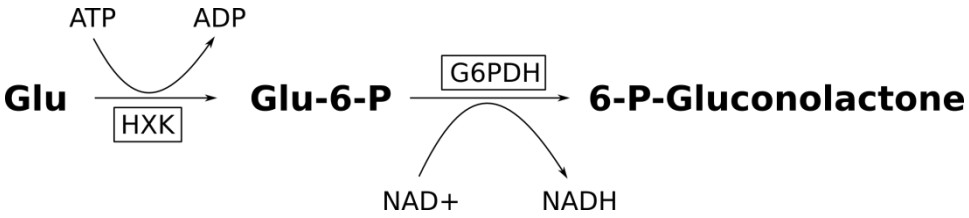
1. **WT** : unmutated wildtype plants 野生型
2. **sex1** : starch degradation mutants 分解澱粉的突變株
3. **pgm1** : starch synthesis mutants 合成澱粉的突變株

All plants were grown for 4 weeks with 8 hours light and 16 hours of darkness per day and then either exposed to complete darkness for 48 hours (dark-incubated or "dark") or to 10 hours of light (light-incubated or "light") immediately prior to harvesting.

所有植物皆先在每天 8 小時光照及 16 小時黑暗下種植 4 週，然後置於全暗處理 48 小時("dark")，或是置於光處理 10 小時("light")，即採收植物進行萃取。

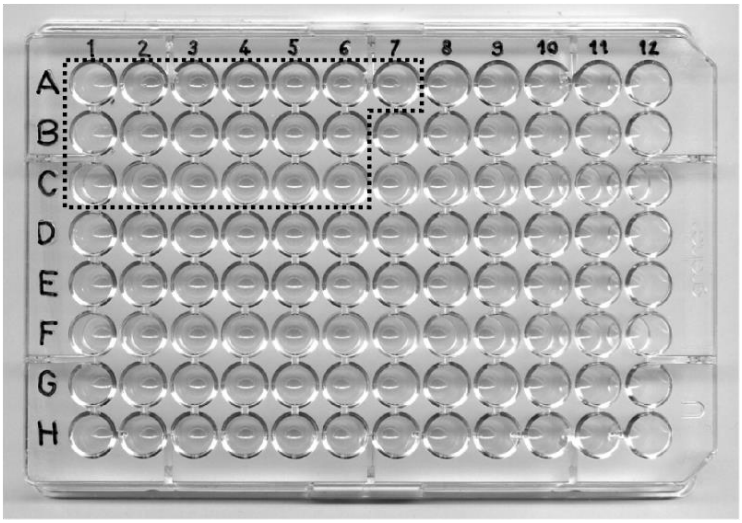
You are going to quantify the glucose content in those plant extracts by measuring the absorbance of NADH. As shown below, one molecule of NAD+ is converted into one molecule of NADH per molecule of glucose in a two-step reaction that is catalyzed by the enzymes hexokinase (HXK) and glucose-6-phosphate dehydrogenase (G6PDH). The "master mix" **[MM]** contains NAD+, HXK and ATP.

你將藉由測量的 NADH 吸光值來計算這幾種植物萃取液的葡萄糖含量。反應式如下所示: 在此兩階段的反應中，每分子的葡萄糖在 hexokinase 酵素(HXK)以及葡萄糖-6 磷酸-去氫酶(G6PDH)的作用下，1 分子的 NAD+可轉成 1 分子的 NADH。而藥品"Master mix"[MM]作用混合液中含有 NAD+, HXK 及 ATP。



You will work with a 96-well microplate (see figure below). **Only touch its edges**! Positions on this plate are indicated by a number (1-12) and a letter (A-H) specifying columns and rows, respectively. **Use only the wells which are listed in the protocol** (contained within the area indicated by the dotted line).

使用 96 孔樣本分析盤(如下圖)來操作實驗，**注意只能碰觸盤的邊緣**! 盤上的行列已分別依序編號(1-12)及英文字母(A-H)，**僅使用操作步驟所列的孔**(如圖中虛線範圍內)。




## Part 1.1: Calibration curve [13.5 points] 校正曲線

In order to quantify glucose by measuring the absorbance of NADH, you will first have to make a calibration curve with different concentrations of NADH. In the table below, indicate the required volumes of the 500 µM NADH stock solution and $H_2O$ that are needed to achieve the desired concentrations of NADH in a total volume of 200 µl. Then pipette the required volumes into the corresponding well on the microplate (A1-A7) and mix by pipetting up and down three times. **[3 points for calculations + 10.5 points for measured raw values]**

為了由測得 NADH 的吸光值換算成葡萄糖，首先你須用不同濃度的 NADH 來作一個校正曲線。下表是以 500 µM 的 NADH 原液稀釋為各指定濃度的溶液達 200 µl，分別計算需要多少 µl 的原液及水，並將數值填入表中。然後以微量吸管吸取所需的原液及水量分別置於樣本分析盤對應的孔(A1-A7)中，並上下吸放三次，以將溶液混合均勻。

