27th International Biology Olympiad

July 17-23, 2016
Hanoi, Vietnam

Theoretical Test

PART **B**

Total points: 50
Duration: 3 hours

DEAR PARTICIPANTS,

Please write your **student code** in the given box.
請在空格中填寫你的 學生編號
Write down your answers using a pen in the **Answer Sheet**. Only answers given in the **Answer Sheet will be** evaluated .
用原子筆將答案寫在答案紙上，只有在答案紙上的答案才會被評分 。

Part B consists of 50 questions:

- Q51-Q60: Cell Biology
- Q61-Q68: Plant Anatomy and Physiology
- Q69-Q80: Animal Anatomy and Physiology
- Q81-Q83: Ethology
- Q84-Q93: Genetics and Evolution
- Q94-Q98: Ecology
- Q99-Q100: Biosystematics

For each True/False multiple choice question, indicate in the **Answer Sheet** if each of the four statements is True or False. **Mark "√" for True and False statements** in the **Answer Sheet**. If you need to change an answer, you should strikethrough the wrong answer and write in the new one.
每個選擇題中有多個 正確/錯誤 選項，在答案紙上，分別註明四項敘述正確或錯誤。
以"√" 在答案紙上對正確及錯誤的敘述作記 。若你需要更改答案，你應該將寫錯的答案完全劃掉，然後寫上新的答案。

Scoring for one question:
每題的評分方式

- If all four answers are correct, you will receive 1 point.
  四個答案皆正確，得 1 分
- If only three answers are correct, you will receive 0.6 point.
  若三個答案正確，則得 0.6 分
- If only two answers are correct, you will receive 0.2 point.
  若只有兩個答案正確，則得 0.2 分
- If only one answer is correct, you will not receive any points (0).
  若只有一個答案正確，則沒有得分

You can use the ruler and the calculator provided.
你可以使用所提供的直尺及計算機
Stop answering and put down your pen immediately when the bell rings at the end of the exam. Enclose the **Answer Sheet** and **Question P**aper in the provided envelope.
當考試結束，鐘聲響起，停止作答並立即放下筆。將答案紙及試題卷放入所提供的信封中。

Good luck!!!

CELL BIOLOGY 細胞生物學

Q.51

A scientist has prepared 3 essential components for high-throughput screens of protein kinase inhibitors. First, individual protein kinase genes are fused to the major capsid (head) gene of T7 phage. When expressed in bacteria, the fusion proteins are assembled into the phage capsid, with the kinases displayed on the outer surface. Second, an analog of ATP, which can bind to the ATP-binding pocket of the kinases, is attached to magnetic beads. Third, a bank of test compounds is prepared.

有一位科學家準備3種進行蛋白激酶抑制劑高通量篩選的必須成分。首先，個別蛋白激酶的基因被連接到T7噬菌體的主要外殼蛋白的基因。當其在細菌中表達時，重組基因編碼的融合蛋白會組裝到噬菌體外殼，將蛋白激酶呈現在噬菌體表面上。再者，ATP類似物，其可與蛋白激酶的ATP結合袋結合，將此ATP類似物接到磁性珠上。第三，製備好要測試的各式化合物。

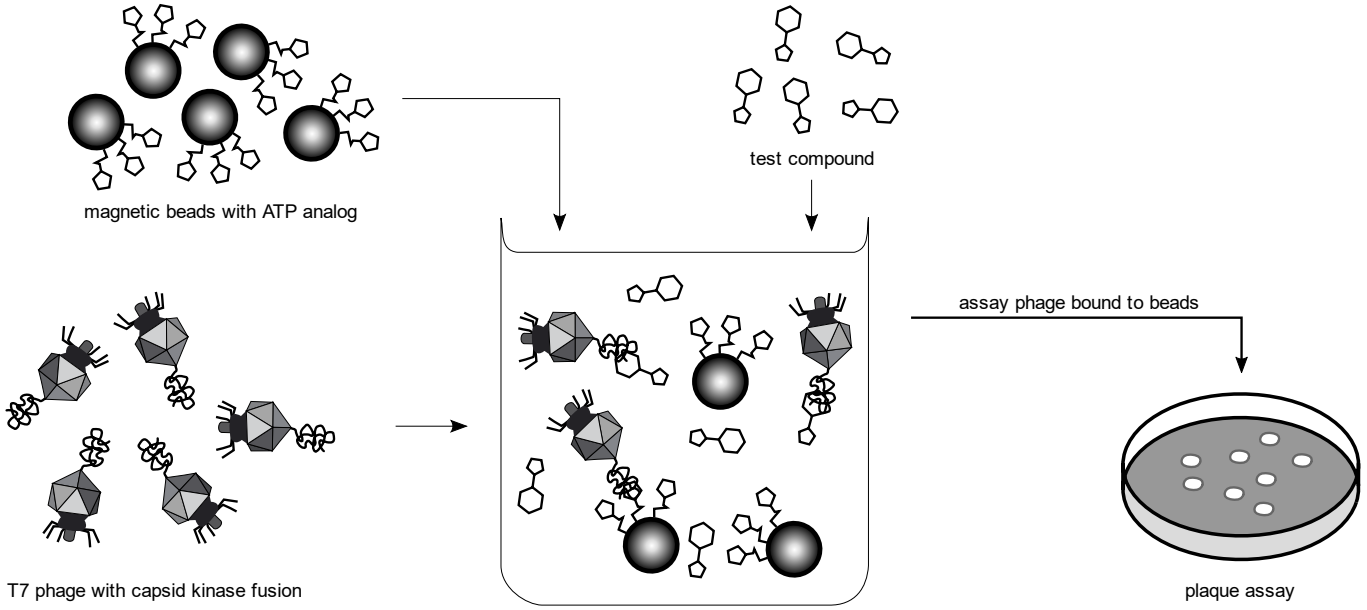


Figure Q.51 Screening potential inhibitors of protein kinases

To measure the ability of a test compound to bind a kinase, phage displaying a specific kinase is mixed with the magnetic beads in several wells of a 96-well plate. Then the test compound is added to individual wells over a range of different concentrations. The mixtures are incubated with gentle shaking for 1 hour at 25°C, the beads are pulled to the bottom with a strong magnet, and all the free (unbound) components are washed away. Finally, the remaining, attached phage are dissociated from the beads using an excess of the same ATP analog that is attached to the beads, and counted by measuring the number of plaques they form on a bacterial lawn on a Petri dish (Fig.Q.51).

為了檢測待測化合物結合激酶的能力，表面呈現特定激酶的噬菌體在一個96孔盤的樣品槽中與結有ATP類似物磁珠混合。然後將不同濃度的待測試化合物各別添加到各樣品槽中。並在25℃溫度下振盪作用1小時，將磁珠以強力磁鐵拉往樣品槽底部，並將未結合的化合物清洗移除。最後，附著的噬菌體以過量的ATP類似物置換下來，並量測計數這些吸附噬菌體在細菌培養皿上所形成的溶菌斑(plaque)數目（**Fig.Q. 51**）。

Indicate in the **Answer Sheet** if each of the following statements is True or False.
請在答題卷中填入下列各敘述為真或假。

A. When the binding process reaches equilibrium, all potential inhibitor molecules will be bound to the kinase.
當結合過程達到平衡時，所有可能的抑製劑分子將會與激酶結合。

B. Test compounds that show high inhibition in this assay must bind the ATP-binding cleft of the kinase.
本試驗中顯示具高抑制能力的待測化合物必定是結合在激酶的ATP結合袋上。

C. Small differences in evolutionary conserved ATP binding sites on kinases allow targeting specific kinases.
在激酶上具演化保守性的ATP結合袋之微小變異，讓我們可以專一性的標靶鎖定特定的激酶。

D. A strongly binding test compound will yield a low count in the plaque assay.
一個待測化合物的結合力強，所產生的溶菌斑數目較少。

Q.52

You identified a gene in fission yeast, homologous to a telomerase subunit from a protozoan. You then make a targeted deletion of one copy of the gene in a diploid strain of the yeast and then induce sporulation to produce haploid organisms. All four spores germinate perfectly, and you are able to grow colonies on nutrient agar plates. Every 3 days, you re-streak colonies onto fresh plates. After four such serial transfers, the descendants of two of the original four spores grow poorly, if at all. You take cells from the 3-, 6-, and 9-day master plates, prepare DNA from them, and cleave the samples at a chromosomal site about 35 nucleotides away from the start of the telomere repeats. You separate the fragments by gel electrophoresis, and hybridize them to a radioactive telomere-specific probe (dark bands) (Fig.Q.52). Assume that generation time is 6 hours.

你在裂殖酵母菌中找到一個與原生動物端粒酶次單位基因同源的基因。然後，你在酵母菌的二倍體菌株中將該基因的一個等位基因剔除，並誘導其孢子形成，以產生單倍體菌株。所有四個孢子皆能完美萌發，且可在營養瓊脂培養皿中長成菌落。你每3天再將菌落重新畫盤培養。經連續四次，有兩個菌株的後代生長不良。你將第3-，6-，和9天的主培養皿取出，從其中的菌體製備DNA，並將距染色體端粒重複序列開始處約35個核苷酸以外的位置切割下來，在膠體上進行電泳分開此片段,並以放射性同位素標定的端粒專一性探針進行雜交(形成黑條帶)。(Fig.Q.52 ）。假設每個世代時間(generation)為6小時。

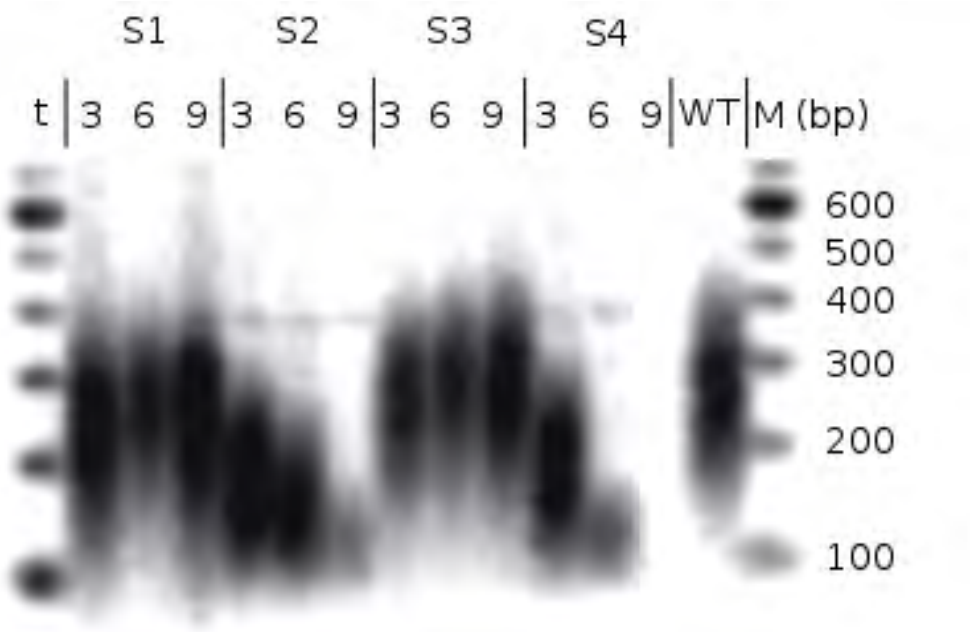


Figure Q.52 Analysis of telomeres from descendants of four fission-yeast spores (S1-S4) at different days (t). WT is the normal diploid yeast
圖Q.52 不同天(t)數之四個裂殖酵母孢子（S1-S4）的端粒分析。
WT是正常二倍體酵母菌

Indicate in the **Answer Sheet** if each of the following statements is True or False
請在答題卷中填入下列各敘述為真或假

A. The average length of telomere in fission yeast is 300 nucleotides.
裂殖酵母菌端粒的平均長度為300個nucleotides。

B. Spores 2 and 4 appear to lack telomerase.
孢子2和4似乎缺少端粒酶。

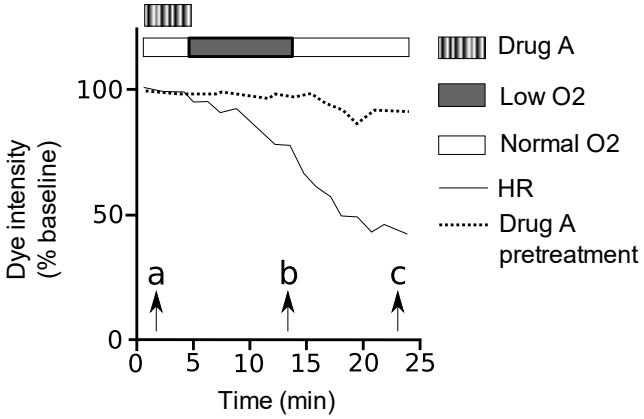
C. Fission yeast telomeres lose less than 20 nucleotides per replication.
裂殖酵母菌的端粒每次複製丟失小於20個核苷酸。

D. The fission yeasts that lose their telomeres will have normal cell size.
失去端粒的裂殖酵母仍具有正常細胞大小。

Q.53

Reoxygenation after a period of lack of oxygen causes cardiomyocyte damage. One of the most important indices evaluating myocardial functions is mitochondrial membrane potential, which is labelled by a cell permeant dye (positively-charged, red color in the attached figure) readily accumulating in active mitochondria due to their relative negative charge.
The figure below illustrates hypoxia/reoxygenation (HR)-treated single myocyte model (1) with or without pre-hypoxic treatment of drug A. Myocyte images were captured at time points (a, b, c).

缺氧一段時間後再恢復氧供給會引起心肌損害。一種評估心肌功能最有重要的指標是粒線體膜電位，這可用一種細胞透膜染料（帶正電荷的，次頁附圖中為紅色）會在有活性粒線體中累積因其相對較帶負電荷。
下圖所示為缺氧/復氧（HR）處理的單一肌肉細胞模型（1）經或未經藥物A缺氧預處理。肌細胞圖像擷取的時間點（a，b，c）。



No translation found

Indicate in the **Answer Sheet** if each of the following statements is True or False.
請在答題卡中填入下面各敘述為真或假。

A. As seen in Fig.Q.53.(2)a , cardiomyocytes are a type of striated muscle cells.
如在Fig.Q.53.(2)a, 所看到的;心肌是一種橫紋肌細胞。

B. Hypoxia leads to a drop in pH in the matrix.
缺氧導致基質中pH值的下降。

C. Drug A pretreatment is good for cell because it prevents the collapse of mitochondrial membrane potential in HR.
藥物A預處理對細胞有好處，因為它可以防止在HR時粒線體膜電位的崩毀。

D. Captured images in drug A pretreatment group are presented in (2) and captured images in HR treatment without pretreatment of drug A are presented in (3).
在藥物A預處理組拍攝的圖像如（2）所示，而無藥物A預處理的HR實驗組取得之影像參見（3）。

Q.54

Antifreeze glycoproteins (AFGPs) possess the ability to inhibit the formation of ice and are therefore essential to the survival of many marine teleost fishes that routinely encounter sub-zero temperatures. A typical AFGP consists of repeating tripeptide units, the alanyl-threonyl-alanyl (Ala-Thr-Ala)n unit connected to a disaccharide through a glycosidic bond at the second hydroxyl group of the threonine residue. To identify chemical groups which affect antifreeze activities of this glycoprotein, scientists synthesized numerous AFGP analogues by modifying both the structure of the sugar moieties and the peptide by replacing three groups R1, R2, R3 as shown in Fig.Q.54 with different chemical groups and recorded the antifreeze activity.

抗凍醣蛋白(AFGPs）具有抑制冰形成的能力，因此對許多海洋硬骨魚類能在其經常遇到的零下溫度環境中生存至關重要。典型的AFGP常由 (Ala-Thr-Ala)組成的tripeptide重複單位內的threonine的OH基與雙糖經由糖苷鍵連接所組成。為能識別影響該醣蛋白的抗凍活性的化學基團，科學家合成許多AFGP類似物，並在其糖或胜肽上加以修飾,以不同化學基團取代R1, R2及R3如Fig.Q.54所示，並記錄其抗凍活性。

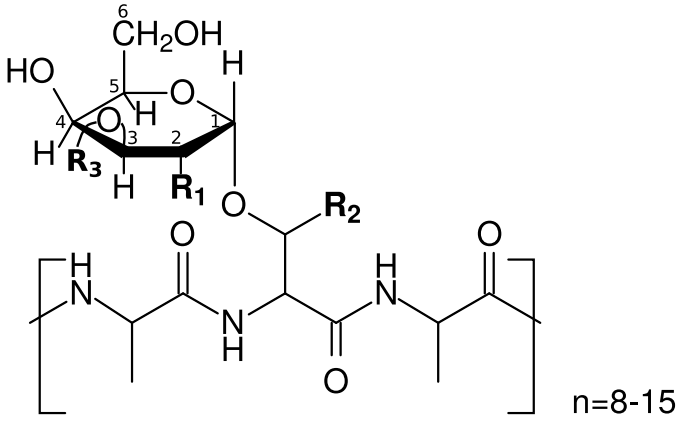


Figure Q.54 The structure of a typical AFGP

該研究的結果列於下表。

R_1	R_2	R_3	Antifr **eeze activity**
HO	CH_3	Galactosyl	No
N-Acetyl	CH_3	Galactosyl	Yes
N-Acetyl	H	Galactosyl	No
N-Acetyl	CH_3	H	Yes
O-Acetyl	O-Acetyl	H	No
N-Acetyl	CH_3	Galactosyl-Galactosyl	No

Indicate in the **Answer Sheet** if each of the following statements is True or False.
請在答題卷中填入下列各敘述為真或假。

A. A disaccharide bound to the threonine residue is required for antifreeze activity.
一個雙糖與蘇氨酸(threonine)的鍵結是抗凍活性所必需。

B. A mutant that has threonine residues replaced with serine residues generally reduces antifeeze activities.
用serine胺基酸取代threonine的突變通常會降低抗動能力。

C. N-acetyl group at the C-2 position is required for antifreeze activity.
N-乙醯基在C-2位置是抗凍活性所需。

D. Different numbers of repetitive motifs in AFGP genes amongst closely related species might have been caused by DNA polymerase inaccuracy.
在密切相關的物種中其AFGP基因重複序列數目的不同，可能是因DNA聚合酶不準確所造成。

Q.55

F1 subunit (a peripheral membrane protein) of the ATP synthase catalyses ATP synthesis using proton motive force responsible for the rotation of F0 subunit (integral membrane protein complex) in one direction. F1 is composed of three alpha and three beta subunits arranged in alternating manner around a central shaft, the gamma subunit.
To study the rotation, Masasuke Yoshida and his team attached a fluorescently labelled actin filament to gamma and watched its movement.

ATP合成酶的F_1次單元（一個膜周邊蛋白）利用質子動力單向轉動F_0次單元以催化ATP合成。F_1由三個α及三個β次單元以交替方式沿著γ次單元組成的中軸排列。為研究該旋轉裝置，Masasuke Yoshida團隊將螢光標記的肌動蛋白絲與γ次單元相連並觀其運動狀況。

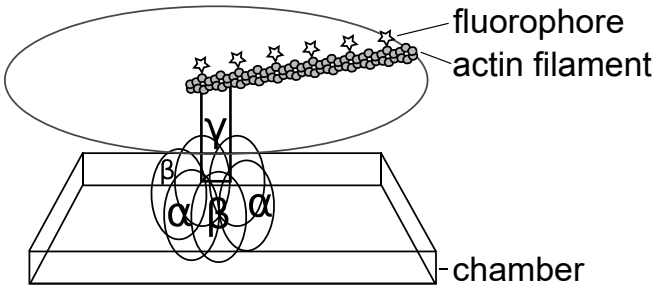


Figure Q.55A Attachment of labelled actin filament to ATP synthase.
將標定之肌動蛋白絲連接到ATP合成酶上

Rotating actin filaments were observed by an inverted fluorescence microscope after addition of 2 mM ATP into a chamber containing actin-tagged F_1 complex immobilized on the bottom side as a mirror image formed on a camera. The time interval between images was 220 ms. A series of 12 images were taken and is shown in **Fig. Q.55.**
肌動蛋白絲標定的 F1複合體固著在腔室底側與相機鏡頭呈鏡像影像用以觀察其在加入2毫摩爾ATP後的旋轉情形可在倒立螢光顯微鏡下觀察
。每一影像間隔時間為220秒，**Fig. Q.55.**中顯示一系列12張影像

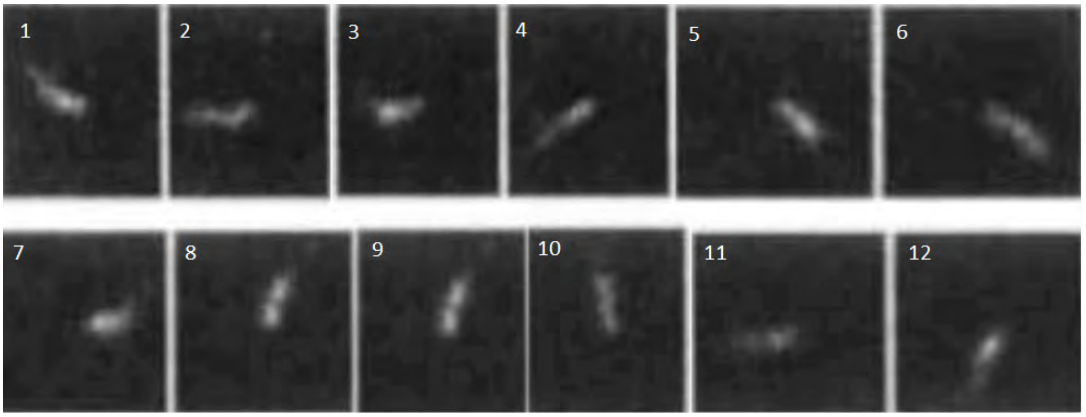


Figure Q.55B Sequential images of a rotating actin filament attached to the subunit in the F1 complex. The numbers indicate the shot images.
Figure Q.55B 圖示一系列肌動蛋白絲與 F1複合體旋轉影像，數目代表影像照相順序

Indicate in the **Answer Sheet** if each of the following statements is True or False.
請在答題卷中填入下列各敘述為真或假