**Q 1**

| Well | A1 | A2 | A3 | A4 | A5 | A6 | A7 |
|---|---|---|---|---|---|---|---|
| [NADH] (µM) | 0 | 50 | 100 | 150 | 200 | 250 | 300 |
| 500 µM NADH solution (µl) | | | | | | | |
| $H_2O$ (µl) | | | | | | | |

## Part 1.2: Glucose content [15 points for measured raw values] 葡萄糖含量

To determine the concentration of glucose in the different plant extracts, you will now prepare two solutions for each plant extract. The Wells B1-B6 will serve as a blank to quantify the base absorption and differ from the Wells C1-C6 which will contain a solution of G6PDH. Begin by pipetting the following into Wells B1-B6 and C1-C6:

為確定不同植物萃取液的葡萄糖含量，你須為每一種植物萃取液配製兩種溶液。B1-B6 孔作為測量吸光值所需的空白對照，而 C1-C6 孔則是含有 G6PDH 溶液。依照以下步驟吸取溶液分別置於 B1-B6 孔及 C1-C6 孔中。

1. 100 µl "Master mix" into the Wells B1-B6 and C1-C6
   分別吸 100 µl 的"Master mix"作用混合液於 B1-B6 孔及 C1-C6 孔中
2. 20 µl $H_2O$ into the **Wells B1-B6**
   分別吸 20 µl 的水於 B1-B6 孔中
   20 µl G6PDH solution into the **Wells C1-C6**
   分別吸 20 µl 的 G6PDH 溶液於 C1-C6 孔中
3. 80 µl of the corresponding plant extract **as indicated in the table** below and mix by pipetting three times up and down
   下表為不同孔中所應加入 80 µl 的植物萃取液，然後上下吸放三次，以將溶液混合均勻。

| Wells | B1 and C1 | B2 and C2 | B3 and C3 | B4 and C4 | B5 and C5 | B6 and C6 |
|---|---|---|---|---|---|---|
| Plant extract | WT light | WT dark | sex1 light | sex1 dark | pgm1 light | pgm1 dark |

Incubate for at least 20 and up to 60 minutes at room temperature. After incubation, call an assistant by placing your flag into the tube on your left partition wall. The assistant will measure the absorbance at 340 nm and bring you a printout of the absorbance values measured for each well. You will need these values for the analysis in Part 1.3.

接著讓混合液在室溫中靜置作用 20 至 60 分鐘(至少 20 分鐘)。然後將旗子插入左側隔牆上的管中，以通知監試人員，他將幫你測量每一孔在 340 nm 下的吸光值，並印出數據給你。這些數據將用於 Part 1.3 的分析。

**NOTE:** Due to the limited number of microplate readers, you might have to **wait up to 15 minutes** to have your microplate measured after putting up your flag. During incubation time and waiting time you may work on Tasks 2 and 3.

注意: 由於讀取樣本分析盤的儀器數量有限，在你插旗通知後，你可能需要等 15 分鐘才輪到你的分析盤被測。等待時，你可繼續作答第二及第三部分。

## Part 1.3: Data analysis [15 points] 數據分析

**Important:** Label the printout with your name and your student code. At the end of the exam, put it into your exam envelope.

**重要: 在列印紙上寫英文姓名及學生編號，在實作結束後，將它放入裝測驗紙的信封中。**

### 1.3.1 NADH calibration curve NADH 校正曲線

Calculate the scaled extinction coefficient ($\varepsilon_s$) for all measured NADH concentrations according to

$$\varepsilon_s = \varepsilon \cdot l = \frac{A_C - A_0}{c_{NADH}}$$

where $A_0$ is the background absorbance value at 0 µM NADH (Well A1) and $A_c$ the absorbance value at concentration $c_{NADH}$. $\varepsilon_s$ is equivalent to the extinction coefficient $\varepsilon$ multiplied with $l$, the path length of light through the solution. Write the calculated values in the answer fields (precision: five positions after the decimal point). **[3 points]**

用各 NADH 濃度及其吸光值，代入公式算出校正係數，公式中的 $A_0$ 為空白對照(0 µM NADH 即 A1 孔)的吸光值，$A_c$ 是在特定 NADH 濃度下的吸光值。而 $\varepsilon_s$ 校正係數相當於消失係數 $\varepsilon$ 乘上透過溶液的光波波長($l$)。在答案空格中填入數值(計算至小數點後第五位)。

| Well | A2 | A3 | A4 | A5 | A6 | A7 |
|---|---|---|---|---|---|---|
| [NADH] (µM) | 50 | 100 | 150 | 200 | 250 | 300 |
| Q 2 $\varepsilon_s$ (µM$^{-1}$) | | | | | | |