A. Hydrolysis of ATP by F_1 leads to the conformational change of a and b subunits.
F_1導致的ATP水解造成a和b次單元構型的變化。

B. From the set of figures, the filament rotated anticlockwise (looking from the cytosolic side).
由圖中影像看來肌動蛋白絲轉動為逆時針方向(由細胞質側看)

C. Rotary rate is below 0.3 rounds per second.
旋轉速率低於每秒0.3轉

D. Rotating the actin filament in the opposite direction is coupled with ATP synthesis.
肌動蛋白絲往相反方向轉動需與ATP合成耦合

Q.56

Lactic fermented vegetables are traditional food in many Asian cuisines. Microorganisms commonly found in the fermentation broth are lactic acid bacteria, yeast and filamentous fungi.
Fig.Q.56 below shows the flowchart of viable cell counts (log CFU/mL) of three different microbial groups and the pH value during the lactic fermentation course of cabbage. Oxygen dissolved in fermentation broth decreased with time and was completely consumed after the 22nd day
乳酸菌發酵的蔬菜是許多亞洲美食中的傳統食品。在發酵液中通常發現的微生物是乳酸細菌，酵母和絲狀真菌。
圖Q.56顯示甘藍菜乳酸發酵過程中三種不同的微生物群的活菌數 (log CFU/mL) 與pH質變化的流程圖。在發酵液中的氧氣含量隨時間下降，在第22天後完全被消耗掉。
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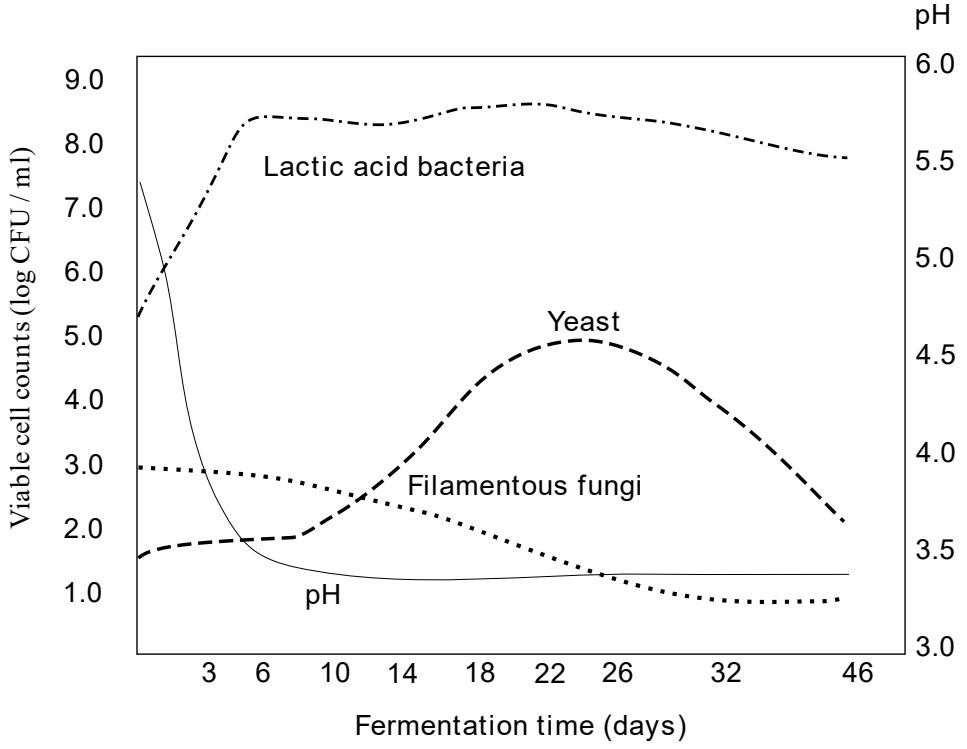


Figure Q.56 Changes in microflora during lactic acid fermentation of cabbage.
甘藍菜乳酸發酵過程中微生物菌群的改變情況

Indicate in the **Answer Sheet** if each of the following statements is True or False.
請在答題卷中填入下列各敘述為真或假

A. The drop in pH value from day 1 to day 3 was caused by only organic acids produced exclusively by lactic acid bacteria.
第1天到第3天pH值的下降是由乳酸菌產生的有機酸所造成

B. Lactic acid produced by lactic acid bacteria favours the growth of yeast cells from day 10 till day 26.
乳酸菌產生的乳酸有利於酵母細胞在第10天到第26天的生長。

C. Yeast cells shifted from fermentation to aerobic respiration after day 22.
酵母細胞在第22天後由發酵轉而進行有氧呼吸。

D. Some filamentous fungi showed tolerance to low pH.
有些絲狀真菌對低pH值有耐受性。

Q.57

Microorganisms that live at high salt concentration (above 2 M of NaCl) are exposed to media with low water activity, and must have mechanisms to avoid water loss by osmosis. Analyses of intracellular ionic concentration of Halobacteriales living in salt lakes show that these microorganisms maintain extremely high salt (KCl) concentration inside their cells. The presence of high intracellular salt concentration requires special adaptations of the proteins and other macromolecules of the cells.
住在高鹽濃度（2 M NaCl以上）微生物暴露於具低水活性介質環境下，因此其必定具有一些機制以避免因滲透作用而造成水的損失。針對生活在鹽湖內的嗜鹽菌(Halobacteriales)細胞內離子濃度的分析顯示，這些微生物維持其細胞內具有非常高鹽度（氯化鉀）。細胞內蛋白及其他大分子需得先具有特別適應胞內高鹽度的策略。

Indicate in the **Answer Sheet** if each of the following statements is True or False
請在答題卷中填入下列各敘述為真或假

A. Most intracellular proteins of Halobacteriales contain a large excess of charged amino acids on their outer surface.
嗜鹽菌(Halobacteriales)的大部分胞內蛋白的表面含有大量的負電荷。

B. Halobacteriales spend a lot of ATPs to maintain osmotic pressure.
嗜鹽菌(Halobacteriales)消耗大量ATP用以維持其滲透壓

C. Most intracellular enzymes of Halobacteriales lose their catalytic activity when suspended in solutions containing less than 1 M NaCl.
當嗜鹽菌(Halobacteriales)懸浮於小於1M NaCl的溶液時其胞內酶大多會失去其催化活性。

D. In Halobacteriales, amino acids can be imported through Na^+/amino acids antiporters.
在嗜鹽菌(Halobacteriales)，胺基酸可以利用其鈉離子/胺基酸逆向轉運蛋白(Na+/amino acids antiporters)往細胞內運送

Q.58

Influenza A genome consists of 8 separate single stranded RNA molecules, which encode a total of 11 viral proteins. Influenza A viruses are categorized by their two surface antigens, the hemagglutinin (H), of which there are 18 different subtypes (H1-18); and neuraminidase (N), of which there are 11 different subtypes (N1-11) (Fig.Q.58A). The influenza A virus life cycle is presented in **Fig. Q.58B**.
A型流感基因組由8個獨立的單鏈RNA分子，共可編碼11個病毒蛋白。 A型流感病毒可依據其兩個表面抗原來加以分類；血凝素（H），有18種不同的亞型（H1-18）神經氨酸酶（N），有11個不同的亞型（N1-11）（Fig.Q.58A）。A型流感病毒的生活週期顯示於圖Q.58B。

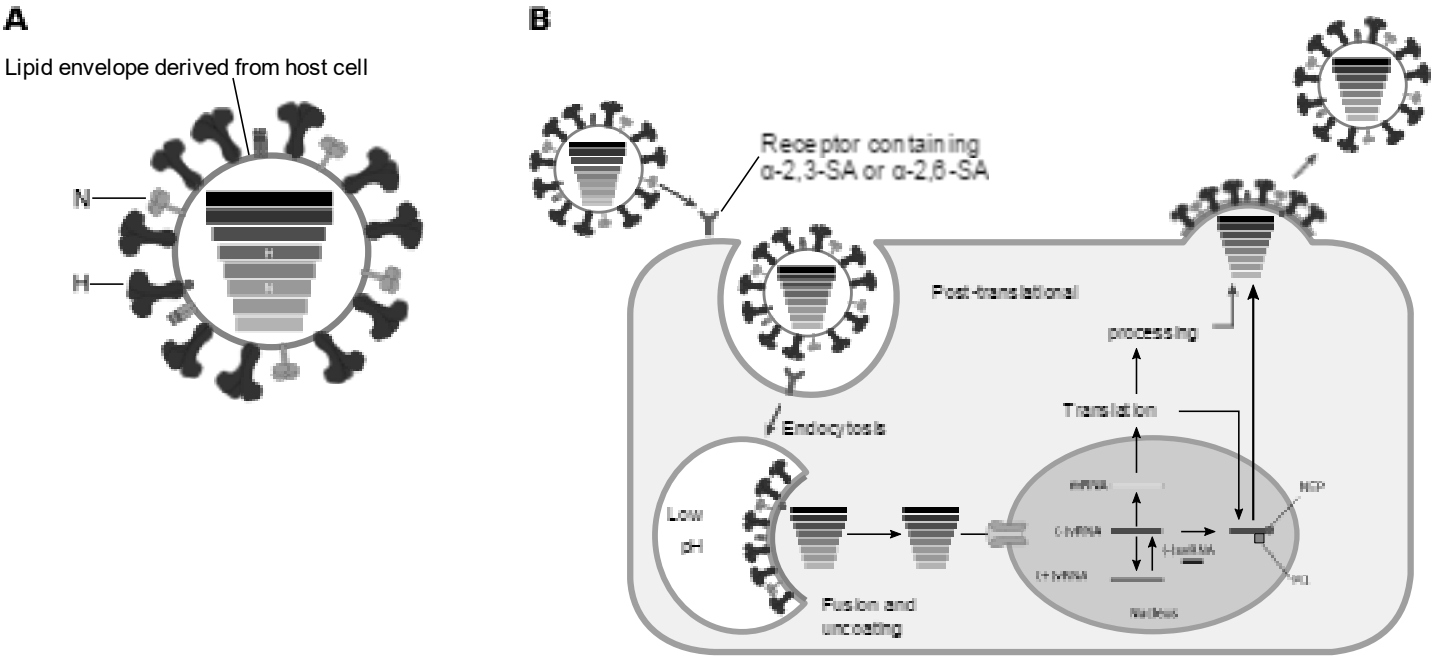


Figure Q.58 Influenza A virus: (A) virus structure and (B) virus life cycle
A型流感病毒: (A) 病毒結構. 及 (B)

Indicate in the **Answer Sheet** if each of the following statements is True or False.
請在答題卷中填入下列各敘述為真或假

A. Influenza A viruses exhibit rapid evolutionary dynamics because the genome is segmented.
A型流感病毒，因為具有分段的基因組而呈現快速演化動力學。

B. In theory, there are 88 types of influenza A viruses.
理論上A型流感病毒有88種類型

C. Influenza A viruses exhibit high mutation rates because the genome is single strand RNA.
A型流感病毒因其基因組組成為單股RNA而具有高突變速率

D. Influenza A virion can infect the cells only if RNA-dependent RNA polymerase is present.
A型流感病毒可只感染具有RNA-dependent RNA聚合酶的細胞

Q.59

Phosphorylation is a major post-translational modification widely used in the regulation of many cellular processes. A method to determine the phosphorylation status of proteins is to run an electrophoresis in a modified gel with a chemical group containing metal ions (M) that can reversibly bind phosphates and thus affects migration of phosphorylated proteins.
磷酸化是一種主要的轉譯後修飾，廣泛用於許多細胞過程的調控。 確定蛋白質的磷酸化狀態的一種方法是以一種特殊的膠進行電泳，在膠中有含金屬離子（M）的化學團，它可以可逆地與磷酸鹽結合，進而影響磷酸化蛋白在電泳膠的的移動。

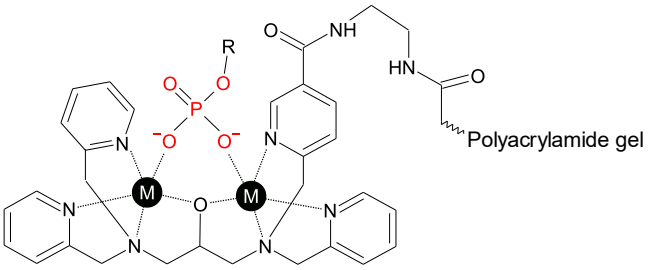


Figure Q.59.A Phospho-tag polyacrylamide gel
抓磷酸基的polyacrylamide gel

This technique was used to study the phosphorylation of protein p35. Three mutant forms of this protein were generated: a serine to alanine substitution in position 8 (S8A); a threonine to alanine substitution in position 138 (T138A) and both amino acid substitutions (2A). Note that serine and threonine can be phosphorylated while alanine cannot. Then two yeast strains with normal (wt) or inactive cyclin-dependent kinase 5 (Cdk5) (kn) were transformed with either the wild type version of p35 gene (wt) or one of the three mutant forms. Cell lysate of the eight resulting strains was loaded on a Phospho-tag gel. The proteins from the gel were transferred by western-blot to a membrane that was treated with anti-p35 antibodies. The result is shown below.
這種技術曾被用來研究p35蛋白質的磷酸化。該蛋白質的三種突變形式：
位置8的serine變成alanine（S8A）;位置138的threonine變成alanine（T138A) ;同時帶有以上二種改變（2A)。
需要注意的是serine和threonine能夠被磷酸化，而alanine不能被磷酸化。現有二種酵母菌種，一種具正常功能的cyclin-dependent kinase 5(Cdk5)，另一則否(kn)，將野生型的p35或任一突變p35分別轉殖入這二種酵母菌中。共計8種酵母轉殖株，將這8種菌株的細胞粗抽物以上述的抓磷酸基膠進行電泳，並以辨識p35的抗體進行western-blot分析。結果如下所示。

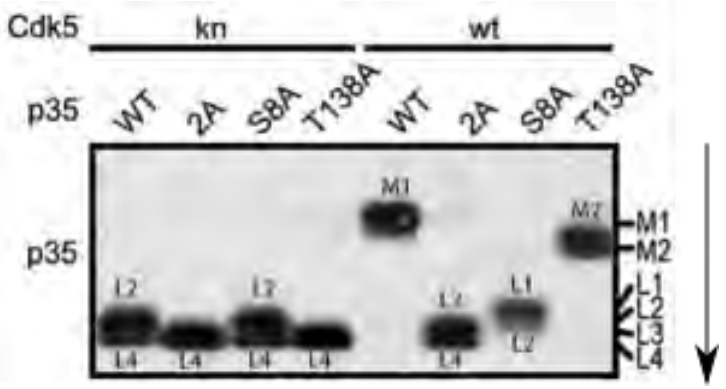


Figure Q.59.B Immunoblotting with anti-p35. The arrow indicates the direction of migration p35 bands are named M1, M2, L1, L2, L3, and L4. L4 band corresponds to the completely non-phosphorylated form of p35
以辨識p35的抗體進行蛋白質免疫分析，箭頭指示電泳移動方向，
各p35條帶以M1, M2, L1, L2, L3, 和 L4命名區分，其中L4是完全沒有磷酸化的p35

Indicate in the **Answer Sheet** if each of following statements is True or False
在答案卷上指出下列各敘述是對，或錯

A. Protein p35 has only two phosphorylation sites: serine 8 and threonine 138.
p35蛋白只有二個磷酸化位置：serine 8 和 threonine 138

B. Protein p35 can be phosphorylated by a protein kinase different from Cdk5.
p35蛋白可以被Cdk5以外的磷酸激酶磷酸化

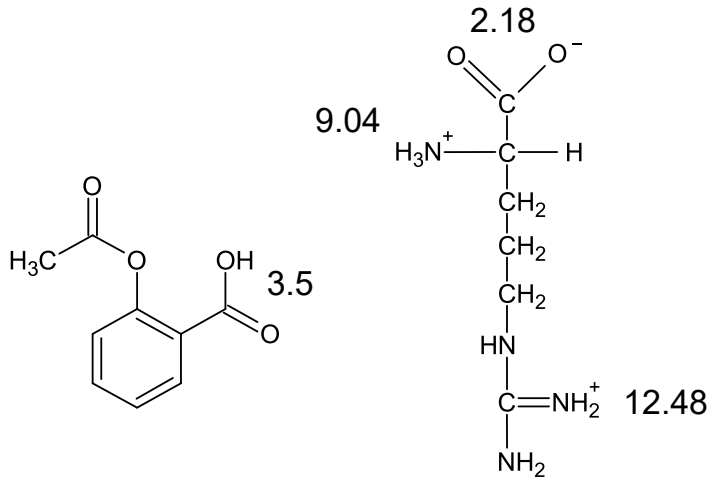
C. In strain Cdk5-wt p35-S8A only a few p35 molecules are phosphorylated at T138.
在Cdk5是野生型，而p35是S8A的菌種中，只有少量p35在T138的位置被磷酸化。

D. Phosphate groups attached to S8 are more accessible to phosphate binding groups of the Phospho-tag gel than phosphate groups attached to T138.
接在S8的磷酸基比接在T138的磷酸基更容易被抓磷酸基的電泳膠抓住

Q.60

Polarity, charge and molecular weight of molecules can affect their rate of passive diffusion through membranes. Amino acids and drugs like aspirin differ in both efficiency and location of absorption. In the figure below the chemical structure the pKa values of aspirin and arginine are represented.

一個分子的極性，電荷和其分子量會影響其被動擴散通過膜的速率。胺基酸和藥物如阿斯匹林在吸收效率和吸收位置上都不同。在下圖中呈現的是阿斯匹林和精胺酸的化學結構和pKa值。



ɔirin 阿斯匹林　　Arginine 精胺酸

Figure Q.60

Indicate in the **Answer Sheet** if each of following statements is True or False.
在答案卷上指出下列各敘述是對，或錯

A. Aspirin diffuses through membranes mainly in the stomach because more aspirin molecules are in deprotonated form at pH of about 1.6 in the stomach.
阿斯匹林擴散通過膜主要在胃中，因為在胃中約1.6的pH值會讓較多的阿斯匹林分子以去質子化形式存在

B. Based on molecular weight, one would expect Aspirin to diffuse more easily through membrane than Arginine
以分子量作為考量時，會預期阿斯匹林比精胺酸更容易通過膜

C. Optimal pH range for Arginine absorption by passive diffusion is between 2.18 and 9.04.
以被動擴散方式吸收精胺酸的最佳pH範圍介於2.18和9.04之間

D. Omeprazole, a proton pump inhibitor, blocks the entry of Aspirin into the blood in the initial few minutes after oral administration.
質子幫浦抑製劑，Omeprazole，在口服阿斯匹林後數分鐘內阻斷阿斯匹林進入血液中。

Q.61

To study the effects of cadmium (Cd) on root development, two experiments on maize seedlings with 6-cm-long root were conducted. First, seedlings were grown either in media supplemented with 5 µM Cd (Cd5) or without Cd (Cd0). Second, seedlings were grown either in two layers of agar without Cd (Cd0-Cd0) or unilaterally to 100 µM Cd (Cd0–Cd100). Four days later, root growth was recorded (Figur **e Q.61-1**) and cross-sections of roots were stained to visualize suberin lamellae in endodermis (Figur **e Q.61-2**, sections correspond to cut sites from Figur **e Q.61-1**).

欲研究鎘(Cd)對根部發育的影響，以具根長 6 cm 的玉米幼苗來進行以下兩個實驗。首先，將幼苗栽種在添加5 µM Cd (Cd5) 或未添加Cd (Cd0)的基質中；其次，幼苗種在兩層未添加(Cd0-Cd0)的明膠或單層添加100 µM Cd(Cd0-Cd100)。四天後，記錄根部的生長狀況(如圖 **Q.61-1**)，以及將根部的橫切切片染色以觀察內皮的木栓化細胞壁 (如圖 **Q.61-2**，切片位置與圖 **Q.61-1**的實驗位置相當)。

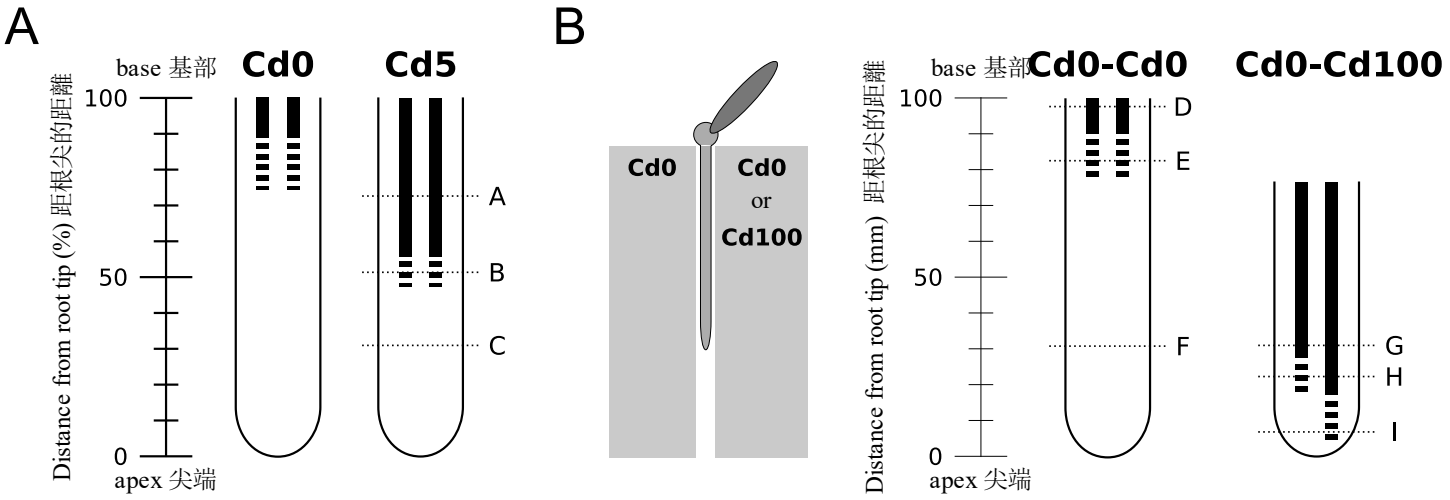


Figure Q.61-1. Distance from root apex to root base as obtained from experiments 1 (A) and 2 (B). The regions of mature endodermis in the roots are shown as solid and dashed lines.

圖Q.61-1. 根尖至根基部的距離是從實驗1 (A) 及實驗2 (B) 所得之結果。圖中的實線及虛線是根中成熟內皮的部位。

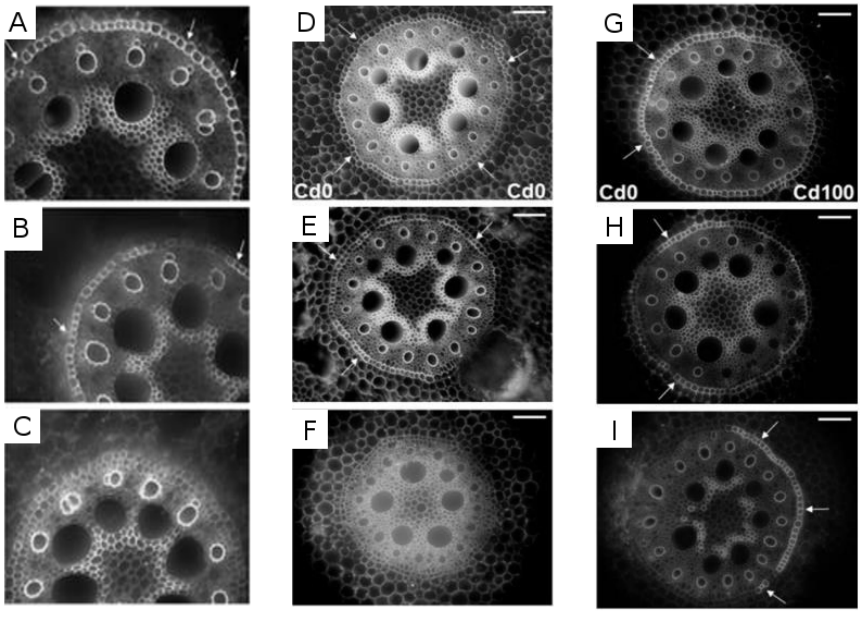


Figure Q.61-2. Cross sections at position marked in Figure Q.61-1. White arrows indicate suberin lamellae in the endodermis.

圖Q.61-2. 在圖Q.61-1中標示部位的橫切切片。白色箭號指出內皮中出現木栓壁處。

Indicate in the **Answer sheet** if each of the following statements is True or False.
在答案紙上，註明下列敘述正確或錯誤

A. The treatment of Cd resulted in the reduction of elongation zone of the root, leading to decreased root length.
鎘處理會造成根的延長部縮短，導致根的長度減少

B. Endodermal cells with suberin lamellae were already present at a distance of approximately 0.5 cm from the root apex in tissues adjacent to agar containing Cd100, however, suberinized cells were found much further from the apex on the other side.
可在距離根尖約 0.5 cm 處、且緊鄰含有Cd100的明膠那一側之組織中，發現具木栓化的內皮細胞；然而在沒有鎘的另一側則在離根尖更遠處才發現木栓化的細胞。

C. In roots exposed unilaterally to Cd (Cd0–Cd100), the development of the endodermis was accelerated and asymmetrical.
在生長於單層鎘(Cd0–Cd100)的根中，內皮的發育會被促進且呈現不對稱性

D. In high Cd containing media, suberin lamellae in endodermal cells were not present in older parts of the root likely due to the restriction of Cd in younger part.
在含有高濃度鎘的基質中，內皮細胞的木栓壁並沒有出現在較老的根部，此可能是因為鎘對根部的影響侷限在較年輕的根部

Q.62

To understand the effect of desiccation on herbaceous plants and their responses, scientists conducted a study on three *Ranunculus* species in their natural habitats, including *R. bulbosus* in dry meadow, *R. lanuginosus* in humid meadow, and *R. acris* in both habitats. They measured leaf water potential and hydraulic conductance of these species in response to dehydration (Fig.Q62). Xylem staining experiment on *R. acris* in dry habitat was used to estimate loss of conductivity due to embolism. An estimated 50% loss of xylem hydraulic conductivity occurred at -2 MPa or less owing to embolism. Previously, leaf hydraulic vulnerability studies found 50% reduction in leaf hydraulic conductance between – 1 and – 1.8 MPa in perennial grasses and at – 1.8 MPa in woody plant species.
欲了解乾旱對草本植物的影響及植物的反應，學者選擇三種毛茛屬植物，並在其生育地進行實驗，包括生長在乾燥草原的*R. bulbosus* 、濕潤草原的*R. lanuginosus* 以及同時在這兩環境生長的*R. acris*。他們藉由測量這些物種的葉片水勢及水分輸導的變化，來了解這些植物對乾旱的反應 (圖Q62)。並以在乾燥環境的*R. acris* 之木質部染色結果，來估算因乾旱導致氣栓作用所喪失的水分輸導比例；氣栓作用造成木質部水分運輸喪失50%時，水勢為2 MPa或更少。先前針對葉片水分受害程度的研究發現，當多年生禾草植物的水分運輸降低50%時，水勢在– 1 MPa和 – 1.8 MPa之間 ； 而木本植物種類則為 – 1.8 MPa。

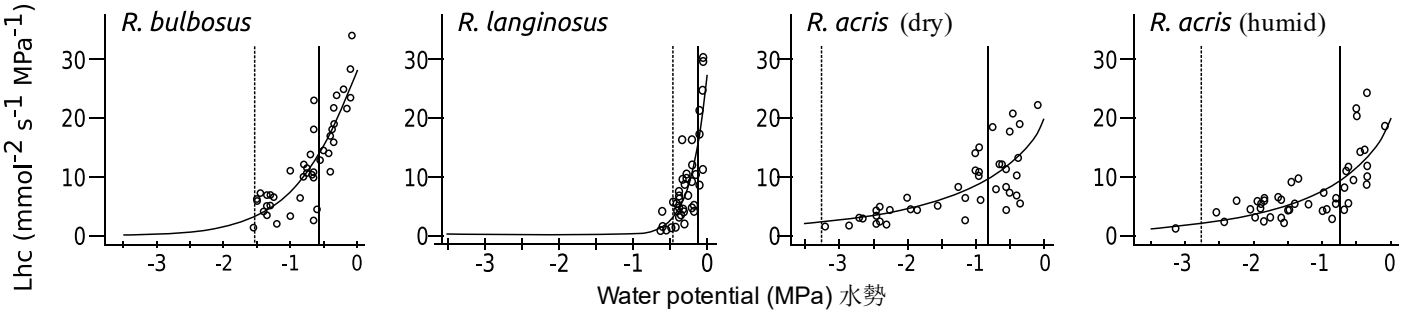


Figure Q.62 Leaf hydaulic conductance (Lhc) of Ranunculus species/populations in response to dehydration. Solid and dashed vertical lines indicate, respectively, fitted 50% and 88% leaf hydraulic conductance losses.
圖Q.62 毛茛屬物種或族群對乾旱反應出的葉片水分輸導變化(Lhc)，縱向的實線與虛線分別為50% 及 88%的水分輸導喪失比例

Indicate in the **Answer sheet** if each of the following statements is True or False.
在答案紙上，註明下列敘述正確或錯誤

A. All species were very vulnerable to water stress. In species with narrow ecological amplitude, the drought-exposed *R. bulbosus* was less vulnerable to desiccation than the humid habitat *R. lanuginosus*.
這些物種對水分逆境都很脆弱。對生態適應範圍窄的物種而言，在乾旱中的*R. bulbosus* 比在濕潤環境的*R. lanuginosus*對乾旱較沒有那麼脆弱

B. Herbaceous species would be more vulnerable to water stress than woody species and perennial grasses, but also would show interspecific and intraspecific adjustments in hydraulic vulnerability based on the water availability of their respective habitats.
面對水分逆境，草本植物比起木本植物與多年生禾草植物來得更脆弱，然而也顯示出物種間及物種內的水分易受害程度，可藉由其所在環境之水分多寡來調節適應

C. The leaf hydraulics method employs hydraulic conductance including both xylary and extraxylary pathways.
葉片可藉由木質部及木質部以外的兩種水分輸導途徑來獲得水分

D. The effect of drought in these plant species is found to be a loss of leaf hydraulic conductance at moderate water potential based on extraxylary pathways rather than embolism formation.
乾旱對這些植物的影響是: 葉片的水分輸導喪失是在緩和的水勢下，藉由木質部以外的途徑，而不是因為有產生氣栓作用

Q.63

A protein can be integrated into a membrane through a polypeptide sequence or via a lipid anchor. The attachment of eukaryotic proteins to the outer leaflet of the plasma membrane occurs only via Glycosylphosphatidylinositol (GPI) anchors. The biosynthesis of GPI glycolipid is a multistep process relies on many proteins, including GPI transamidase. In Arabidopsis plants, AtGPI8 gene encodes the enzyme GPI transamidase. To study the role of this gene in plant development, scientists constructed a mutant (atgpi8-1) plant line. They observed phenotypes of both wild type (WT) and mutant plants.
蛋白質可藉由一個多肽序列或一個脂質定錨來嵌入膜中。真核生物的蛋白質接在細胞膜外層的情況只能藉由Glycosylphosphatidylinositol (GPI)定錨來完成。GPI glycolipid (糖脂類) 的生成是一個須依賴多種蛋白來進行的多步驟流程，其中包括GPI transamidase (轉醯胺酶)。在阿拉伯芥體內， AtGPI8 基因負責製造出GPI transamidase，為研究此基因在植物發育上所扮演的角色，學者構築一突變植株(atgpi8-1)，並觀察野生型及突變型植株的表現型。

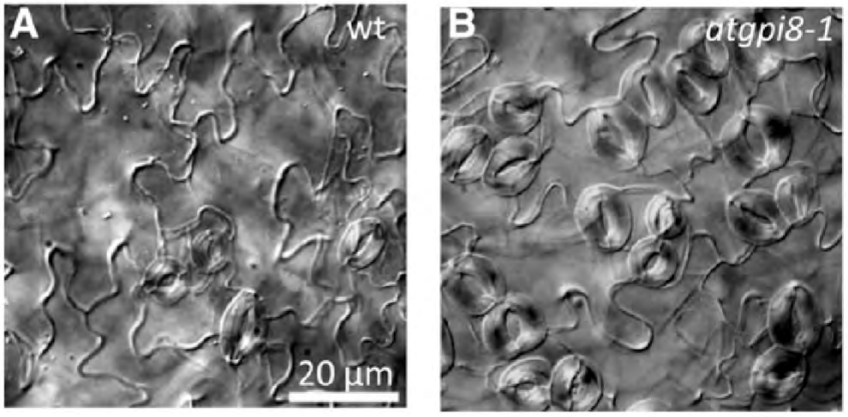


Figure Q.63.1 Cotyledonous epidermis of wild type (A) and atgpi8-1 (B) plants.
圖 Q.63.1 野生型(A) 及 atgpi8-1 突變型植株 (B)的子葉表皮

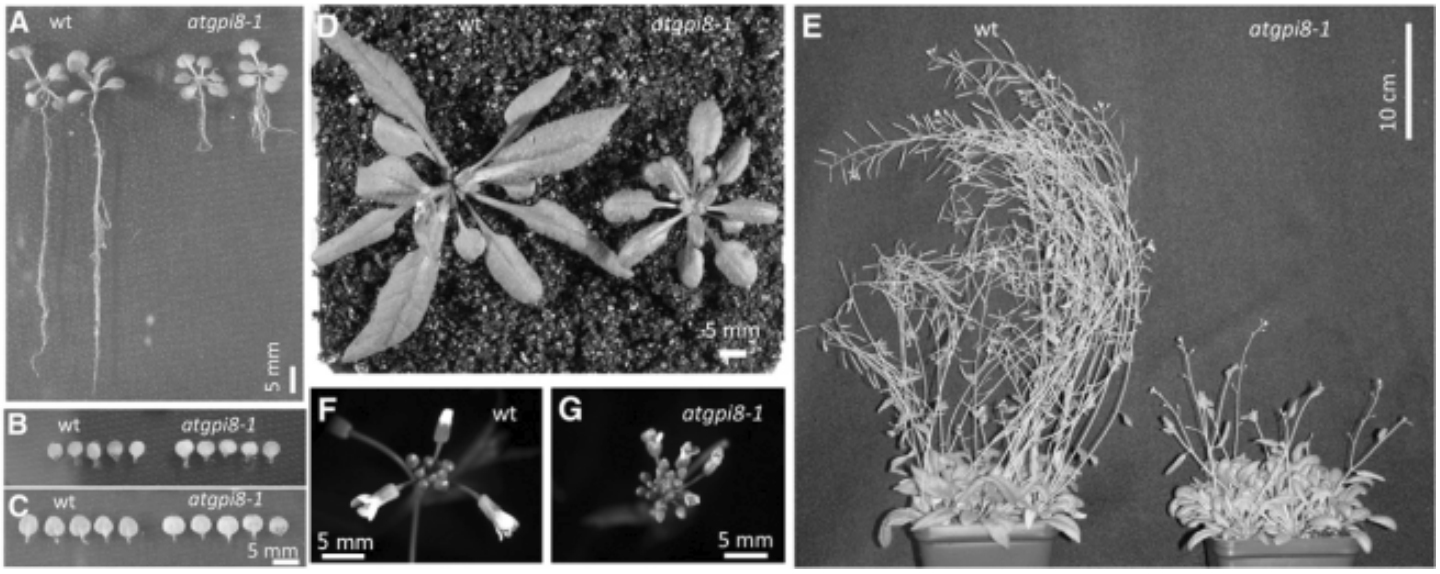


Figure Q.63.2 Growth phenotypes of wild type and atgpi8-1 plants. (A) Seedlings, (B) cotyledons and (C) first two leaves of seedlings. (D) 30-day-old and (E) 60-day-old plants. F- G: Inflorescences.
圖Q.63.2 野生型及突變型植株的生長表現型。(A) 幼苗、(B) 子葉及(C) 幼苗中最早長出的兩片葉子；(D) 30 天大的植株 及 (E) 60天大的植株；. F- G: 花序

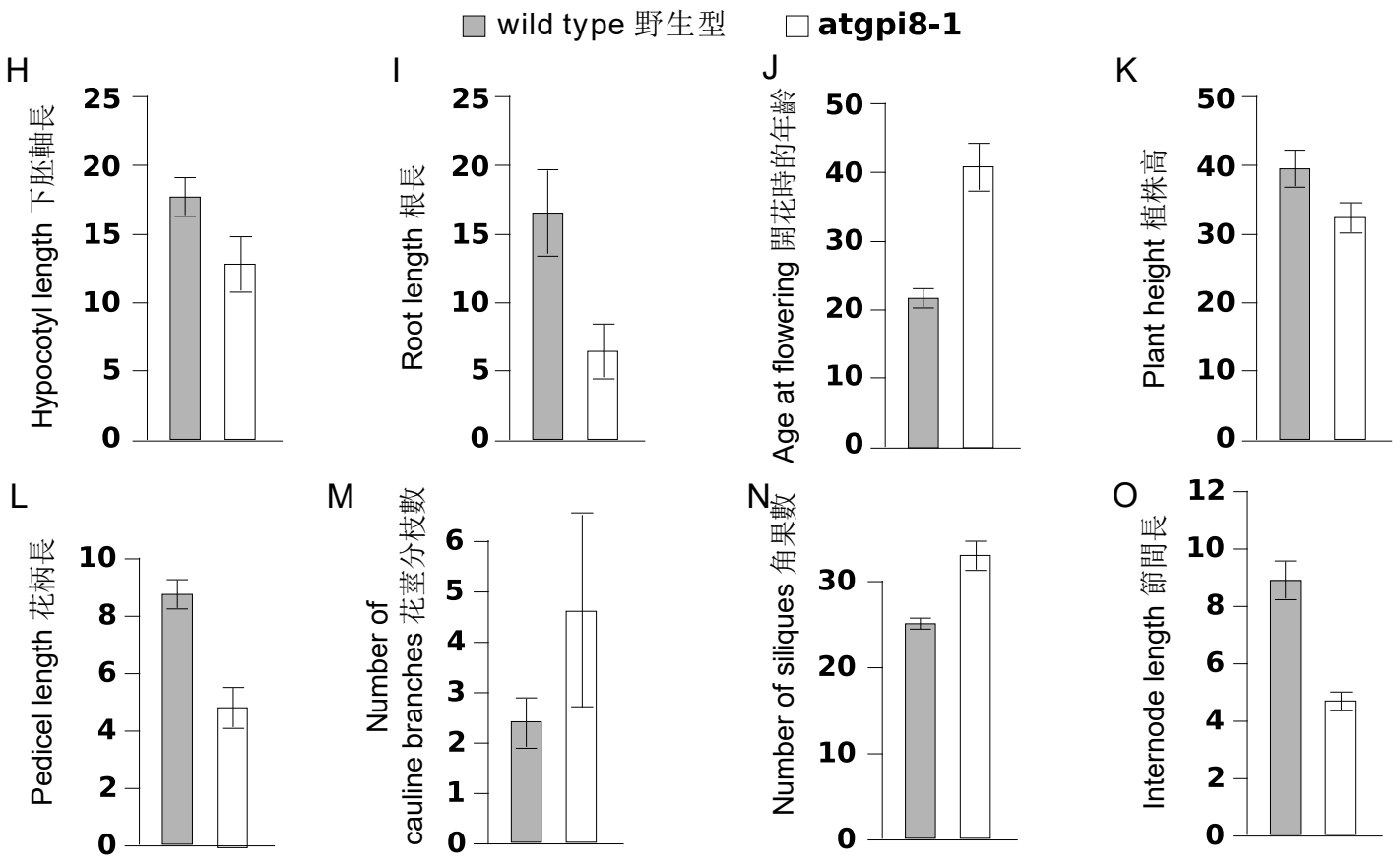


Figure Q.63.3 Morphometric analysis of wildtype (gray bars) and atgpi8-1 (white bars) seedlings and mature plants. All differences are statistically significant.
Measurements for D-H were carried out at full maturation at 60 days for wildtype and 90 days for mutants.
圖Q.63.3 野生型 (灰色直條) 及突變型 (白色直條)幼苗及成熟植株的形態測定分析。所有差異皆具統計上的顯著性。
D-H的測量是用完全成熟的60天大的野生型及90天大的突變型植株

Indicate in the **Answer sheet** if each of the following statements is True or False.
在答案紙上，註明下列敘述正確或錯誤

A. The early post germination growth of cotyledons and first two leaves are not affected by the mutation. However, root growth, hypocotyl elongation and stomata differentiation are strongly affected by the mutation.
子葉及最早兩片葉子在萌芽後初期的生長不受突變影響，然而根的生長、下胚軸的延長以及氣孔的特化都會受到突變劇烈的影響

B. The data suggest that GPI anchoring promotes the growth of leaves in vegetative plants; however, it inhibits axillary shoot formation.
數據顯示GPI定錨可促進營養時期植株的葉片生長，然而卻抑制莖的形成

C. The atgpi8-1 mutation leads to reduced internode and pedicel elongation. However, the height of atgpi8-1 plants is only moderately reduced likely because the number of internodes is increased.
atgpi8-1 突變導致節間縮短及花柄延長，然而其植株高則僅出現輕微下降，可能是因為節間的數目增加

D. The results indicate that AtGPI8 gene promotes early transition to flowering, but inhibits fruit production.
結果顯示AtGPI8基因可促進提早進入花期，但抑制果實的產生

Q.64

Photosynthesis of submerged aquatic plants is severely impeded by many environment factors. In seawater and freshwater, light density and its spectrum is changed with depth in the water column and thus influence photosynthesis. Other factors affecting photosynthesis include level of carbon dioxide (CO_2) and oxygen (O_2).
沉水性水生植物的光合作用嚴重受到許多環境因子阻礙。在海水及淡水中，光強度及其光波長會因水深而變，故而影響光合作用，此外影響因子還有CO_2及O_2的含量。
Swamp Raspwort (*Meionectes br*ownie) is a wetland plant species but can grow as a submerged aquatic plant in freshwater. An experiment was conducted to study the photosynthesis of the aquatic vegetation. Diurnal fluctuations in surface irradiance, partial pressure of O_2, CO_2 concentration and pH of the water in Swamp Raspwort-rich ponds are shown in Figur **e Q.64**.
Swamp Raspwort (*Meionectes br*ownie)是一種濕地植物，但可在淡水中沉水生長。以此材料來研究水生植被的光合作用，在一個長滿Swamp Raspwort 的池塘中，白天水面處的光照波動情形、O_2分壓、CO_2濃度及水的pH值之變化如圖Q.64所示