Calculate the mean value of all calculated scaled extinction coefficients $\bar{\varepsilon}_s$ and write your result in the corresponding field below (precision: five positions after the decimal point). **[1 point]**

計算所有校正係數的平均值$\bar{\varepsilon}_s$，並將數值填入答案空格中(計算至小數點後第五位)。

| | |
|---|---|
| Q 3 | $\bar{\varepsilon}_s$ (µM$^{-1}$) |

### 1.3.2 Glucose concentration in plant extracts 植物萃取液的葡萄糖含量

Calculate the glucose concentration $c_{glucose}$ in each well (diluted plant extract) measured as

$$c_{glucose} = \frac{A_{G6PDH} - A_{H2O}}{\bar{\varepsilon}_s}$$

where $A_{G6PDH}$ is the absorbance measured for the sample incubated with G6PDH (Wells C1-C6), $A_{H2O}$ is the absorbance measured for the sample incubated with $H_2O$ only (Wells B1-B6), and $\bar{\varepsilon}_s$ is the mean scaled extinction coefficient you have calculated above. Then, use these values to calculate the initial glucose content that was present in the fresh leaves, indicated as mmol/g. Each plant extract was made

of 25 g leaf material per liter. Report your values in the table below (precision: one position after the decimal point). **[7 points]**

根據公式計算每孔(稀釋後的植物萃取液)的葡萄糖含量。公式中的 $A_{G6PDH}$ 是與 G6PDH 作用(C1-C6 孔)之樣本的吸光值， $A_{H2O}$ 是只有和水作用(B1-B6 孔)之樣本的吸光值，而$\bar{\varepsilon}_s$ 是前面所得之校正係數的平均值。然後用這些數值來計算當初在新鮮葉片中的葡萄糖含量(mmol/g)；每種植物萃取液是以每公升中有 25 克的葉片而製得，將你計算出的結果填入下表中。

Q 4

| Sample | Concentration in well (μM) | Content in leaves (mmol/g) |
|---|---|---|
| WT light | | |
| WT dark | | |
| sex1 light | | |
| sex1 dark | | |
| pgm1 light | | |
| pgm1 dark | | |

### 1.3.3 Interpretation of your results 解釋你的結果

Indicate with a tick (√) for each of the following statements if it is true or false based on **your** measurements. **[4 points]**

根據結果判斷下列敘述的真偽，並以√作記。

Q 5

| | true 真 | False 偽 |
|---|---|---|
| Plants light-incubated prior to extraction contain more glucose than those incubated in the dark. 植物萃取前進行光處理者比暗處理者含有較多的葡萄糖 | | |
| Dark-incubated plants have used up all their carbohydrate energy sources in the dark period. 暗處理的植物已將黑暗期的碳水化合物能量用完了 | | |
| Glucose levels in light-incubated wild-type plants are lower than in dark-incubated wild-type plants. 在光處理後之野生株中，其葡萄糖含量比在暗處理者低 | | |
| Both "pgm1 light" and "sex1 light" samples contain more glucose than "WT light" samples. "pgm1 light"及"sex1 light"兩樣本的葡萄糖含量比"WT light"樣本高 | | |
| The "sex1 light" sample contains more glucose than the "pgm1 light" sample. "sex1 light"樣本的葡萄糖含量比 the "pgm1 light" 樣本高 | | |
| The difference in glucose concentrations between dark- and light-incubated plants is bigger in wild type plants than in mutant plants. 野生株在光處理及暗處理後的葡萄糖含量差異程度較兩種突變株高 | | |
| sex1 plants are likely to grow faster than pgm1 plants. sex1 突變株長得比 pgm1 突變株快 | | |
| Measuring samples without addition of G6PDH is needed to correct the effect of the background concentration of 6-P-Gluconolactone. 為修正植物本身的 6-P-Gluconolactone 濃度的影響，必須測量未加 G6PDH 的樣本 | | |
| ~~The concentration of NADH in plant leaves is proportional to the concentration of glucose. 植物葉片中的 NADH 濃度與葡萄糖濃度呈比例關係~~ **(此部分刪除)** | | |

# Task 2: Staining of transitory starch [9 points] 暫存澱粉的染色

Transitory starch can be easily visualized in leaves by staining it with "Lugol's solution" containing iodine in ethanol-destained leaves. On your lab bench you find two groups of plant samples.

在經過以酒精去色的葉片中，暫存澱粉可藉由含有碘的"Lugol's solution"染色而輕易辨識。在實驗桌上有兩組植物樣本(如下)

| | | | | |
|---|---|---|---|---|
| **GROUP I** | **A** | **B** | **C** | **D** |
| **GROUP II** | **E** | **F** | **G** | **H** |

While all plants of one group have been harvested after incubating for 12 hours in light, all plants of the other group have been harvested after incubating for 12 h in complete darkness. Each group contains **at least** one wild type plant (WT), one starch degradation mutant (sex1) and one starch synthesis mutant (pgm1).