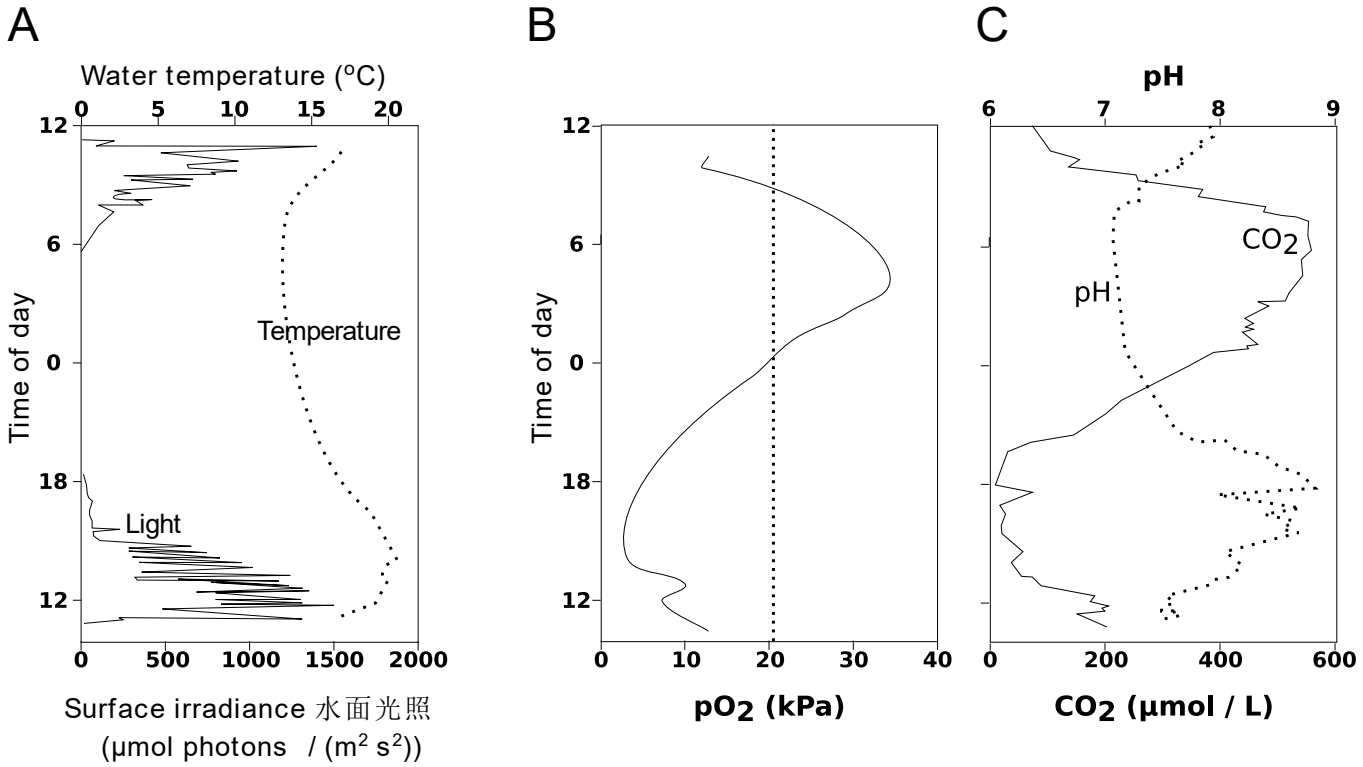


Figure Q.64 圖Q.64

Indicate in the **Answer sheet** if each of the following statements is True or False.
在答案紙上，註明下列敘述正確或錯誤

A. In the underwater of ponds, light limitation appears early in the morning and co-limitation of both light and CO_2 takes place early in the afternoon.
在池塘的深水處，早晨會出現受光的限制，而下午則同時受光及CO_2的限制

B. The decrease in level of O_2 in water column during the night is caused by the Swamp Raspwort respiration.
在晚上，水中的含氧量下降，是因為Swamp Raspwort的呼吸作用所造成

C. In water column of ponds, CO_2 molecules are directly produced by respiration of Swamp Raspwort and by conversion from HCO^-_3 at pH neutral results in increasing CO_2 level.
在池塘水中，CO_2 分子可直接由Swamp Raspwort的呼吸作用產生，也可在中性酸鹼值時由HCO^-_3 轉換而來，故而導致CO_2 含量增加

D. As indicated in the figure, temperature variation in ponds rich Swamp Raspwort is from 13 to 20ºC. The alteration in temperature is mainly maintained by high density of this plant species.
由圖顯示，在長滿Swamp Raspwort的池塘中，其溫度變化是13 - 20ºC，溫度的改變主要是靠此植物物種的高密度來維持。

Q.65

Nitrogen assimilation plays an important role in plant metabolism as well as in plant cell development. Plant cells can acquire inorganic nitrogen in the form of ammonium (NH_4^+) and nitrate (NO_3^-). When entering the plant cells through membrane-bound nitrate transporter (NRT), NO_3^- can be reduced to NO_2^- by nitrate reductase (NR) and subsequently to NH_4^+ and amino acids (AA). In addition, NO_2^- can be converted into nitric oxide (NO), then forming S-nitrosoglutathione (GSNO) by reaction with glutathione (GSH), and finally into oxidized glutathione (GSSG) and NH_4^+ under catalysis of S-nitrosoglutathione reductase 1 (GSNOR1)
氮的同化作用在植物代謝以及細胞發育上皆扮演重要角色。植物細胞可吸收的無機氮型式為銨鹽(NH_4^+)及硝酸鹽(NO_3^-)。在經由膜上的硝酸移動子(NRT)進入植物細胞時，硝酸鹽會被硝酸還原酶(NR)還原為亞硝酸鹽(NO_2^-)，然後依序再轉為銨鹽及胺基酸(AA)。此外，亞硝酸鹽可被轉化為一氧化氮(NO)，然後與glutathione (GSH)反應而形成S-nitrosoglutathione (GSNO)，最後在S-nitrosoglutathione reductase 1 (GSNOR1)的催化下，再成為氧化態的glutathione (GSSG)與銨鹽。

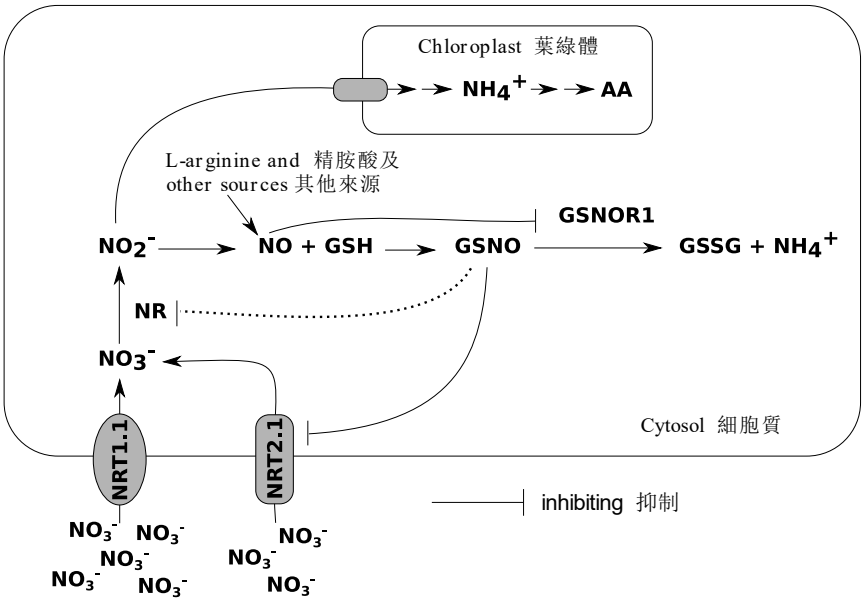


Figure Q.65 A schematic model for the control of nitrogen assimilation in plants through NO signalling
圖Q.65 植物中，經由一氧化氮的訊息傳遞，氮的同化作用之控制示意模式圖。

Indicate in the **Answer sheet** if each of the following statements is True or False.
在答案紙上，註明下列敘述正確或錯誤

A. In the nitrogen metabolism process of the plant cells, NO is one of the products but plays a role signaling regulation of NH_4^+ formation and NO_3^- assimilation.
植物細胞的氮代謝作用過程中，一氧化氮是其中的一種產物，但在調節銨鹽形成與硝酸鹽同化作用中扮演訊息傳遞之角色。

B. NH_4^+ level in chloroplasts of plant cells is controlled by activity of GSNO.
植物細胞裡，葉綠體中的銨鹽含量受到GSNO活性的控制

C. Reduction of NO_2^- ions mainly occur in cytosol
亞硝酸鹽的還原主要發生在細胞質中

D. NO feedback regulates flux through nitrate assimilation pathway and controls its bioavailability by modulating its own metabolism.
一氧化氮會經由硝酸鹽同化作用途徑來反饋調節其通量，並藉由調節其本身的代謝來控制它的生物可用性

Q.66

A study on the effects of lead (Pb), a toxic heavy metal, on growth and photosynthesis of two microalgae, Chlorella and *Scenedesmus* was conducted. The figure on the left below shows the growth of these strains responded differently to lead concentration after 4 day treatment. From growth rate (Ke), generation time (G) of each strain at each concentration of lead can be calculated as equation: G= (ln2)/*Ke.* The right hand Figur **e Q.66** is result of the effect of lead on photosynthesis of these strains, indicated by Fv/Fm, a sensitive parameter that decreases when photosynthesis is impaired. The concentration of lead that gives half-maximal response, the IC_{50}, can be estimated based on response versus lead concentration plots.
研究有毒重金屬 鉛(Pb)對兩種微藻(Chlor*ella* and Scenedesmus)的生長和光合作用的影響，左下圖Q.66 顯示，在四天處理之後，兩種藻系的生長情形顯示其對鉛濃度的反應不同。各藻系在不同鉛濃度下的生長速率(Ke)、世代時間(G)，可用以下公式計算而得: G=(ln2)/Ke. 右下圖Q.66 是鉛對此兩種藻系之光合作用的影響，以Fv/Fm 表示；Fv/Fm是個敏感的變數，當光合作用受損時，Fv/Fm的比值即會下降。IC_{50}表示導致最大反應時的50%的鉛濃度，此可根據反應對照鉛濃度曲線圖來估算。

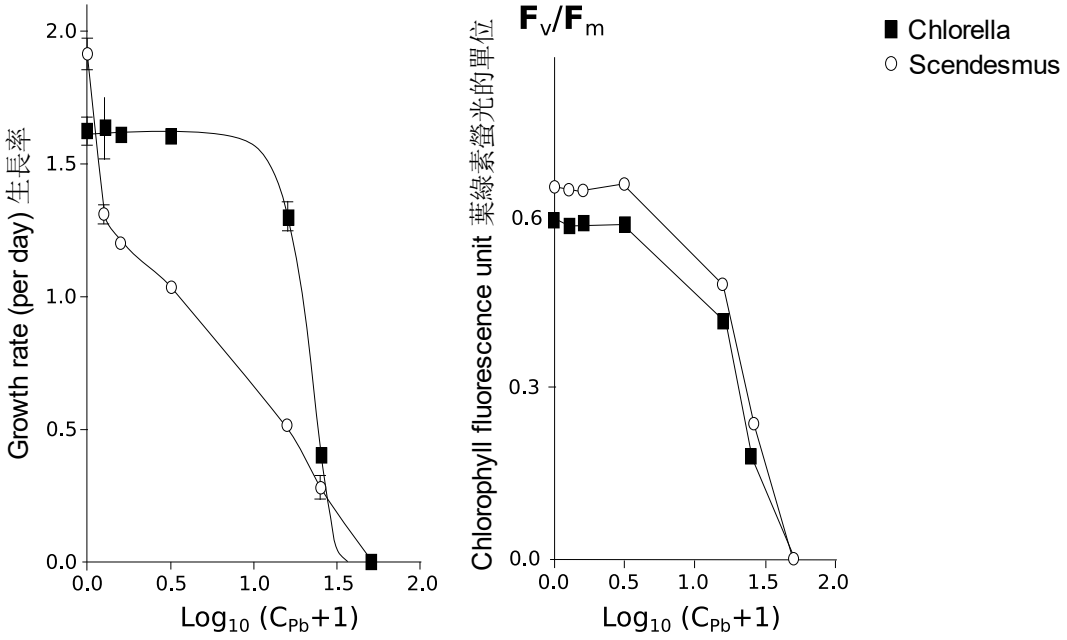


Figure Q.66

Indicate in the **Answer sheet** if each of the following statements is True or False.
在答案紙上，註明下列敘述正確或錯誤

A. Estimated IC_{50} of growth for the Scenedesmus was higher than that for the Chlorella.
Scenedesmus 生長的 IC_{50} 比Chlor*ella* 者高

B. Photosynthetic impairment by Pb was likely responsible for the growth decrease in the Chlorella but this was not the scenario in the Scenedesmus
鉛造成的光合作用損害可能是造成在Chlor*ella* 生長下降的原因，但在*Scenedesmus* 則不是此情形

C. The estimated IC_{50} for effects on F_V/F_m was higher than that for growth in Scenedesmus
在*Scenedesmus* 中，影響其F_V/F_m 螢光變化指數的 IC_{50} 濃度比影響其生長的 IC_{50} 濃度高

D. At lead concentration that $Log_{10}([Pb]+1)$ is 0.5, the Scenedesmus reproduced faster than the Chlor*ella* did.
當鉛濃度的$Log_{10}([Pb]+1)$ 為 0.5 時，Scenedesmus 的生殖速率較Chlor*ella* 快

Q.67

Scientists constructed gibberellic acid (GA)-deficient and GA-insensitive transgenic lines of poplar plants. They measured concentration of phytohormones, including GA1 and GA4 and IAA, in the leaves and roots of transgenic and wildtype plants (T**able Q.67**). They also measured the growth of plants in greenhouse and in vitro conditions (Figur **e Q.67**).
科學家構築吉貝素缺失與吉貝素不敏感的白楊樹轉殖基因植株，他們在轉殖株與野生型植株的葉片及根部測量三種植物激素濃度，(包括GA1、GA4 及 IAA)，結果如表 Q.67。他們也測量種植在溫室及試管中的植株之生長情形，如圖 Q.67所示。

Table Q.67 Phytohormone concentrations (ng/g dry weight) in leaves and roots of the wild type and the two transgenic types
表 Q.67. 轉基因與野生型植株的葉片及根部之植物激素濃度 (ng/g dry weight)

Organ	**Plant types**	GA1	GA4	IAA
Leaf	Wild-type	58.1 ± 15.4	6.64 ± 3.18	22.5 ± 3.1
Leaf	GA-deficient 缺失	19.9 ± 9.4**	5.53 ± 2.33*	21.1 ± 5.9
Leaf	GA-insensitive 不敏感	139.6 ± 21.9**	12.2 ± 3.6**	19.6 ± 3.7
Root	Wild-type	77.1 ± 29.3	2.24 ± 0.74	61.4 ± 4.1
Root	GA-deficient	48.8 ± 9.6**	1.15 ± 0.62**	72.9 ± 5.2*
Root	GA-insensitive	97.7 ± 31.5**	3.93 ± 0.68**	69.1 ± 9.7*

* and ** indicate significant differences compared to wild-type at 0.05 and 0.01 levels by Student T-test.
* 及 ** 表示: 經統計檢定，與野生型相較，其進行T-test的數值為0.05 及 0.01。

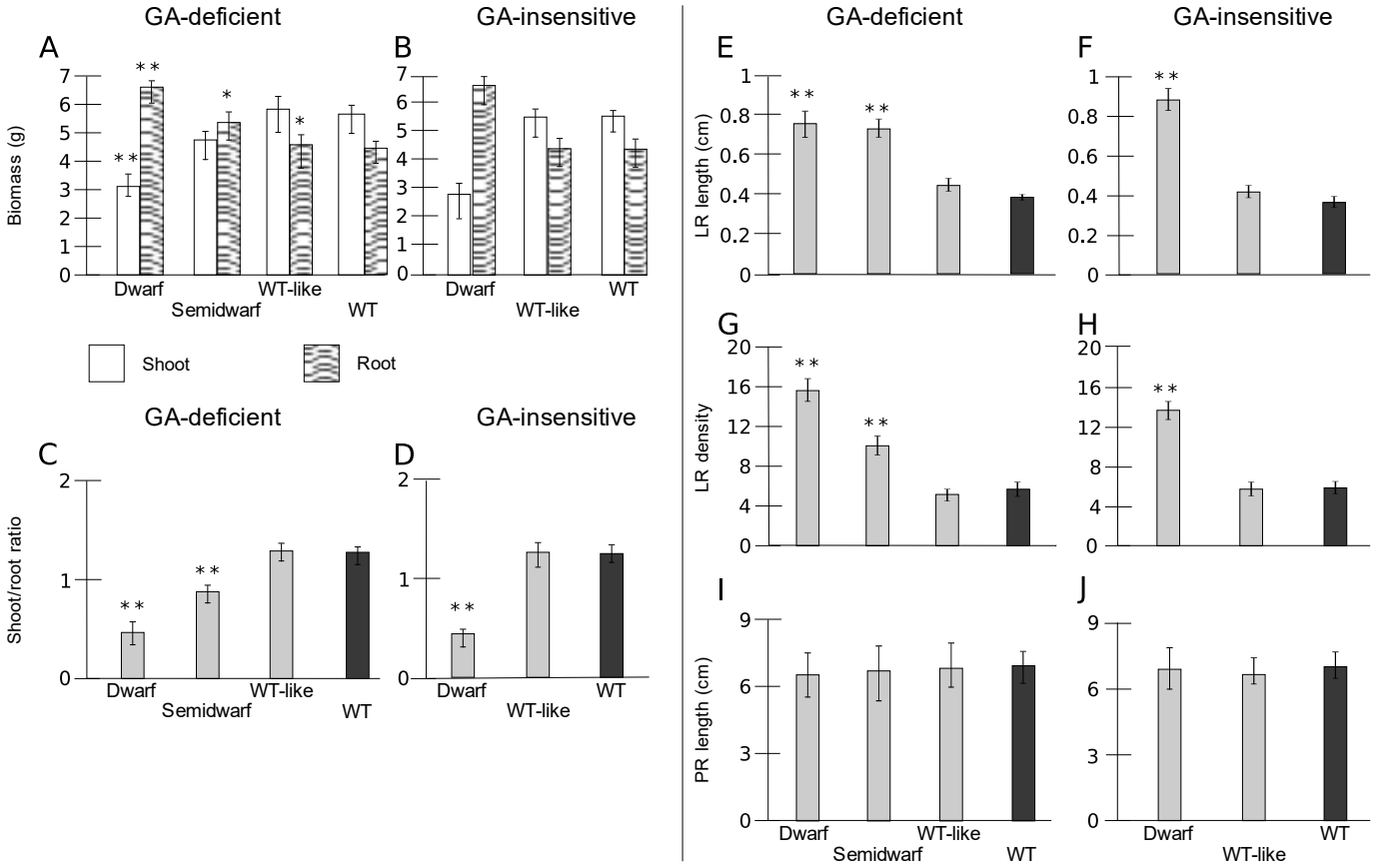


Fig.Q.67 A-D: Root and shoot biomass under greenhouse conditions. Top panel shows the fresh biomass of shoots and roots in GA-deficient (A) and GA-insensitive (B) transgenics. Bottom is the shoot/root ratio in GA-deficient (C) and GA-insensitive (D) transgenics. * and ** indicate significant differences.
圖Q.67 A-D: 在溫室種植的根及莖之生物量。上半部顯示在GA-缺失(A)與GA-不敏感(B)轉殖植株的莖與根之鮮重。下半部則為GA-缺失(C)與GA-不敏感(D)轉殖植株莖/根的比值，* 及 ** 表示具顯著性差異。

E-J: Root development in GA-deficient and GA-insensitive transgenic lines grown in vitro. LR - Lateral root; PR - Primary root. * and ** indicate significant differences compared to wild-type plants (WT).
E-J: GA-缺失(A)與GA-不敏感(B)轉基因植株在試管中培養的根部發育。LR - 側根； PR - 主根。* 及 ** 表示與野生型(WT)植株相較具顯著性差異。

Indicate in the **Answer sheet** if each of the following statements is True or False.
在答案紙上，註明下列敘述正確或錯誤

A. Greenhouse-grown dwarf plants of both transgenic types display a significant reduction in aerial biomass and an increase in belowground biomass, leading to a significant reduction in the shoot-to-root ratio relative to the wild-type control.
溫室栽種的兩種轉殖矮種植株表現出地上部生物量明顯下降，和地下部生物量增加的情形，導致莖/根比值 比野生型對照組有明顯之下降

B. The most severely dwarfed plants have more, as well as longer, lateral roots than the wild-type control.
相較於野生型對照組，最嚴重的矮種植株有較多且較長的支根

C. The degree of dwarfism in both GA-insensitive and GA-deficient lines is positively correlated with the extent of primary and lateral root formation and elongation.
在GA-不敏感與GA-缺失植株系中，其矮化程度 與 其主根及支根形成及延長的程度呈現正相關

D. In poplar plants, gibberellins negatively affect lateral root formation, and there may be an interaction between gibberellins and auxin that regulates lateral root formation.
在白楊樹中，吉貝素對支根的形成有負面影響，且吉貝素與植物生長素間的交互作用可調節支根的形成

Q.68

Scientists grew cucumber plants in different nutrient conditions to obtain either super ovary or normal ovary types. They labelled flowers when they emerged and observed the development of flowers. Based on the color and shape, corolla development was divided into four consecutive stages: green bud (G), green-yellow bud (GY), yellow bud (Y), and flowering (F). They also measured plant growth regulator concentrations in different flower developmental stages.
科學家將黃瓜種植在不同營養條件下，以獲得上位子房或正常的子房型態。當開花時，即將花作標記，根據花色及形狀、花冠發育而將之分成四個連續階段: 綠色花芽(G)、黃綠色花芽(GY)、黃色花芽(Y)及開花(F)。他們還測量在花發育的不同階段下的植物生長調節因子的濃度。

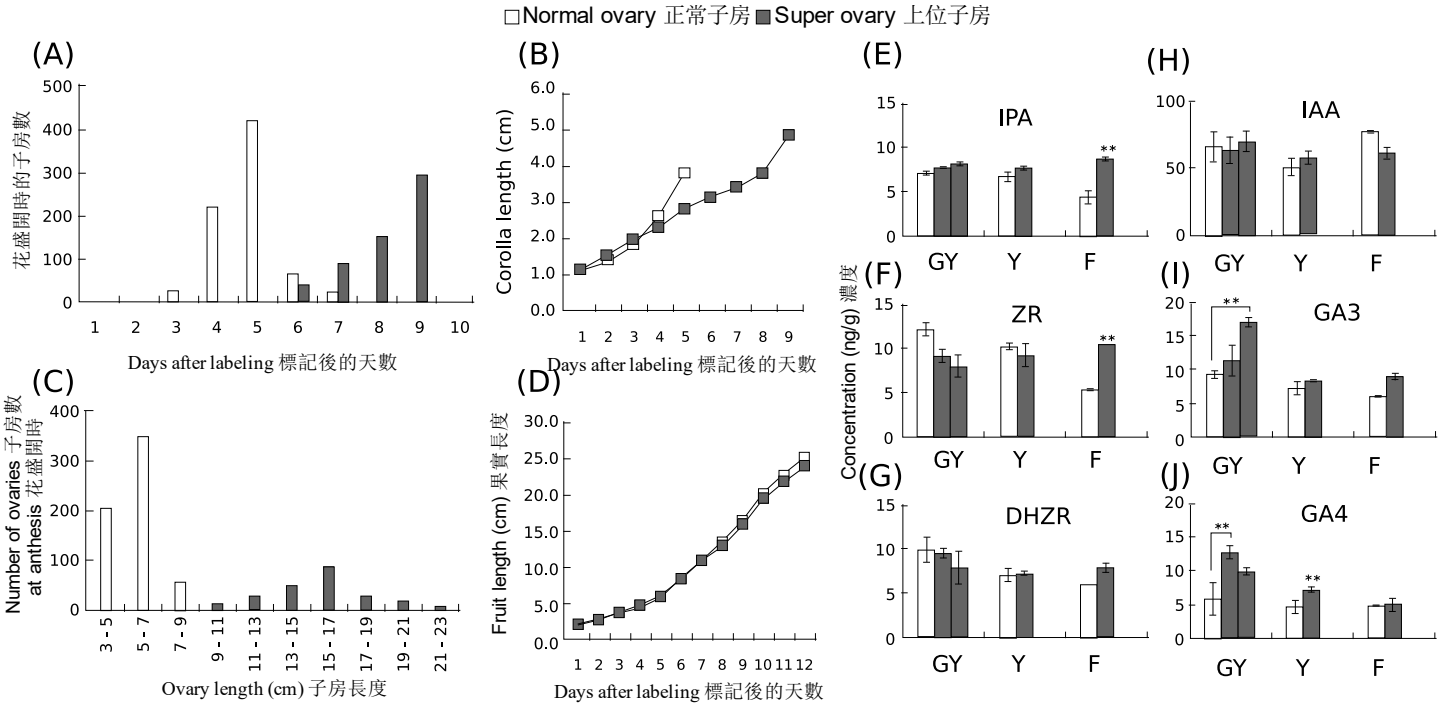


Fig.Q.68 A-D: Morphological characterization of the normal ovary and super ovary types. E-J: Concentration of cytokinins (IPA, ZR, DHZR), gibberellins (GA3, GA4) and auxin (IAA) in different flower developmental stages. In super ovary type, two sub-stages were included. ** indicates statistically significant differences within one developmental stage.
圖Q.68 A-D: 正常子房與上位子房的形態特徵。E-J: 花發育之不同階段下的細胞分裂素(IPA, ZR, DHZR), 吉貝素 (GA3, GA4) 及植物生長素 (IAA) 之濃度。在上位子房類型中，另包含兩個次階段。**表示在同一發育階段中有顯著性差異。

Indicate in the **Answer sheet** if each of the following statements is True or False.
在答案紙上，註明下列敘述正確或錯誤

A. The corolla progression between stages was much delayed in the super ovary
在上位子房的花中，在發育階段間花冠的伸長情形出現明顯延遲

B. The ovary at anthesis was on average much longer in the super ovary than the normal ovary, while at the same time courses after labelling, fruit length was not different between two types.
花盛開時，平均而言，上位子房類型的子房較正常者長；而同時標記後的生長狀況，兩類型的果實長度則沒有差異

C. Gibberellins were increased in the super ovary during the early stages of corolla development, which corresponds to the enlarged corolla size.
在上位子房類型中，花冠發育初期的吉貝素上升，此與花冠增大的情形相對應

D. Cytokinins appear to be the primary regulator for the time of flower opening in cucumber, whereas auxin is probably involved in the size control of corolla and fruit.
黃瓜開花時，細胞分裂素是主要調節因子，然而植物生長素可能有參與控制花冠及果實的大小

ANIMAL ANATOMY AND PHYSIOLOGY
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Q.69

Figur **e Q.69** shows the regulation of HCl secretion in the parietal cell of the stomach.
Figure Q.69顯示胃部壁細胞分泌HCl的調節

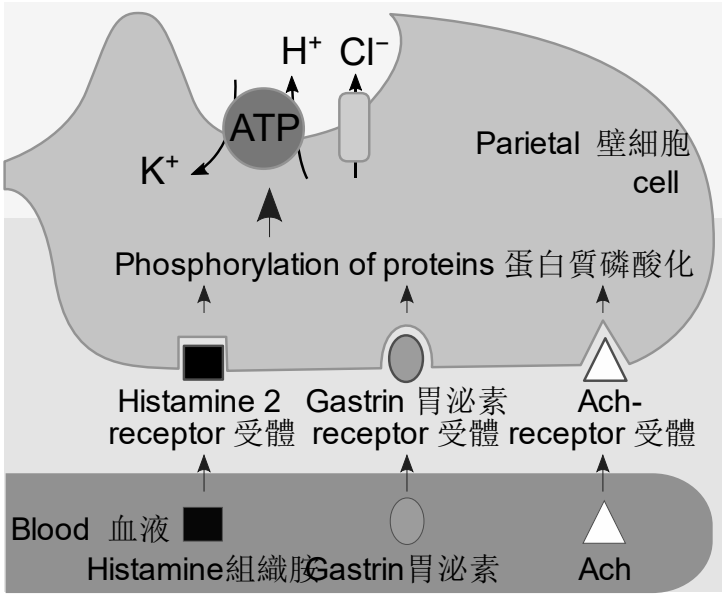


Figure Q.69

Drugs 1,2,3和4 inhibit gastric acid secretion differently *in vivo* via one of the four pathways: inactivating the H^+/K^+ATPase, blocking the Histamine 2 receptor, blocking Gastrin receptor, and blocking Acetylcholine (Ach) receptor.
藥品1、2、3和 4各自通過以下四個不同途徑之一在體內抑制胃酸的分泌：H+/K+ATPase酶的去活化、組織胺 2 受體(Histamine 2 receptor)的阻斷、胃泌素受體的阻斷、乙醯膽鹼 (Ach) 受體的阻斷。
A set of experiments were conducted to determine in which pathway these drugs inhibit gastric acid secretion. Parietal cells were isolated and cultured in different media. Each medium contained one of the four drugs. Each drug-containing medium was added with one of three compounds (Histamine, Gastrin, Ach). The HCl secretion of parietal cells in the cultures was determined. The following table shows the results of the experiments.
進行一組實驗以確定這些藥物抑制胃酸分泌的途徑。分離胃壁細胞並培養在不同培養基中，每個培養基包含四種藥品之一，每種含藥品的培養基中會再附加三種化合物 （組織胺、 胃泌素、乙醯膽鹼） 之一。測定培養之壁細胞的HCl分泌。下表顯示實驗結果。

(–: No HCl secretion; +: HCl secretion; ?: not shown).
(–: 無 HCl 分泌; +: 有HCl 分泌; ?: 未顯示).

	No drug	Drug 1	Drug 2	Drug 3	Drug 4
No addition 不加	–	–	–	–	–
Histamine added 加組織胺	?	?	?	?	–
Gastrin added 加胃泌素	?	?	?	+	?
Ach added 加乙醯膽鹼	+	–	?	?	–

Indicate in the Answer sheet if each of the following statements is True or False.
在答案卷上回答下列各敘述是 正確 或 錯誤

A. HCl was secreted by the parietal cells cultured in the medium containing Drug 1 and Histamine.
HCl可由含藥物 1 和組織胺之培養基培養的壁細胞分泌

B. Drug 2 blocked Gastrin receptors.
藥物 2 阻斷胃泌素受體

C. Drug 3 blocked Histamine 2 receptors.
藥物 3 阻斷組織胺 2 受體

D. The parietal cells cultured in the medium containing Drug 4 and Ach had lower levels of intracellular K^+ than the cells cultured in the medium containing only Ach.
比較細胞內K^+的濃度，含藥物 4 與乙醯膽鹼之培養基培養的壁細胞較僅含乙醯膽鹼培養基培養者為低

Q.70

The glycoprotein 4-1BB is a receptor that is highly expressed on the surface of active T-cells. The 4-1BB ligand (4-1BBL) is a molecule that binds to and activates 4-1BB. It is found strongly expressed on antigen-presenting cells. Bidirectional signals of 4-1BB and 4-1BBL interaction increase the activity of white blood cells and increase the production and secretion of cytokines, such as MCP-1 which promotes the infiltration of leukocytes (Figur **e Q.70**). Currently, many studies have shown a relationship between the signaling pathways via 4-1BB/4-1BBL interaction and several human diseases, including those related to metabolism.
醣蛋白4-1BB是在活化的T細胞表面高度表現的受體，4-1BB配體(4-1BBL)則為能結合並活化4-1BB的分子，特別在抗原呈現細胞表面高度表現。當4-1BB和4-1BBL交互作用時的雙向訊息能刺激白血球活性，並增加細胞激素(如MCP-1)的產生和分泌，MCP-1是促進白血球浸潤的因子(圖Q.70)。目前，有研究顯示4-1BB/4-1BBL交互作用的訊息通路與人類的許多疾病具有關聯性，其中包括一些代謝相關疾病。

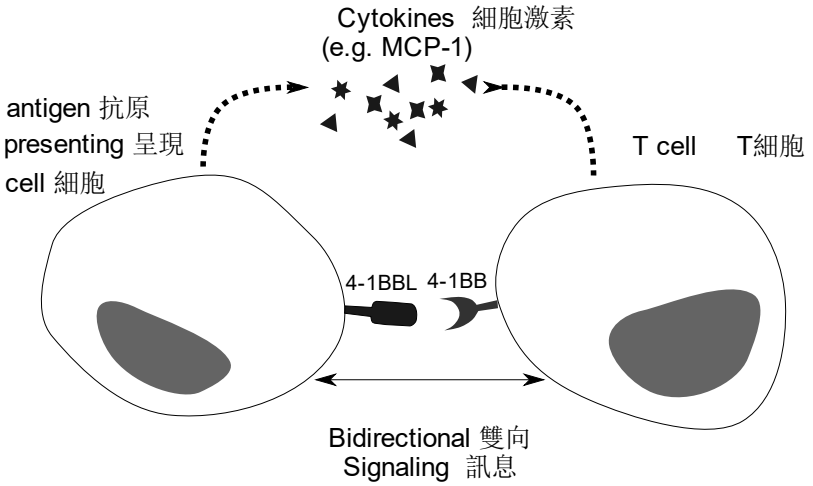


Figure Q.70

Indicate in the Answer sheet if each of the following statements is True or False.
在答案卷上回答下列各敘述是 正確 或 錯誤

A. Inhibition of 4-1BB expression diminishes the development of atherosclerosis.
抑制4-1BB的表現可減少動脈粥狀硬化的發生

B. Activation of 4-1BB limits the effect of autoimmune diseases on the body.
4-1BB的活化能限制自體免疫疾病對身體的影響

C. All three kinds of cells, macrophages, dendritic cells and natural killer cells strongly express 4-1BBL.
巨噬細胞、樹突細胞及自然殺手細胞上均有4-1BBL的大量表現

D. Blocking the 4-1BB and 4-1BBL interaction increases graft tolerance.
阻斷4-1BB和4-1BBL的相互作用可以增加對移植物的耐受性

Q.71

The action potential of cardiac muscle cells differs from that of other cells such as skeletal muscle cells and neurons. Figur **e Q.71** displays the different phases of action potential in cardiac muscle cells.
心肌細胞動作電位與骨骼肌細胞、神經元等其他細胞不同。圖Q.71顯示心肌細胞動作電位的不同階段。

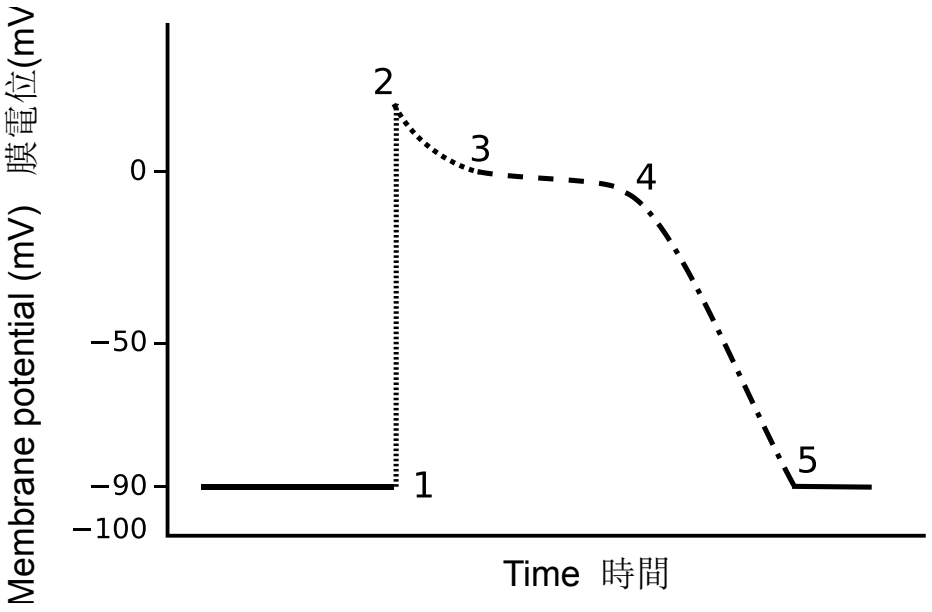


Figure Q.71

Indicate in the Answer sheet if each of the following statements is True or False.
在答案卷上回答下列各敘述是 正確 或 錯誤

A. A substance that inhibits the reuptake of Ca^{2+} into the sarcoplasmic reticulum increases the time interval from 3 to 4.
抑制肌漿網再攝入Ca^{2+}的物質，可增加時間點3到4的時間間隔

B. The concentration of K^+ in the sarcoplasm at position 2 is higher than that at position 3.
在位置2處肌漿網中K^+的濃度較位置3處為高

C. Injection of adrenaline decreases the time interval from 1 to 5.
注射腎上腺素可使從1到5的時間間隔減少

D. The height of action potential (from 1 to 2) is decreased when the sarcoplasmic level of Na^+ is higher than the normal level.
當肌漿網中的Na^+高過正常濃度時，動作電位(從1到2)的高度會降低

Q.72

Parathyroid hormone (PTH) plays an important role in the regulation of plasma calcium and phosphate levels. Figure Q.72 shows the changes in levels of PTH, Ca^{2+}, and phosphate (Pi) in plasma of mice injected with a specific inhibitor of PTH secretion.
副甲狀腺素(PTH)對血漿中鈣與磷酸根的調節非常重要。圖Q.72顯示小鼠注射一種副甲狀腺素分泌的專一性抑制物後，血漿中PTH、Ca^{2+}和磷酸根(Pi)的變化。

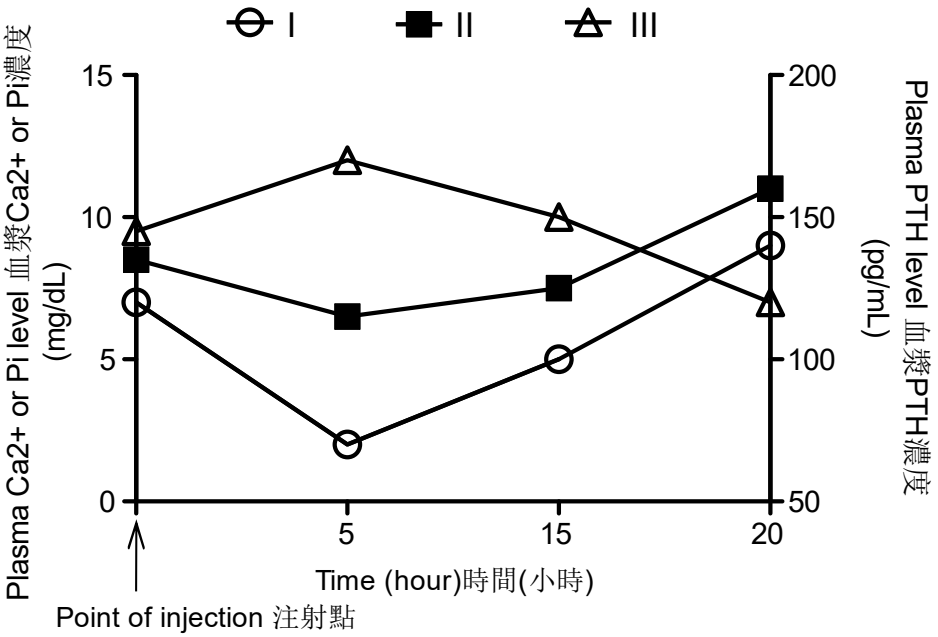


Figure Q.72

Indicate in the Answer sheet if each of the following statements is True or False.
在答案卷上回答下列各敘述是 正確 或 錯誤

A. If Line I shows the level of PTH, then Line II and Line III would likely be showing the levels of Pi and Ca^{2+}, respectively.
如果Line I 表示PTH的濃度、則Line II和Line III分別代表Pi和Ca^{2+}的濃度

B. PTH knock-out mice would have higher Pi levels in their urine compared with the wild type mice on the same diet.
與餵食相同食物的野生型小鼠相比，PTH基因踢除的小鼠在尿液中Pi的濃度較高

C. Eating a calcium-rich diet decreases the plasma level of vitamin D (active form) in healthy people.
吃富含鈣的飲食會降低健康人血漿中維生素D(活化型)的濃度

D. People with calcium-sensing receptor suppression have higher levels of plasma Ca^{2+} compared with healthy people on the same diet.
與有同樣飲食的健康人相比，鈣離子敏感受體被抑制者，其血漿中Ca^{2+}的濃度較高

Q.73

The following table describes the rate of blood flow to different parts of the body including brain, skin, intestines, and cardiac muscle at rest and during strenuous exercise.
下表描述身體不同部位包括腦、皮膚、腸與心肌在休息與劇烈運動期間的血流速率。

Part of the body身體部位	Rate of blood flow 血流速率/cm3/min	
	At rest 休息時	During exercise 運動時
I	250	1200
II	500	500
III	500	1000
IV	2500	90

Indicate in the Answer sheet if each of the following statements is True or False.
在答案卷上回答下列各敘述是 正確 或 錯誤

A. At rest, ATP of the cells of part I comes mainly from oxidation of fatty acid.
在休息時，部位 I 處細胞的ATP主要來自脂肪酸氧化。

B. The activity of insulin receptors in the cells of part II is increased during exercise, enhancing glucose uptake.
在運動時，部位 II 處細胞的胰島素受體的活性增加，可以提高葡萄糖的攝取

C. The increase in blood flow to part III during exercise helps to regulate the body temperature.
在運動時，部位 III 的血流量增加有助於調節體溫

D. Epinephrine decreases blood flow to part IV via β-receptor.
腎上腺素藉由β-受體降低部位IV的血流量

Q.74

A man had lost approximately 700 mL of blood in a severe injury of a major artery in a motorcycle accident. At the time of accident, his blood pressure was 90/50 mmHg. Several physiological changes should be expected in response to hemorrhage.
某人在機車事故中受傷，傷及主要動脈並失去約700毫升血液，在事故發生時，他的血壓是90/50毫米汞柱。幾項生理變化將被用來反應這樣的出血意外。

Indicate in the Answer sheet if each of the following statements is True or False.
在答案卷上回答下列各敘述是 正確 或 錯誤

A. Oxygen affinity of hemoglobin in peripheral tissues was increased .
周邊組織中的血紅素與氧親和力增高

B. Total peripheral resistance was increased.
總周邊阻力增高

C. Hyperpolarization occurred in the cells of the sinoatrial node.
過極化反應發生於竇房結的細胞

D. Vasoconstriction occurred in the brain and in the coronary arteries.
血管收縮發生於大腦和冠狀動脈

Q.75

In a simple way, respiratory disorders can be classified as obstructive or restrictive disorders. Obstructive disorders are characterized by a reduction in the airflow rate in the respiratory tracts. Restrictive disorders are characterized by a reduction of lung volume.
呼吸系統疾病可用一簡單方法來區分為阻塞性或限制性障礙。阻塞性疾病特點是呼吸道氣流速度減少，限制性疾病特點是肺容積減少。
Figur **e Q.75** shows the shapes of the flow-volume loops measured during forced inspiration and forced expiration in healthy people with normal respiratory function and in four patients suffering from four common types of respiratory disorders.
圖Q.75顯示在正常健康人和患有四種常見類型呼吸系統疾病的四個病人身上，強迫吸氣和強迫呼氣時氣流容積環(flow-volume loops)的測定形狀。

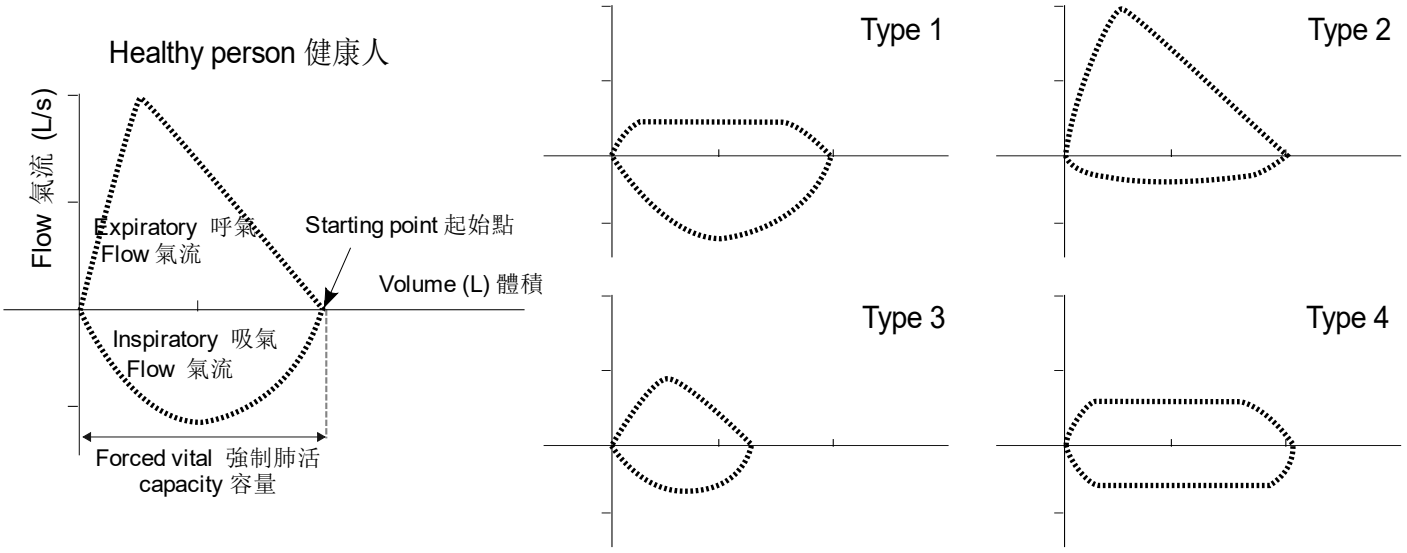


Figure Q.75

Indicate in the Answer sheet if each of the following statements is True or False.
在答案卷上回答下列各敘述是 正確 或 錯誤