一組植物在光處理 12 小時後採收，而另一組則是在黑暗處理 12 小時後採收。每組都至少有一棵野生株(WT)、一棵澱粉分解突變株(sex1)及一棵澱粉合成突變株(pgm1)。

Repeat the following steps for each of the plants A-H to stain them:

對每種植物(A-H)重複相同染色步驟

1. Transfer the plant specimen into a fresh plastic dish.
   將植物標本移到乾淨的培養皿上
2. Remove residual liquid from the dish, with the Pasteur pipette.
   用滴管吸去培養皿中多餘的液體
3. Stain the plants by covering them with some drops of "Lugol's solution" using the Pasteur pipette. 用滴管吸取"Lugol's solution"加幾滴在植物上
4. Incubate at room temperature for 1 minute before doing your observations.
   室溫下靜置 1 分鐘後，觀察結果

Indicate the observed staining pattern of leaves of each plant specimen in Group I (Plants A-D) and Group II (Plants E-H) in the table below with a tick (√). **[4 points]**
記下在兩組待觀察植物葉片的顏色，以√在適當的空格中作答。

Q 6

**Group I**

| Plant | Light orange 淡橘色 | Dark brown 深棕色 | Intense black 深黑色 |
|---|---|---|---|
| **A** | | | |
| **B** | | | |
| **C** | | | |
| **D** | | | |

**Group II**

| Plant | Light orange 淡橘色 | Dark brown 深棕色 | Intense black 深黑色 |
|---|---|---|---|
| **E** | | | |
| **F** | | | |
| **G** | | | |
| **H** | | | |

Based on the observed plants and staining pattern, indicate the corresponding growth condition for Group I and Group II in the table below with a tick (√). **[1 points]**

根據待觀察植物及其染色情形，分別判斷兩組的生長狀態，以√在適當的空格中作答。

Q 7

| | **Growth condition** 生長狀態 | |
|---|---|---|
| | **12 h in light** 光處理 12 小時 | **12 h in darkness** 暗處理 12 小時 |
| **Group I** | | |
| **Group II** | | |

Based on the observed plants and staining pattern, indicate the corresponding strain for each of the plant specimen (A-H) in the table below with a tick (√). **[4 points]**

根據觀察植物及其染色情形，分別判斷每種植物樣本的品系，以√在適當的空格中作記。

Q 8

| | | Strain 品系 | | |
|---|---|---|---|---|
| **Group** | **Plant** | **WT** | **sex1** | **pgm1** |
| **I** | **A** | | | |
| | **B** | | | |
| | **C** | | | |
| | **D** | | | |
| **II** | **E** | | | |
| | **F** | | | |
| | **G** | | | |
| | **H** | | | |

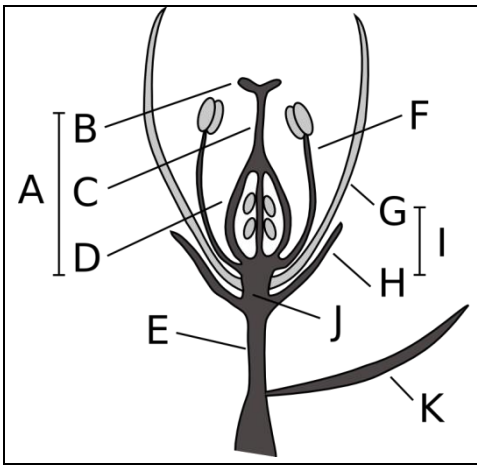
# Task 3: Floral morphology and pollination ecology [35.5 points] 花的形態及授粉生態

Angiosperm flowers show an enormous variety in structure, shape and ecological function. While the number, shape and disposition of different floral parts is often phylogenetically determined, functional characteristics such as the general shape of the flower depend more on ecological factors such as the mode of pollination. In this task, you will study the morphologic traits of five different floral samples (V-Z) and attribute them ecological traits linked with pollination.

在構造、形狀及生態功能上，被子植物的花極為多樣。一朵花的不同部位之數目、形狀及位置通常是判斷親緣關係的依據，而功能性特徵(例如花的共通外形)則多受到一些生態因子(如授粉方式)所影響。在本部分，你將檢視五種不同花的標本(V-Z)之形態特徵，並與其授粉作用作連結，以判斷其生態特性。

To help understand the terminology used below, the following figure gives you an overview of the different parts in a schematic flower.

為便於使用名詞，下圖為一朵花的不同部位之對應代號。




**A:** carpel 心皮
**B:** stigma 柱頭
**C:** style 花柱
**D:** ovary 子房
**E:** pedicel 花柄
**F:** stamen 雄蕊
**G:** petal 花瓣
**H**: sepal 萼片
**I:** tepal (when sepals and petals are undifferentiated) 花被(當萼片與花瓣不易區別時)
**J:** floral axis 花軸
**K:** bract 苞片

## Part 3.1: Floral morphology 花形態

Look at the five specimens V-Z preserved in ethanol, containing a flower or an entire inflorescence of plant species commonly found in Switzerland. The flowers are all hermaphrodite, with male and female parts present in the same flowers. The habit, shape and color of the corresponding plants are shown on the color printout.