A. The blood pH of a patient with Type 1 is higher than that of healthy people.
類型1患者血液pH值高於健康人

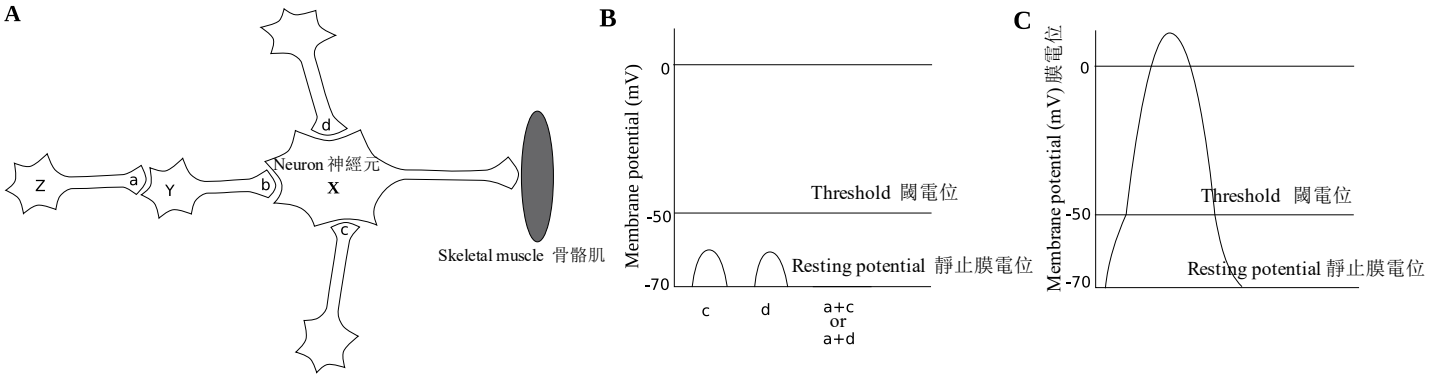
B. The time of the forced inhalation of patient with Type 2 is shorter than that of healthy people.
類型2患者強迫吸氣的時間比健康人短

C. A patient with Type 3 displays a higher breathing rate than healthy people.
類型3患者呼吸頻率高於健康人

D. Residual volume in a patient with Type 4 is higher than that of healthy people.
類型4患者的肺餘容積高於健康人

Q.76

Figur **e Q.76A** shows neuron X receives signals directly from three separate nerve terminals b, c and d. Neuron Y receives signals from nerve terminal a.
圖Q.76A顯示神經元X直接從b、c、d三個不同神經末梢接收信號，神經元Y從神經末梢a接收信號
Figur **e Q.76B** shows the various postsynaptic potentials recorded in neuron X after receiving input signals directly from terminals b, c, and *d* and indirectly from terminal a.
圖Q.76B顯示神經元X直接從末梢 b、c、d接收輸入信號後，記錄到的不同突觸後電位
Figur **e Q.76C** shows the action potential recorded in neuron Y after receiving input signals from the presynaptic terminal a.
圖Q.76C為神經元Y從末梢 a 接收輸入信號後所顯示的動作電位記錄



Figures Q.76A, B, and C

Indicate in the Answer sheet if each of the following statements is True or False.
在答案卷上回答下列各敘述是 正確 或 錯誤

A. Action potentials could be generated in neuron X if nerve terminal c is stimulated rapidly.
如果快速地刺激神經末梢 c，神經元 X 可能產生動作電位

B. When three nerve terminals a, c and d are stimulated simultaneously, the postsynaptic potentials recorded in neuron X are smaller than those when the nerve terminals c and d are stimulated simultaneously.
同時刺激a、c、d三個神經末梢時，在神經元X記錄到的突觸後電位會比同時刺激c、d二末梢時為小

C. Nerve terminal a releases inhibitory neurotransmitter and nerve terminal b releases excitatory neurotransmitter.
神經末梢 a 釋出抑制性神經傳遞物質，神經末梢 b 釋出興奮性神經傳遞物質

D. In the mammalian body, there are many neurons like neurons Z, Y, X. Neurons Z, Y, X are sensory neurons, Renshaw cells (inhibitory neurons) and motor neurons, respectively. If a substance (e.g., Strychnine) injected in the body blocks glycine receptors, diaphragm contracts fully and remains contracted.
哺乳動物體內有許多不同的神經元如Z、Y、X，神經元 Z、Y、X分別是感覺神經元、Renshaw細胞（抑制神經元）、運動神經元。若一種物質(如馬錢子鹼)注入體內時能阻斷甘氨酸受體，橫膈膜會完全收縮且保持收縮狀態

Q.77

A set of experiments on the regulation of hormone secretion and effects of various drugs on the activities of endocrine glands were conducted on rats. Rats were divided to different groups and each group was injected with a hormone or a drug. Some physiological parameters were collected and analysed.
使用大鼠進行一系列實驗，以了解激素分泌的調節及不同藥物對內分泌腺活性的影響。大鼠被分為不同群組，每組被注射一種激素或一種藥物後，收集一些生理參數並作分析。

Indicate in the Answer sheet if each of the following statements is True or False.
在答案卷上回答下列各敘述是 正確 或 錯誤

A. The group of rats injected with the drug that reduces the sensitivity of hypothalamus to cortisol resulted in higher plasma levels of both glucose and insulin than those in the group of rats injected with the drug that reduces the sensitivity of adrenocorticotropic hormone (ACTH) receptors.
比起注射降低對促腎上腺皮質激素(ACTH)受體敏感藥物的大鼠組，注射了降低下視丘對皮質醇敏感度藥物的大鼠，其血漿中的葡萄糖及胰島素濃度均較高。

B. The group of rats injected with the drug that increases the sensitivity of hypothalamus to thyroxine resulted in higher metabolic rate and body temperature than those in the group of rats injected with the drug that increases the sensitivity of target cells to thyrotropin-releasing hormone (TRH).
比起注射增加甲狀腺釋放素(TRH)目標細胞敏感藥物的大鼠組，大鼠注射了增加下視丘對甲狀腺素敏感的藥物會有較高的代謝率和體溫

C. The group of rats injected with propylthiouracil (which blocks thyroid hormone synthesis) resulted in smaller thyroid gland and body weight than those in the group of rats injected with placebo.
與注射安慰劑的大鼠組相比，注射丙硫尿嘧啶(能阻斷甲狀腺素的合成)的大鼠組之甲狀腺較小、體重較輕。

D. The group of rats injected with thyroid stimulating hormone (TSH) had smaller pituitary gland and bigger adrenal glands compared with the group of rats injected with corticotrophin-releasing hormone (CRH).
比起注射促腎上腺皮質素釋放激素(CRH)的大鼠組，注射甲狀腺刺激素(TSH)的大鼠組有較小的腦垂腺和較大的腎上腺

Q.78

Some researchers studied the changes in the level of saliva cortisol and 2-AG (2-arachidonoylglycerol) concentration in blood in two groups of people with motion sickness and without motion sickness (no sickness) during parabolic flight maneuvers (PFs). During PFs, the saliva cortisol levels and 2-AG blood concentrations were measured from samples taken in-flight before start of the parabolic maneuvers (T0), after 10 parabolas (T1), 20 parabolas (T2), and 30 parabolas (T3), termination of PFs (T4) and 24 h later (T5). The results are shown in Figur **e Q.78**.
研究人員將會暈車(含飛機及船)與不會暈車(沒有疾病)的兩組人，他們經拋物線飛行(PFs)後，唾液皮質醇及血液2-AG (2-arachidonoylglycerol)在濃度上的變化。唾液皮質醇與血液2-AG濃度待測樣本的採集時間如下，拋物線飛行開始前(T0)、10次拋物線飛行後(T1)、20次拋物線飛行後(T2)、30次拋物線飛行後(T3)、拋物線飛行終止時(T4)、24 小時後(T5)。結果如圖Q.78 所示。

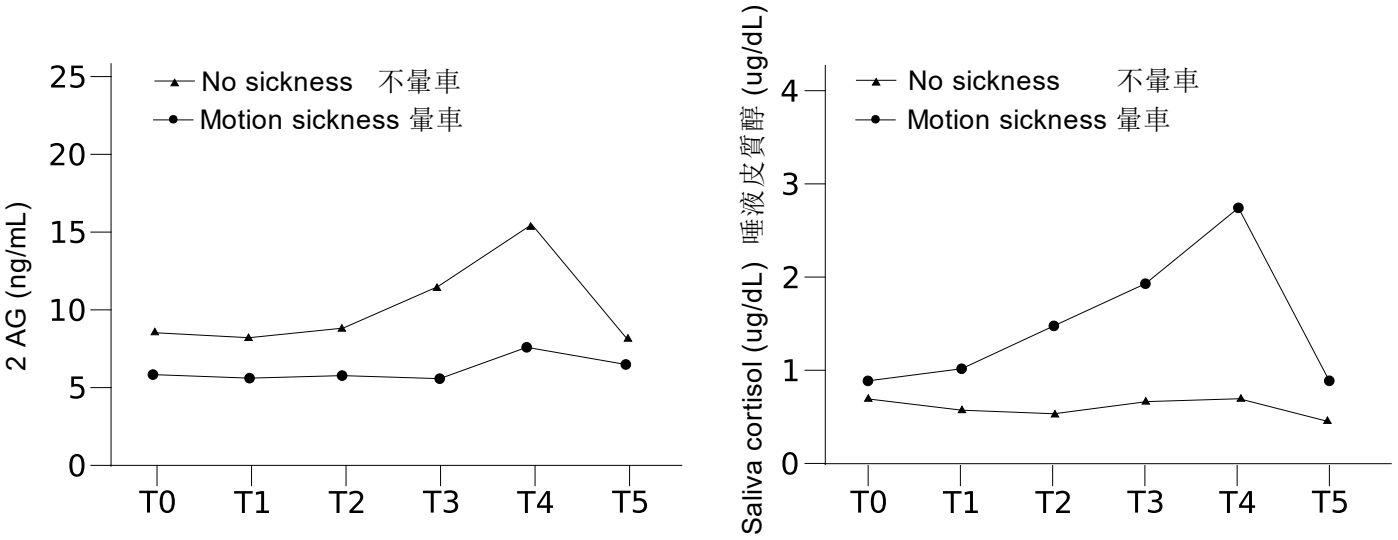


Figure Q.78

Indicate in the Answer sheet if each of the following statements is True or False.
在答案卷上回答下列各敘述是 正確 或 錯誤

A. A 2-AG inhibitor can be used to reduce motion sickness.
2-AG抑制劑可以用於減少暈車

B. In motion sickness group, the blood glucose level at T4 was higher than at T1.
暈車組的人在T4時的血糖濃度高於在T1時

C. At T2, the blood ACTH (adrenocorticotropic hormone) level in the no sickness group was higher than that in the motion sickness group.
在T2時，不暈車組的血液中ACTH(促腎上腺皮質素)濃度明顯高於暈車組的

D. In motion sickness group, the blood CRH (corticotropin-releasing hormone) level at T5 was lower than that at T2.
在T5時，暈車組血液中CRH(促腎上腺皮質素釋放激素)的濃度低於在T2時

Q.79

When a person born and brought-up at sea level and then moves to a village at an altitude of 3000 metres above sea level by helicopter, some adaptations of their body occur to compensate for the decreased oxygen pressure at high altitude.
一個人在海平面高度出生、長大，後來搭直升機移到海拔3000公尺以上的村莊，身體要發生一些適應以彌補在此高度減少的氧分壓。

Indicate in the Answer sheet if each of the following statements is True or False.
在答案卷上回答下列各敘述是 正確 或 錯誤

A. The moment the person arrives at the high altitude, oxyhemoglobin dissociation curve shifts to the left (indicating greater affinity of hemoglobin for oxygen).
在他到達高海拔地區的時候，氧合血紅素的解離曲線向左側移(表示血紅素對氧有更大的親和力)

B. After several days living at the high altitude, the person's blood viscosity is decreased, enabling his blood to deliver more oxygen to his tissues.
經過幾天在高海拔區的生活，他血液的粘度降低，使他的血液能對組織提供更多的氧。

C. After several weeks living at the high altitude, the person's lung cells of this person produce more nitric oxide (NO).
在高海拔地區生活幾星期後，他的肺細胞產生更多一氧化氮(NO)

D. Many people who ascend rapidly to high altitude experience some degree of acute mountain sickness (e.g., headache, malaise, and nausea). Which may be treated with a drug that causes bicarbonate to be excreted in the urine.
很多人若快速升到高空，會經歷某種程度的急性高山症(如頭痛、不適、噁心)，這可以用能讓碳酸氫鹽經尿液排泄的藥物治療。

Q.80

Figur **e Q.80** demonstrates the relationship between oxygen concentration and oxygen partial pressure (Po_2) in blood of two species of vertebrates (species a and b). Each sample was subjected to two levels of carbon dioxide pressure (Pco_2): curve I represents the values measured at normal Pco_2 and curve II represents the values measured at elevated Pco_2. The blood having passed through the lungs of the two species normally has a Po_2 of 100 mm Hg and the deoxygenated blood leaving the tissues has a Po_2 of 40 mm Hg.
圖Q.80顯示兩種脊椎動物(物種a和b)血液中氧的濃度和氧分壓(Po_2)之間的關係。每個樣本承受到兩層次的二氧化碳分壓(Pco_2)：曲線I代表正常Pco_2測得的數值、曲線II代表提高Pco_2時測得的數值。這兩物種通過肺的充氧血液中Po_2通常為100毫米汞柱，離開組織的缺氧血Po_2為40 毫米汞柱。

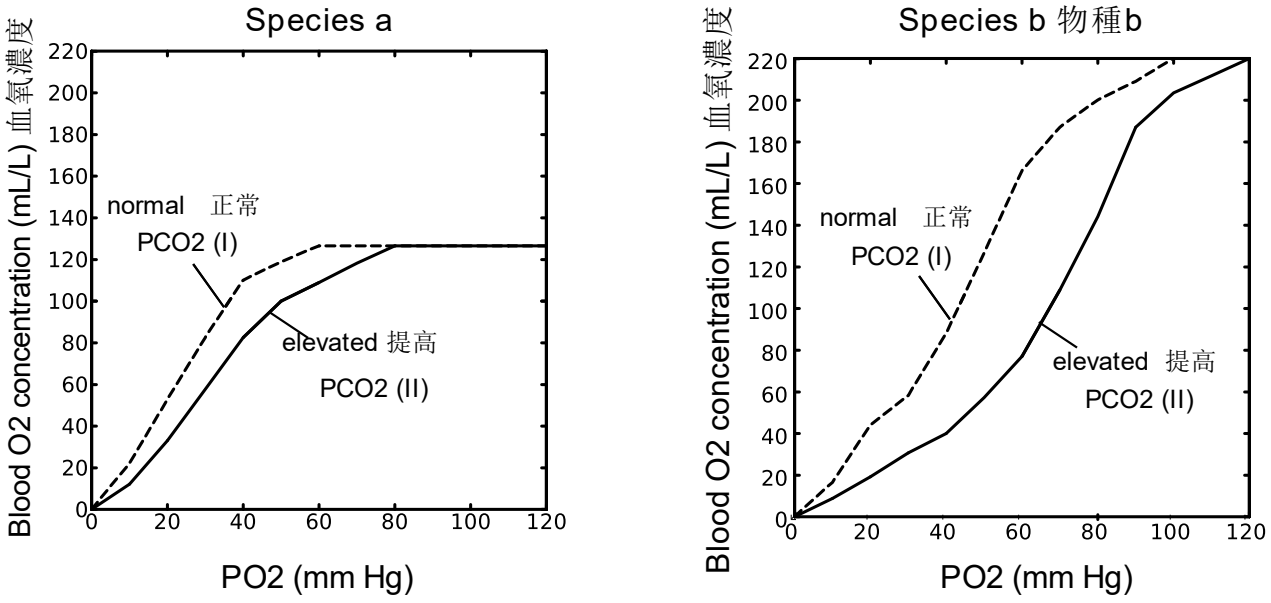


Figure Q.80

Indicate in the Answer sheet if each of the following statements is True or False.
在答案卷上回答下列各敘述是 正確 或 錯誤

A. While comparing curve I of species a with curve I of species b, you can predict that the O_2 concentration of the blood in the lungs of species a will be higher than that of species b.
比較物種 a 與物種 b 的曲線 I，你能預測在物種 a 肺中血液的O_2濃度高於物種 b 的

B. If you expose deoxygenated blood of the two species at the same level of Pco_2 to increasing Po_2, the first blood to become saturated with O_2 would be that of species a.
如果你將兩物種缺氧血(含有相同的Pco2)暴露在逐漸增加Po_2的環境中，先與O_2飽和的會是物種 a 的血液

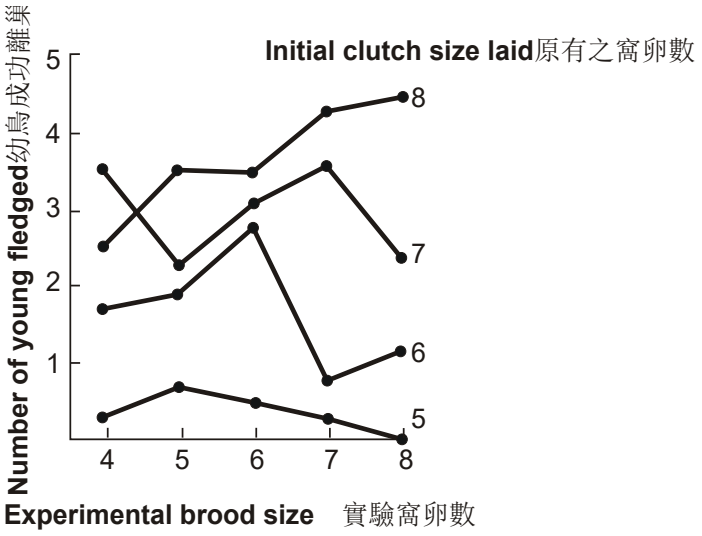
C. In species b, if curves I and II represent the Pco_2 of oxygenated and deoxygenated blood, respectively, there will be less than 160 mL of O_2 released from a litre of blood as it passes through the tissues.
在物種 b，如果曲線 I 和 II 分別代表含氧和缺氧血的Pco_2，1公升血液通過組織時釋放出的O_2將少於160毫升。

D. In species a, an increase in Pco_2 in the blood reduces the affinity of hemoglobin for oxygen but has no effect on the maximum oxygen-carrying capacity in the blood.
當物種 a 的血液中Pco_2增加時，會降低血紅素對氧的親和力，但並不影響在血液中的最大攜氧能力

ETHOLOGY 行為學

Q.81

In an experimental study on magpies *Pica pica*, conducted in Sweden, Goran Högstedt manipulated the original clutch size (shown on the right of the graph) of experimental birds to generate a number of different clutch sizes for each category of bird, as shown in the X-axis.
The number of young fledged successfully by the birds under these different conditions is indicated by the Y-axis. Food abundance and quality of territory are thought to be associated with clutch size. Predation is lower in large clutches.
瑞典針對喜鵲進行一項試驗性研究，Goran Högstedt利用實驗鳥的原有窩卵數(在圖的右側顯示)經過增減的組合，來建構一批新的窩卵數如X軸之數據顯示。在此設計的新情境中，幼鳥成功離巢的數量如Y軸所示，食物豐富度及領域的品質被認為與窩卵數有關。大的窩卵數，天敵壓力較小。



Analyse the following statements, with reference to the data provided and indicate in the answer sheet if each of the statements is true or false.
參考所提供的資料，分析下列的敘述，在答案卷上指出每一敘述是正確或錯誤。

A. The birds, in general, did better with experimentally manipulated, larger broods.
一般而言，鳥在此實驗的操作下，成為較大窩卵數者其表現較佳

B. The reproductive rate of birds is closest to that which maximises individual breeding success.
當每隻雌鳥個體達到最大的繁殖成功時，即最接近此種鳥類的繁殖率

C. Birds in high quality territory tend to have larger clutches.
鳥在高品質的領域中，傾向有較大的窩卵數

D. Experimentally-manipulated clutches experience higher starvation.
實驗操作下的窩卵數面臨較大的飢餓

Q.82

The behaviour of two similar-sized species of fiddler crabs (*Uca latimanus* and *U. musica*) that intermingle in the same habitat was studied. Males build hoods over their burrows for mate attraction. Mate searching is a dangerous activity for fiddler crab females, so these females may be forced to make suboptimal choices for their own safety, especially in areas where their conspecifics are in lower densities. The figures Fig.Q.82 below show the approaches made by females of the two species to male crabs as well as to burrows (with and without hoods) of conspecific males.
研究在同一環境中，兩種生活其間體型相似潮招蟹的行為。雄蟹在牠的洞穴建築頂蓋來吸引雌蟹。對雌蟹而言尋找對象是危險的，故雌蟹有時為了牠本身的安全，被迫做出不是最佳的選擇，尤其是在同類密度較低的地區。
下圖Fig.Q.82 顯示兩種不同種的雌蟹，造訪雄蟹及同種雄蟹的洞穴(有頂蓋及無頂蓋)。

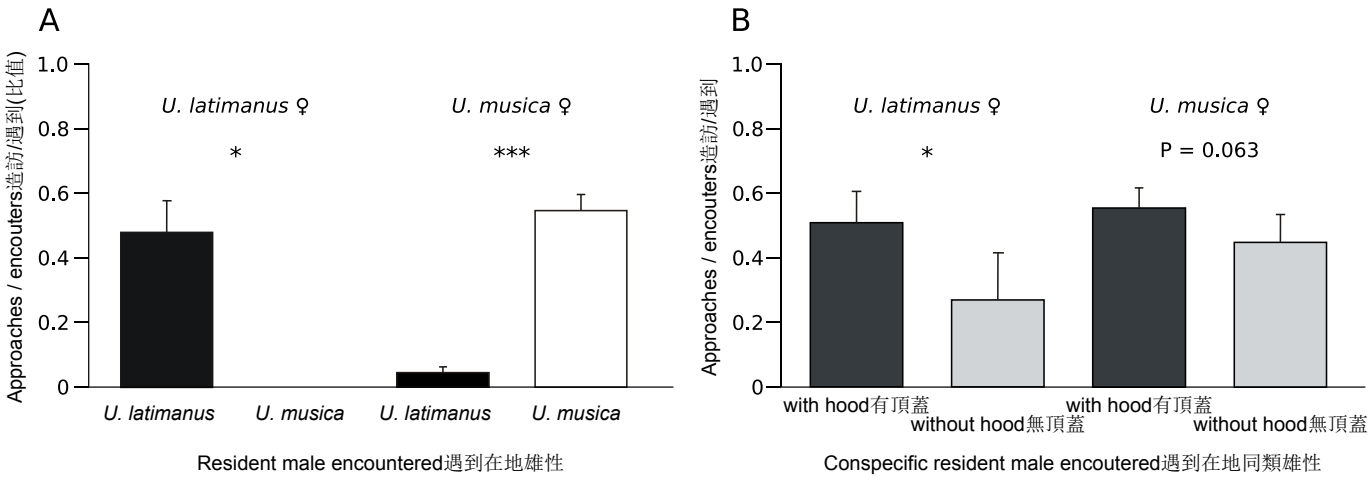


Fig. Q.82(A) Mean (±SE) proportion of resident Uca latimanus and U. musica males approached by wandering U. latimanus females and U. musica females. * $p < 0.05$; *** $p < 0.0001$.
(B) Mean (±SE) proportion of resident conspecific males with and without hoods approached by wandering U. latimanus females and U. musica females. * $p < 0.05$.
圖. Q.82(A)在地的Uca latimanus and U. musica雄性招潮蟹被遊走中的 U. latimanus females and U. musica雌性招潮蟹造訪的平均比例(±SE). * $p < 0.05$; *** $p < 0.0001$.
(B)在地的Uca latimanus 及 U. musica有無頂蓋的雄性被遊走中同種的 U. latimanus 雌性及 U. musica雌性造訪的平均比例(±SE). * $p < 0.05$; *** $p < 0.0001$.

Indicate in the answer sheet if each of the following statements is true or false.
在答案卷上指出下列各敘述何者正確或錯誤

A. Females of both species approached a greater proportion of the conspecific males than the heterospecific males they encountered.
兩物種的雌蟹遇到雄蟹時，造訪同種雄蟹的比例高於異種

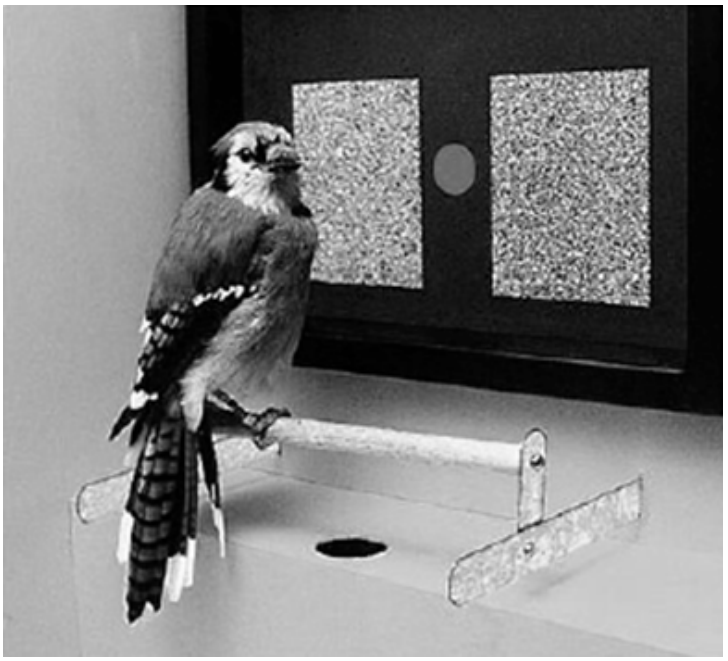
B. Attraction of *U. musica* females to hoods is not as strong as that of *U. latimanus* females.
U. musica 雌蟹被頂蓋所吸引的程度不及*U. latimanus* 雌蟹強

C. A male fiddler crab's willingness to court all females, regardless of species, is made used of by females of both species for shelter-seeking and avoidance of predators.
雄性招潮蟹不分種類對所有雌蟹皆表歡迎交配的特質，此特質會被此兩種不同的雌蟹利用做為尋找庇護所及躲避天敵

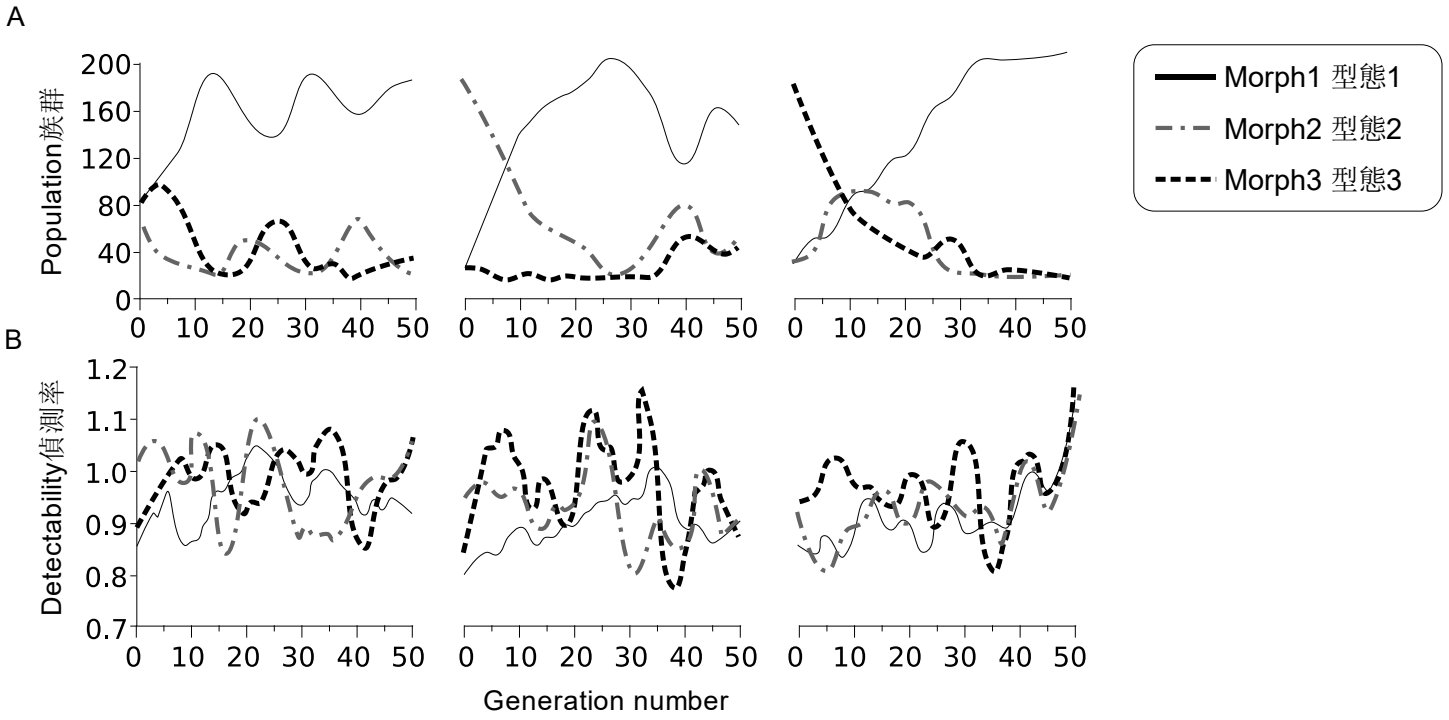
D. An overlap in habitat use between these two similar-sized fiddler crabs has no impact on both signalers and receivers.
此兩種體型相似招潮蟹對棲地的使用重疊，對訊息傳遞及接收不會產生影響

Q.83

Three morphs of a polymorphic species of *Catocala* moths differ only in the patterns on the forewings.Six experienced blue jays (*Cyanocitta cristata)* searched for prey on a computer screen in a series of trials.
Catocola 蛾為一具3種型態變異之多型性物種，其差異只在前翅的型態。在一系列的測試中，利用6隻經過訓練的藍樫鳥(*Cyanocitta cristata)*，在電腦螢幕前尋找獵物。



Each trial involved a screen showing the presence or absence of a moth from three distinct morphs of a moth population.If the bird found the moth, it was rewarded with food. Each bird had 36 prey and 84 no-prey trials and lasted for 50 days. Three replicates were carried out, with the second having a larger population of morph 2 and third replicate starting off with a larger relative abundance of morph 3.
每一測試包括在螢幕中顯示或不顯示有蛾，若顯示有蛾，蛾有3種不同型態，如鳥發現蛾則給予食物獎勵，每隻鳥在50天的試驗中，皆經歷36次有獵物及84次無獵物的測試。本實驗被重覆3次，第2次給予較多比例型態2(morph 2)的蛾個體，第3次給予較多比例型態3(morph 3)的蛾個體。



A, Population numbers of the three morphs.
A.3種型態蛾族群的數量
B, Prey detectability
B.獵物偵測率

Indicate in the answer sheet if each of the following statements is true or false.
在答案卷上指出下列各敘述何者正確或錯誤

A. Morph 1 was the most cryptic morph.
型態1是最不顯眼的型態

B. Relative numbers that escaped detection determine the abundance of each prey type.
未被偵測到的相對數量決定了每個變異型的數量

C. Preferential feeding behavior of the blue-jays of the most prevalent morph maximizes their foraging success.
藍樫鳥對出現數量最多型態的蛾，具有覓食偏好，最大化了牠們覓食的成功率

D. Polymorphisms are maintained in the population through frequency-dependent selection by predators.
多型性在族群中的維持係藉由天敵對頻度依賴(frequency-dependent) 所產生的天擇壓力

Q.84

An organism has four genes, A, B, C and D with two alleles each. An individual heterozygous for these genes was bred with one that is homozygous recessive. The cross produced 3288 offspring with phenotypes shown in the table below:
一種生物的四個基因，A, B, C, D，各有二種等位基因。一個體為這些基因的異型合子，與另一全部隱性同型合子個體雜交，得到3288個子代，其表現型如下表

Phenotypes 表現型	Number of individuals 個體數目
ABCD	675
ABCd	83
ABcD	1
ABcd	74
AbCD	73
AbCd	1
AbcD	84
Abcd	670
aBCD	655
aBCd	86
aBcD	1
aBcd	73
abCD	71
abCd	1
abcD	87
abcd	653

Indicate in the answer sheet if each of the following statements is true or false.
在答案卷上指出下列各敘述是對，或錯

A. The four loci are genetically linked.
這四個基因座為連鎖

B. The distance between gene B and gene D is 9 cM.
B基因和D基因間的距離為 9 cM

C. The distance between gene D and gene C is 10.5 cM.
D基因和C基因間的距離為 10.5 cM

D. Interference happened with a value less than 0.25.
Interference = 1-(observed frequency of double crossover/expected frequency of double crossover).
有互換干擾，其值小於 0.25
互換干擾 = 1 - (觀測雙互換頻率 / 期望雙互換頻率)

Q.85

A plant is normally red-flowered. Plant breeders obtained three genetically different pure mutated lines of white-flowered plants (designated as a, b and c). They performed crosses and observed progeny phenotypes as follows:
一種植物通常開紅花，植物育種者得到三種不同的開白花突變純系(a、b、和 c)，不同品系間雜交所得之子代表現型如下表

Cross 雜交	Parent 親本	Progeny 子代
1	line a x line b 品系 a x 品系 b	F_1 all white F1全開白花
2	line a x line c 品系 a x 品系 c	F_1 all red F1全開紅花
3	line b x line c 品系 b x 品系 c	F_1 all white F1全開白花
4	red F_1 from cross 2 x line a 雜交2的F1子代中開紅花者 x 品系 a	1/4 red : 3/4 white 1/4開紅花 : 3/4開白花
5	red F_1 from cross 2 x line b 雜交2的F1子代中開紅花者 x 品系 b	1/8 red : 7/8 white 1/8開紅花 : 7/8開白花
6	red F_1 from cross 2 x line c 雜交2的F1子代中開紅花者 x 品系 c	1/2 red : 1/2 white 1/2開紅花 : 1/2開白花

Indicate in the answer sheet if each of the following statements is true or false.
在答案卷上指出下列各敘述是對，或錯

A. Line (a) has only one homozygous mutated gene.
品系 a 只有一個同結合型突變基因

B. Line (b) shares two homozygous mutated genes with line c.
品系 b和品系 c 有二個同結合型突變基因是相同的

C. Line (c) shares one homozygous mutated gene with line a.
品系 c 和品系 a 有一個同結合型突變基因是相同的

D. Line (b) has three homozygous mutated genes.
品系 b 有三個同結合型突變基因

Q.86

Indicate in the answer sheet if each of the following statements is true or false.
在答案卷上指出下列各敘述是對，或錯

A. A completely recessive allele is lethal when homozygous. If the dominant allele mutates to recessive allele at a rate of 10^{-6}, then the frequency of the lethal allele when the population reaches mutation-selection equilibrium is 0.001.
一完全隱性等位基因在同型合子時會致死，若顯性等位基因變成隱性等位基因的突變率是10^{-6}，則當族群達到突變和淘汰平衡時，此隱性致死等位基因之頻率為 0.001

B. If the frequency of a completely recessive lethal allele is 0.2 and it remains unchanged from generation to generation due to the superior fitness of heterozygotes, then the intensity of selection against the dominant homozygotes should be 0.025.
若一完全隱性致死等位基因的頻率為 0.2，而且因為異型合子優勢的適應度，此等位基因頻率不再變動，據此，對顯性同型合子的淘汰強度為0.025

C. Selection for recessive alleles is less effective than selection against recessive alleles.
對隱性等位基因的天擇保留 比對 隱性等位基因的天擇淘汰較無效力

D. In a large, randomly mating population, the frequency of an autosomal recessive lethal allele is 0.2. The frequency of this allele in the next generation will be 0.07 if the lethality takes place before reproduction.
在一個很大的隨機交配的族群中，一個體染色體上的隱性致死等位基因的頻率是0.2，若其致死性發生於生殖前，則在下一世代中，此等位基因頻率將變成 0.07

Q.87

Indicate in the answer sheet if each of the following statements about cancers is true or false.
在答案卷上指出下列各敘述是對，或錯

A. A particular type of colon cancer can be caused by recessive alleles even though its inheritable pattern appears similar to that of a dominant trait.
有特殊類型的大腸癌可以由隱性等位基因導致，雖然它的遺傳模式看起來像是顯性遺傳性狀

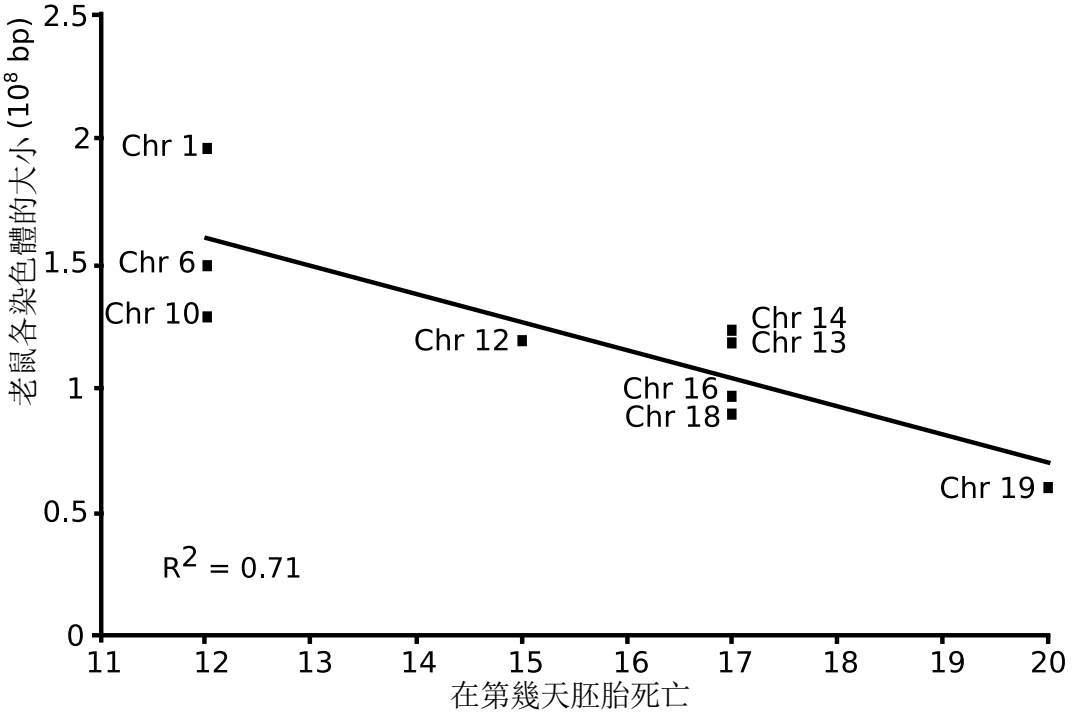
B. In one patient, normal cells have only one mutated p53 allele but cancer cells have two identical mutated p53 alleles. Then it can be concluded that the second mutated *p53* allele is formed by gene conversion.
在一個病人的正常細胞中只有一個突變的p53等位基因，但此病人的癌細胞中卻有二個相同的突變的p53等位基因，所以可以推論第二個突變p53等位基因是由基因轉換造成

C. Some cancers have been effectively treated with drugs that cause demethylation. Then it can be concluded that genes causing those cancers are more likely to be oncogenes.
有些癌症可以用去甲基化的藥物有效治療，因此可以認定造成這些癌症的原因可能是致癌基因(oncogene)

D. Chromosome inversions can produce novel oncogenes.
染色體倒位(inversion)可以造成新的致癌基因

Q.88

Mouse embryos that were trisomic for each of the 20 different chromosomes were monitored during embryonic development. Their survival time was plotted against the size of trisomic chromosome in Fig.Q.88.
對具不同染色體三倍體(trisomic)的老鼠胚胎做比較，分析它們在胚胎發育時的存活時間和三倍體染色體大小的關係如圖 Q.88



Based on this information, indicate in the answer sheet if each of the following statements is true or false.
根據此資料，在答案卷上指出下列各敘述是對，或錯

A. Chromosome 19 likely encodes fewer transcripts than other chromosomes shown in the graph.
第19條染色體可能比其它染色體帶有較少的轉錄訊息

B. The total amount of genetic material of the additional chromosome solely determines the severity of the defects associated with the chromosome imbalance.
與染色體不平衡相關的缺失完全是由超額染色體的遺傳物質總量決定

C. Assuming that genes on chromosome 1 and 10 have similar contribution to embryo development, gene density on chromosome 1 is probably lower than that on chromosome 10.
假設第1條染色體和第10條染色體上的基因對胚胎發育有相似的影響，則第1條染色體上的基因密度可能低於第10條染色體

D. Genes on chromosomes 12 are probably more important for embryo development than those on chromosome 13.
第12條染色體上的基因可能比第13條染色體上的基因對於胚胎發育更重要

Q.89

mRNAs in the cytoplasm of eukaryote cells frequently form closed loops by circularization. Indicate in the answer sheet if each of the following statements concerning closed loops is true or false.
真核生物細胞質中的mRNA常常會變成封閉環狀，在答案卷上指出下列有關封閉環的敘述是對，或錯

A. Circularization is due to a phosphodiester bond between the 5’end and the 3’end of mRNA.
環狀化是因為在mRNA的5' 端和3'端間形成磷酸二酯鍵

B. Circularization increases stability of mRNAs.
環狀化增加mRNA的穩定性

C. Circularization enhances translocation speed of the ribosomes.
環狀化增強核糖體移動的速率

D. Controlling circularization is a mechanism of post-transcriptional regulation.
控制環狀化是一種轉錄後的調控機制

Q.90

Pedigrees 1-4 show the inheritance of four different rar e disorders. It is known that the disease in pedigree 4 is X-linked recessive.
族譜1- 4 呈現四種罕見疾病的遺傳模式，已知在族譜4的疾病是隱性X-聯鎖