這些以酒精保存的花標本(V-Z)為瑞士的常見植物，可能包含一朵花或一整個花序。每種標本都是兩性花(一朵花中同時包含雌性及雄性構造)。每種植物的生長習性、形態及花色則如彩色照片所示。

For each specimen V-Z, you will be asked to make a series of morphological observations. It is recommended to do first all observations for one specimen before going over to the next one.

對每個標本(V-Z)作一系列的形態觀察，建議你先完成一個標本的所有觀察項目，再看下一個標本。

Take the specimen out of the tube and place it in a Petri dish filled with water for easier observation. Please close the tube again to avoid excessive ethanol vapor in the room.

從標本瓶中取出標本，置於裝水的培養皿中，以利觀察。並關緊瓶蓋，以免酒精揮發。

Handle the flower specimens carefully, as you have to get along with the given plant material to do all your observations. In the case a specimen consists of more than one flower, isolate individual flowers to observe specific parts. For such plants you may want to observe a specific part in several flowers as some floral parts (notably stamen and carpels) are easiest observed in flowers in a specific state of maturation.

小心操作並避免破壞花標本，以利後續的觀察。若標本中含有多朵花，取一朵花來觀察特定部位；而且你可能需要多朵花，以便觀察某特定部位，因為有些部位(特別是雄蕊及雌蕊)可能需在成熟過程中的特定階段才容易觀察。

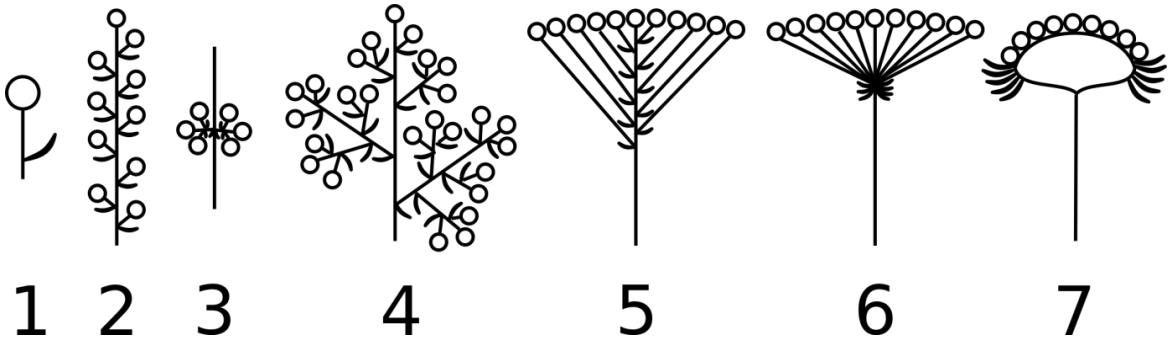
Observe small details with the dissecting microscope. For a part of the observations you might have to dissect the flower, for which you can use the given material (razor blade, forceps and toothpicks). Make all dissections in the Petri dish.

使用解剖顯微鏡觀察細微構造，你可能需要使用工具(刀片 、鑷子及牙籤)來解剖花，請在培養皿中進行所有解剖動作。

### 3.1.1 Type of inflorescence 花序的類型

The figure shows schematic illustrations of different types of inflorescences. Each small circle represents a single flower and is often accompanied by a bract.

下圖為不同類型的花序示意圖。每個小圓圈代表一朵花、且通常配有一個苞片 。



Indicate the most appropriate type of inflorescence for each Specimen V-Z with a tick (√).**[2.5 points]**

判斷每種標本(V-Z)的花序類型，並在適當空格中打勾(√)。

Q 9

| | V | W | X | Y | Z |
|---|---|---|---|---|---|
| Inflorescence type 1 | | | | | |
| Inflorescence type 2 | | | | | |
| Inflorescence type 3 | | | | | |
| Inflorescence type 4 | | | | | |
| Inflorescence type 5 | | | | | |
| Inflorescence type 6 | | | | | |
| Inflorescence type 7 | | | | | |

### 3.1.2 Number of floral parts 花部位的數目

Determine the number of sepals, petals (or tepals), stamen and carpels per flower for of each of the Specimens V-Z and write your results in the table below. When more than 10 parts of a specific floral part are present within a single flower, indicate ">10". Omit counting floral parts indicated by a black cell in the table. **[11.5 points]**

確定標本(V-Z) 一朵花中的萼片、花瓣(或花被)、雄蕊及雌蕊之數目，並在答案適當空格中填入數字。當一朵花中的某特定花部位之數目多於 10，則以">10"表示。塗黑的空格則不須回答。

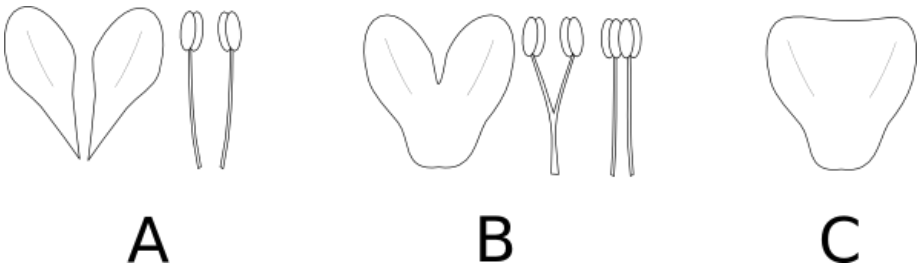
Q 10

| | V | W | X | Y | Z |
|---|---|---|---|---|---|
| number of sepals 萼片數目 | | | ■ | | |
| number of petals or tepals 花瓣或花被數目 | | | | | |
| number of stamens 雄蕊數目 | | | | ■ | |
| number of styles (count branched styles only once) 柱頭數目(分叉的柱頭當作一個柱頭) | | | | | |
| number of distinct ovaries 分離的子房數目 | | | | | |

### 3.1.3 Fusion of floral parts 花部位的癒合

As illustrated in the figure with schematic petals and stamen, floral parts can either be free (A), partially fused (B) or completely fused (C). A: free (fused part <10%), B: partially fused (fused part 10-90%), C: completely fused (fused part >90%).

以下圖為例，就花瓣、雄蕊或其他花部位而言，圖 A 為分離(癒合部分<10%)，圖 B 為部分癒合(癒合部分 10-90%)，圖 C 為完全癒合(癒合部分 part >90%)。




Indicate the correct state of fusion of sepals, petals and stamen for flowers of plant Specimens V-Z with a tick (√) in the table below. **[6.5 points]**

在答案表格中，分別表示出花標本 V-Z 的萼片、花瓣及雄蕊之癒合情況，在適當空格中打勾(√)。

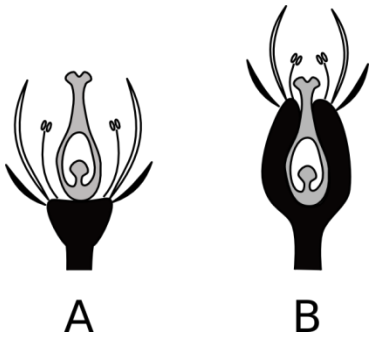
Q 11

| | | V | W | X | Y | Z |
|---|---|---|---|---|---|---|
| **Sepals** | Free (fused part <10%)分離 | | | | | |
| | Partially fused (fused part 10-90%)部分癒合 | | | | | |
| | Completely fused (fused part >90%)完全癒合 | | | | | |
| **Petals / tepals** | Free (fused part <10%)分離 | | | | | |
| | Partially fused (fused part 10-90%)部分癒合 | | | | | |
| | Completely fused (fused part >90%)完全癒合 | | | | | |
| **Stamens** | Free 分離 | | | | | |
| | Partially fused to other stamens at the base or the top tepals (fused part 10-90%) 在雄蕊的基部或花藥部分癒合 | | | | | |
| | Partially fused with petals / tepals (fused part 10-90%),與花瓣或花被部分癒合 | | | | | |
| | Partially fused to other stamens AND with petals / tepals (fused part 10-90%) 與其他雄蕊部分癒合，且也與花瓣或花被部分癒合 | | | | | |

### 3.1.4 Ovary position 子房位置

The position of the ovary of a flower can be classified as superior (A) or inferior (B), as is shown in the figure below.

一朵花的子房位置可分為上位(A)及下位(B)，如下圖所示。




Indicate the ovary position of the flowers for each specimen V-Z with a tick (√) in the table below. **[2.5 points]**

以√標示各種花標本 V-Z 的子房位置。

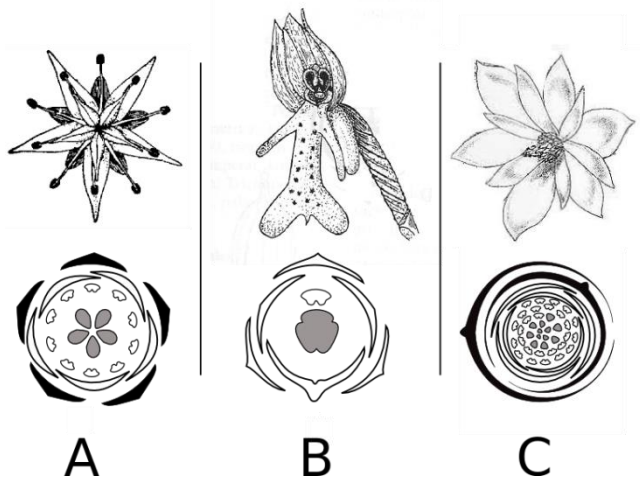
Q 12

| | V | W | X | Y | Z |
|---|---|---|---|---|---|
| A (superior)上位 | | | | | |
| B (inferior) 下位 | | | | | |

### 3.1.5 Floral symmetry 花的對稱性

The symmetry of a flower can be classified into radial (A), bilateral (B) or asymmetrical (C). The following figure illustrates these symmetries both with example flowers as well as floral diagrams (second row). Floral diagrams show from outside to inside sepals (filled and curved), petals or tepals (open and curved), stamen (open and round) and carpels (grey and round).

花的對稱性可分為輻射對稱(A)、兩側對稱(B)或非對稱性(C)。下圖為舉例及花式圖。花式圖中由外而內分別代表萼片(實心的彎曲塊)、花瓣或花被(空心的彎曲塊)、雄蕊(空心圓形)及雌蕊(灰色圓形)。



Indicate the floral symmetry for flowers of each of the specimens V-Z with a tick (√) in the table below. **[2.5 points]**

以√標示各種花標本 V-Z 的對稱性。

Q 13

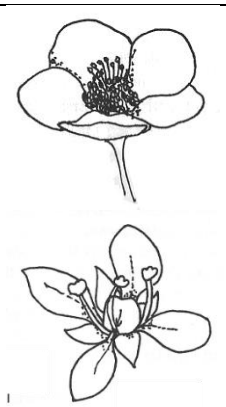
| | V | W | X | Y | Z |
|---|---|---|---|---|---|
| A (radial) 輻射對稱 | | | | | |
| B (bilateral) 兩側對稱 | | | | | |
| C (asymmetrical) 非對稱性 | | | | | |

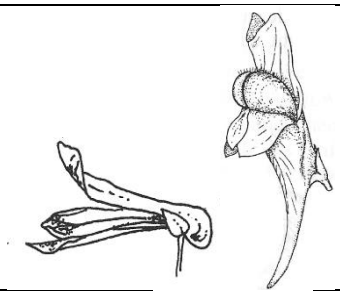
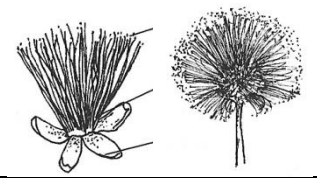
## Part 3.2: Pollination ecology 授粉生態

### 3.2.1 Floral shape 花形

Floral shapes evolved as adaptations to the morphology and behavior of different pollinators. Despite the enormous diversity of flowers and inflorescences, most of them can be classified into one of several broad classes shown in the table below. Note that the relevant unit for attracting pollinators can be a single flower or an entire inflorescence.

花形是形態與不同授粉者行為演化出的適應結果。即使花及花序非常多樣化，大多可歸類為下表幾種類型之一。請留意: 吸引授粉者的相關部位可以是一朵花或是整個花序。

| n° | **Floral shape** 花形 | **Illustration of example flowers or inflorescences** 花或花序的圖例 | **General characteristics** 共通特徵 |
|---|---|---|---|
| **1** | Open disk flower 開放式盤狀花 |  | • Pollen and/or nectar freely presented 花粉及/或花蜜可開放取用<br>• Flat landing place. 著陸處平坦 |
| **2** | Tubular flower with radial symmetry 輻射對稱的管狀花 |  | • Radial symmetry 輻射對稱<br>• Pollen and/or nectar partially or completely hidden in a narrow tube 花粉及/或花蜜部分或完全隱藏在細管中<br>• Tube may be built from free or fused floral parts 管狀構造可能與其他花部位分離或癒合 |

| | | | |
|---|---|---|---|
| **3** | Tubular flower with bilateral symmetry<br>兩側對稱的管狀花 |  | • Bilateral symmetry 兩側對稱<br>• Pollen partially or completely hidden in a narrow tube 花粉部分或完全隱藏在細管中<br>• Tube may be built from free or fused floral parts 管狀構造可能與其他花部位分離或癒合 |
| **4** | Brush flower<br>叢狀的花 |  | • Absent or inconspicuous perianth / petals 花被/花瓣 缺乏或不明顯<br>• Numerous and predominant stamens 雄蕊數目很多且明顯 |

Based on the morphological characteristics you determined above, indicate the most appropriate floral shape class for each specimen V-Z with a tick (V) in the table below. **[5 points]**

根據你的觀察判斷花標本 V-Z 為哪一種花形，在下表中以V作答。

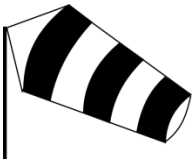
**Q 14**

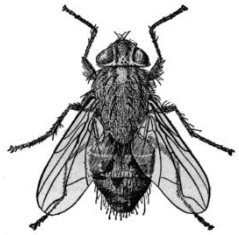
| | **V** | **W** | **X** | **Y** | **Z** |
|---|---|---|---|---|---|
| Floral shape 1 | | | | | |
| Floral shape 2 | | | | | |
| Floral shape 3 | | | | | |
| Floral shape 4 | | | | | |

### 3.2.2 Pollinators 授粉者

As is shown for a subset of common pollinators in the following table, the floral shape and other characteristics of the flowers or inflorescences are often strongly associated with their pollinators.

如下表中所示的共通授粉者，花形以及花或花序的其他特徵通常與其授粉者有密切關聯性。

| n° | **Pollinator** 授粉者 | **Characteristics of pollinator**<br>授粉者特徵 | **Common shapes of flowers / inflorescences** 花或花序的共通形狀 |
|---|---|---|---|
| **1** | Wind 風<br>  | • Unspecific 非專一<br>• Non-directional 無方向性的 | • Inconspicuous 不明顯<br>• Lack of optically attractive floral parts 缺少具吸引性的花部位<br>• Nectar and scent absent 沒有花蜜及氣味<br>• Huge amount of pollen 大量花粉<br>• Anthers and stigma well exposed to the wind 花藥及柱頭完全暴露於風中 |
| **2** | Bees/ bumblebees 蜜蜂/熊蜂<br>  | • Day-active 在白天活動<br>• Biting mouthparts 咬式口器<br>• Long tongue 舌頭長<br>• Attracted by pollen and nectar 被花粉及花蜜所吸引<br>• Pollen gathering 收集花粉<br>• Able to hang upside down 可倒掛著 | Either 不是~<br>• Bilateral 兩側對稱<br>• Brightly colored (often yellow, violet or blue) 顏色鮮豔(通常為黃色、紫色或藍色)<br>• Nectar hidden in a tube 花蜜藏於管中<br>• Offering a landing place 提供著陸處<br>Or 就是~<br>• Flat 平坦<br>• Brightly colored (often yellow, violet or blue) 顏色鮮豔(通常為黃色、紫色或藍色)<br>• Offering a lot of pollen 提供大量花粉 |
| **3** | Moths 蛾<br>  | • Night-active 夜間活動<br>• Long proboscis 口器長<br>• Do not need a landing platform 不需著陸處<br>• Seeking for nectar 找尋花蜜 | • White or nearly white 白或近似白色<br>• Fragrant scent 有香味<br>• Open during the night 在夜間開花 |
| **4** | Butterfly 蝴蝶<br>  | • Day-active 在白天活動<br>• Long proboscis 口器長<br>• Do not need a landing platform 不需著陸處<br>• Seeking for nectar 找尋花蜜 | • Upright position 直立向上<br>• Tight tube 細長管狀<br>• Deeply hidden nectar 花蜜深藏 |
| **5** | Flies 蒼蠅 | • Licking mouthparts 舔吮式口器<br>• Like bright flat surfaces to sit in | Either 不是~<br>• Small and flat 小型且平坦<br>• Without scent 無氣味 |

| | | | |
|---|---|---|---|
| |  | the sun 喜歡明亮平坦的表面，可以站在陽光下 | • Nectar reward freely presented 花蜜可開放取用<br>Or<br>• Brown/purple advertisement 呈現為棕色/紫色<br>• Carrion- or excrement-scented 氣味似腐肉或排泄物 |

The following table lists additional floral traits of the plant specimen that cannot be observed from the prepared samples (*+: present, ++ : strongly present, -: (nearly) absent*).

下表中列出這些植物標本的其他無法觀察到的特徵(*+:* 具有, *++ :* 明顯具有, *-:* (幾乎) 缺乏).

| | **V** | **W** | **X** | **Y** | **Z** |
|---|---|---|---|---|---|
| presence of nectar 花蜜 | ++ | + | + | - | ++ |
| scent 氣味 | ++ | + | + | - | + |

Based on the characteristics of the flowers or inflorescences you observed and given in the table above, indicate with a tick (√) for each of the different plant specimens V-Z its most likely group of pollinators in the table below. Use the numbers indicated for each group in the table above. If several groups are equally likely, pick any one of them. **[5 points]**

根據所觀察之花或花序及上表所提供的特徵，判斷每種植物標本 V-Z 的可能授粉者(對應授粉者編號)，以√在達適當空格中作答。若有多個可能的授粉者，標示出所有可能答案。

**Q 15**

| | **V** | **W** | **X** | **Y** | **Z** |
|---|---|---|---|---|---|
| Pollinator 1 | | | | | |
| Pollinator 2 | | | | | |
| Pollinator 3 | | | | | |
| Pollinator 4 | | | | | |
| Pollinator 5 | | | | | |

## End of the Practical Exam 本實作結束