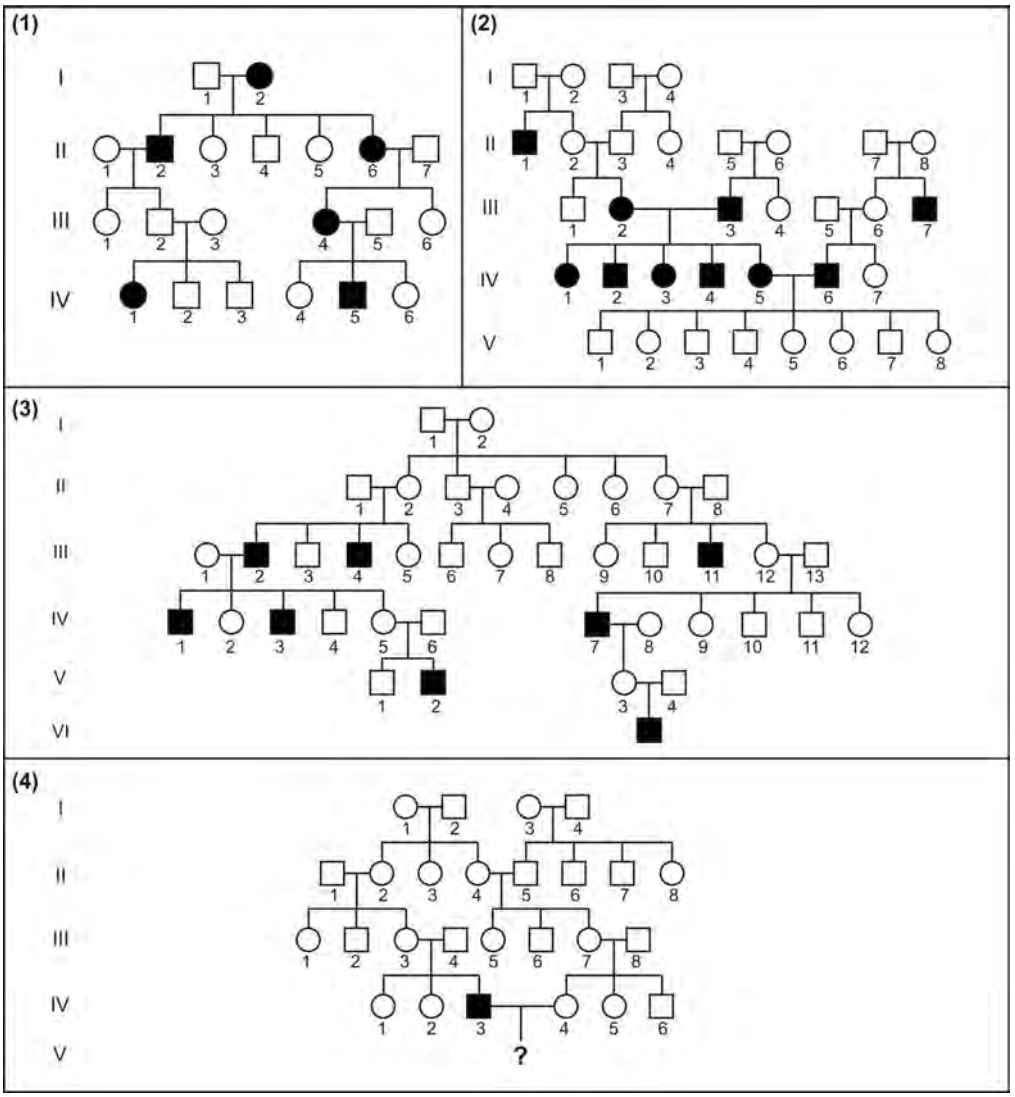


Figure Q.90 圖Q.90

Studying the pedigrees and indicate in the answer sheet if each of the following statements is true or false.
研究這些譜系後，在答案卷上指出下列各敘述是對，或錯

A. The disorder in pedigree 1 is most likely caused by a recessive allele.
譜系1的疾病最可能是由一個隱性等位基因造成

B. Person III_2 and III_7 in pedigree 2 have the same genotype.
譜系2中的III2和III7具有相同的基因型

C. Pedigree 3 shows the inheritance of the disorder can be caused by a recessive allele on X-chromosome.
譜系3顯示此疾病可以是由X-聯鎖的隱性等位基因造成

D. If the affected man and his unaffected wife in pedigree 4 have a son then the probability of this son be affected is 0.125.
若在譜系4中的患者和它的正常妻子有一個兒子，則這個兒子得病的機率是0.125

Q.91

Polymorphic DNA sequences are widely used for molecular identification. Short tandem repeat (STR) is composed of multiple repeats of 2-8 nucleotides flanked by two conserved sequences. Each STR locus normally has more than two alleles. Single nucleotide polymorphism (SNP) is a variation at a single position in a DNA sequence among individuals. Each SNP usually has only two alleles. Seven individuals were genotyped for two autosomal and two mitochondrial (mtDNA) SNPs, two autosomal and two Y-linked (NRY) STRs (T**able Q.91**).

DNA序列的多型性被廣泛使用於分子身分辨識：短重複序列(STR)由特定2-8個核苷酸序列重複多次組成，其二側則是高度保留的序列，每一個STR基因座通常有超過二個以上的等位基因。而單核苷酸多型性(SNP)則是個體間在DNA序列上特定單一個位置有變異，每一個SNP通常只有二個等位基因。以二個體染色體和二個粒線體(mtDNA)上的SNP，以及二個體染色體和二個Y染色體(NRY)上的STR為指標，對七個人做基因型鑑識，結果如表Q.91

	.utosomes 體染色體				NRY		mtDNA	
Individuals	SNP1	SNP2	STR1	STR2	STR1	STR2	SNP1	SNP2
Ind_1	A/A	A/A	13/15	18/20	13	12	C	A
Ind_2	A/C	A/G	12/14	18/21	13	15	T	A
Ind_3	C/C	A/G	14/15	18/21	13	15	C	G
Ind_4	A/C	G/G	13/15	19/19	11	14	T	G
Ind_5	C/C	A/G	14/15	18/19	-	-	C	G
Ind_6	A/C	G/G	14/14	18/19	-	-	T	G
Ind_7	C/C	G/G	14/16	19/21	-	-	C	A

Table Q.9 表Q.9

Indicate in the answer sheet if each of the following statements is true or false.
在答案卷上指出下列各敘述是對，或錯

A. If the same number of SNPs or STRs are used, SNPs are better than STRs for distinguishing individuals.
如果使用相同數目的SNP或SRT，SNP對區分個體的效果比STR為佳

B. Ind_6 is more likely a child of Ind_2 and Ind_5 than Ind_3 is.
個體6比個體3更有可能是個體2和個體5的小孩

C. Ind_4 is possibly a brother of Ind_6.
個體4可能是個體6的兄弟

D. It is possible that Ind_7 is a granddaughter of Ind_1 and Ind_6.
不能排除個體7是個體1和個體6的孫女的可能性

Q.92

A wildtype female Drosophila was mated with a wildtype male that had been X-ray irradiated. One of the F1 females was mated with a male that had recessive phenotype (caused by recessive allele a). Progenies of the second mating were unusual in two aspects. Firstly, there were twice as many females as males. Secondly, while all the males were wild type, ½ of the females were wild type, and the other ½ exhibited the recessive phenotype a.

一隻野生型雌果蠅和一隻經X光照射過的野生型雄果蠅交配，再將其F1子代中的一隻 雌果蠅與一隻隱性表現型的雄果蠅(因為隱性等位基因a所致)交配，所得子代有二個特殊現象：1. 雌果蠅數量是雄果蠅數量的二倍；2. 所有雄果蠅都是野生型，1/2雌果蠅是野生型，其餘1/2雌果蠅是隱性 a 表現型

Indicate in the answer sheet if each of the following statements is true or false.
在答案卷上指出下列各敘述是對，或錯

A. X-rays converted a dominant allele (A) on the chromosome X, coding for wild type, to a recessive allele (a).
X光照射將一個X染色體上的野生型顯性等位基因A轉變成隱性等位基因a

B. X-rays produced a chromosomal translocation.
X光照射造成一個染色體易位

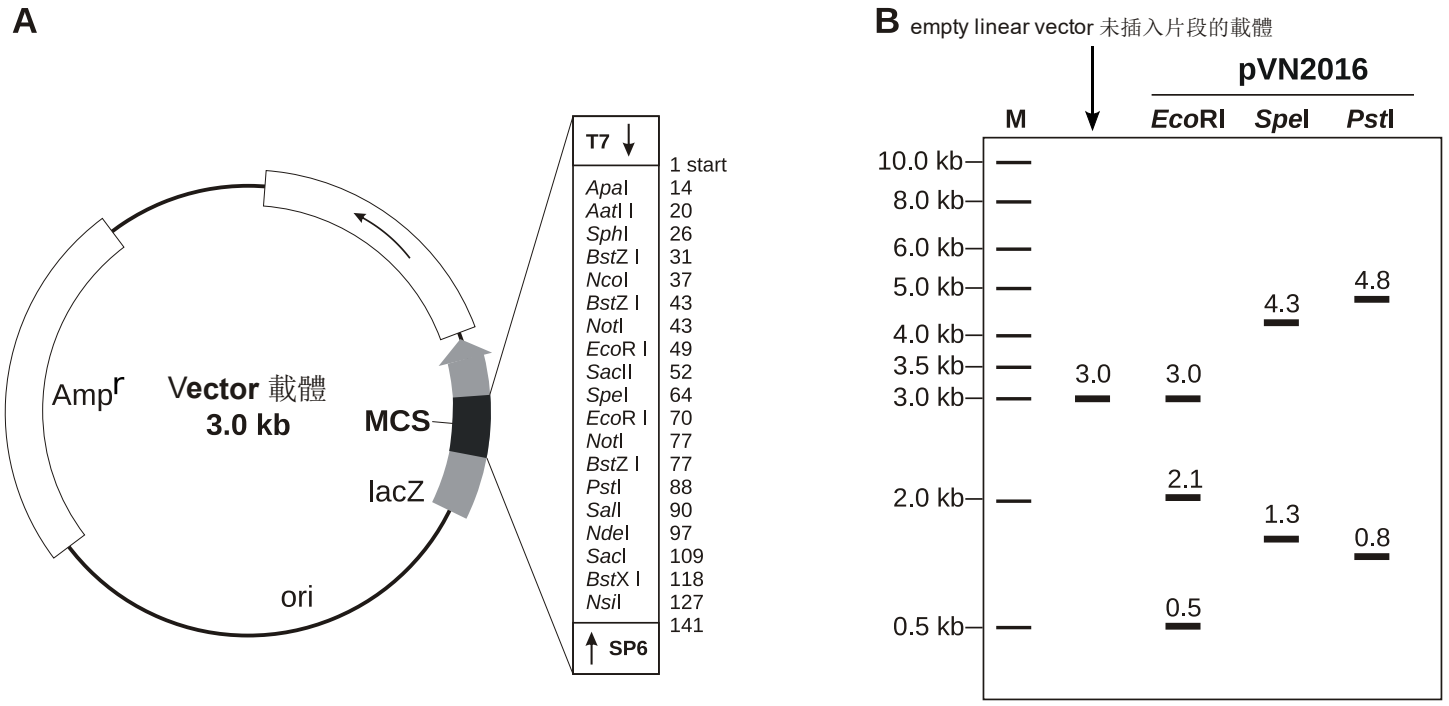
C. A loop might be seen on one pair of chromosomes during prophase of meiosis 1 in the mated F_1 female.
於這隻用於交配的F_1雌果蠅的減數分裂 I 前期，也許可以在一對染色體上看到一個凸出圈

D. If a female from the second mating exhibiting recessive phenotype (a) was crossed to a wild type male then her progenies compose of females and males at the ratio of 2 females to 1 male.
如果將第二次交配後所得的一個隱性表現型雌果蠅和一個野生型雄果蠅交配，則其子代的雌雄比為2 : 1

Q.93

Mr. Trung cloned a coding sequence (CDS) of a gene into a vector, , and namedthe resultedplasmid as pVN2016. The CDS was inserted at the SacII recognition site which is located in the multi cloning site (MCS) region within the lacZ gene of the vector (Fig.Q.93A). The inserted CDS has a PstI restriction site located 0.8 kb upstream of its stop codon. To identify the size and direction of the inserted CDS, Mr. Trung digested this plasmid with different restriction enzymes, and the results of the digestions are shown in Fig.Q.93B .

Mr. Trung 將一基因的編碼區序列(CDS)片段插入載體中，得到質體 pVN2016，此CDS片段的插入點是位於載體lacZ基因內的多重選殖區(MCS)中的SacI切位 (圖Q.93A)，插入的CDS片段上有一個PstI切位，位在終止密碼上游0.8 kb處。Mr. Trung為確認此CDS插入片段的長度和方向(以模板股 3' -> 5'為準)，Trung用不同的限制酶去切割此質體，結果如圖Q.93B



(A) A schematic map of the vector, numbers indicate positions of restriction enzyme recognition sites located in the vector
(B) A schematic electrophoresis of digestive products using different restriction enzymes, M: 1 kb DNA ladder.
(A) 載體圖，數字是其上限制酶辨認的位置 (B)以不同限制酶切割後的電泳圖，M：1 kb DNA 尺標

Based on above data, indicate in the answer sheet if each of the following statements is true or false.
根據以上資料，在答案卷上指出下列各敘述是對，或錯

A. The CDS is 2.6 kb in length and has an EcoRI recognition site at about 0.5 kb from one of its ends.
此CDS片段長 2.6 kb，距端點0.5kb處有一個EcoRI切位

B. SpeI can be used to determine the orientation of the CDS.
SpeI 切割可以用來判定CDS的插入方向

C. The CDS is oriented in the same direction as lacZ .
此CDS的方向和lacZ基因相同

D. If plasmid pVN2016 is digested by both enzymes SpeI and EcoRI in Tango buffer (EcoRI and SpeI cut at 100% and 20% efficiency, respectively), five fragments of 0.5, 0.8, 1.3, 2.1 and 3.0 kb could be detected by gel electrophoresis assuming that fragments smaller than 50 bp are not visible.
如果以SpeI和EcoRI切割pVN2016，但使用的Tango 反應緩衝液會讓EcoRI切割效率達100%，而SpeI切割效率只有20%，則電泳後會看到：0.5、0.8、 1.3、2.1、 和3.0 kb 五個片段，假設小於 50 bp的片段無法被看到

ECOLOGY 生態學

Q.94

Scientists constructed models for four threatened tree species in sub-tropical forests in Vietnam, and used these models to estimate tree ages (figur**e Q.94**). Tree age is measured by ring count and trunk diameter at breast height (DBH). Rates of growth were categorised using changes in DBH from 10 to 1000, with 1000 at the finest-grain measure of change.
科學家對越南亞熱帶森林中4種瀕危的樹種建立了模型，藉此來估算樹齡(圖 **Q.94**)。樹齡是藉由年輪的計算及樹幹的胸高直徑(DBH)來測量。
生長速率用胸徑(DBH)的改變，由10到1000來歸類，以1000為最細微的偵測變化。

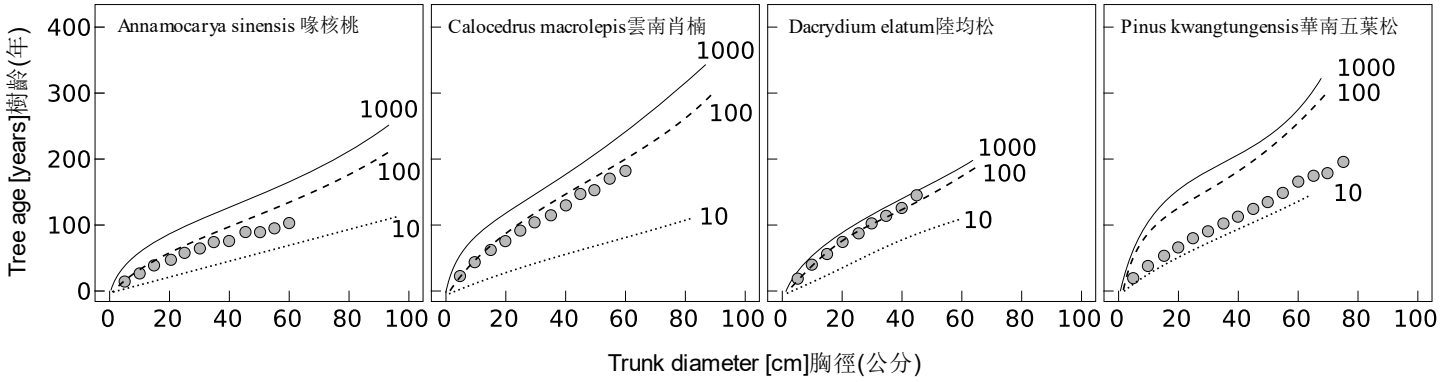


Figure Q.94 Estimated (lines) and observed (circles) ages for DBH categories of four tree species.
由DBH(胸高直徑)尺度估計的(線)及觀察的(圓)4種樹齡

Indicate in the **Answer sheet** if each of the following statements is True or False.
在答案卷上指出下列各敘述何者正確或錯誤

A. Using the smallest category gives the most accurate information of tree age of P. *kwangtungenesis*.
用最小的分類尺度，可獲得有關華南五葉松(P. *kwangtungenesis*.)最正確的樹齡資料

B. Age estimates increase particularly strongly from 100 to 10-category model in *D. elatum*.
在陸均松(*D. elatum)*年齡估算的增加，在100到10的尺度範圍內最強

C. Model with just 10 DBH categories underestimate the observed ages for three species.
用10胸徑(DBH)的模型會低估3種樹種的觀測年齡

D. For *D.elatum,* measuring DBH using either 100 or 1000 will give an accurate estimate of tree age, whereas to estimate the age of *C. macrolepis,* only 100 gives a reliable estimate.
對陸均松(D.elatum)而言，用100或1000尺度來測量胸徑(DBH)，會得到一個正確的年齡估算，而對雲南肖楠(*C. macr*olepis)年齡的估算只有尺度100時才會有較可信的結果

Q.95

To understand the effects of several factors on plants (*Agrimonia rostellata* and T*rillium er*ectum) in forest ecosystems, students transplanted seedlings into experimental sites and observed the proportion of surviving seedlings growing with native or non-native vegetation, with or without slugs, and with low or high earthworm density. The results are shown in the figure below.
為了解幾項因子對森林生態系中植物(龍牙草*Agrimonia rostellata* 及 延齡草T*rillium er*ectum)的影響，研究者將幼苗移植至實驗地，觀察幼苗在有無本地或非本地植物，有無蛞蝓及不同的蚯蚓密度(高低)等條件下幼苗存活的比例

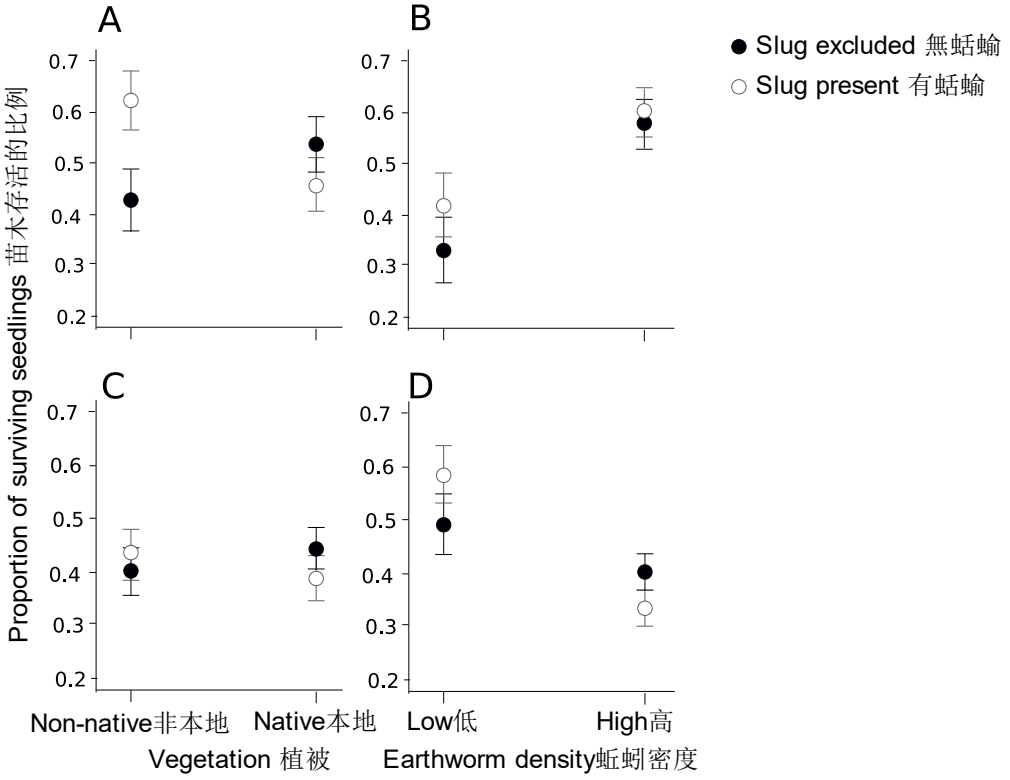


Figure Q.95 Proportion of surviving seedlings.
圖 Q.95幼苗存活的比例
龍牙草Agrimonia rostellata (A, B) 及
延齡草Trillium erectum (C, D)

Indicate in the **Answer sheet** if each of the following statements is True or False.
在答案卷上指出下列各敘述何者正確或錯誤

A. Slug exclusion has a positive effect on the survival of *Agrimonia rostellata* and *T*rillium er*ectum* in high earthworm density.
在無蛞蝓的情況下，具有高密度的蚯蚓對龍牙草(*Agrimonia r*ostellata)及延齡草(Trillium erectum)幼苗的存活是有正面的效果

B. Slug effects are dependent on other stressors, especially on interactions with non-native plants and earthworms.
蛞蝓所產生的影響是依賴其他的逆境因子，尤其是與非本地種植物與蚯蚓所產生的交互作用

C. Earthworms have positive effects on *Agrimonia r*ostellata and T*rillium er*ectum.
蚯蚓對龍牙草(*Agrimonia r*ostellata)及延齡草(T*rillium er*ectum)有正面效應

D. Non-native plants and slugs synergistically decrease seedling survival through increased competition and consumption.
非本地種植物及蛞蝓，藉由增加競爭及消費，對降低幼苗存活具有產生加成效應

Q.96

Students cultured plants, including four grass species (*A. capillaris, A. odoratum, F. rubra*, and *H. lanatus*) and four herbs (*C. jacea, L. vulgare, P. lanceolata,* and *R. acetosa*) without legumes, in different blocks with treatments of monoculture and mixtures of two, four or all eight species. They then measured different parameters as functions of plant species richness, as shown in the figure below. Values are shown in $\log_2$ scale.
研究者培養植物進行實驗，包括4種草(*A. capillaris, A. odoratum, F. rubra*, and *H. lanatus*) 及4種闊草 (*C. jacea, L. vulgare, P. lanceolata,* and *R. acetosa*) 內不含豆科植物，在不同的區塊進行不同物種組合的實驗設計，包括1種、2種、4種或8種植物。
而後測量不同的因子與物種豐富度之間的關連。結果如下圖所示。
數據以自然對數 $\log_2$ 表示

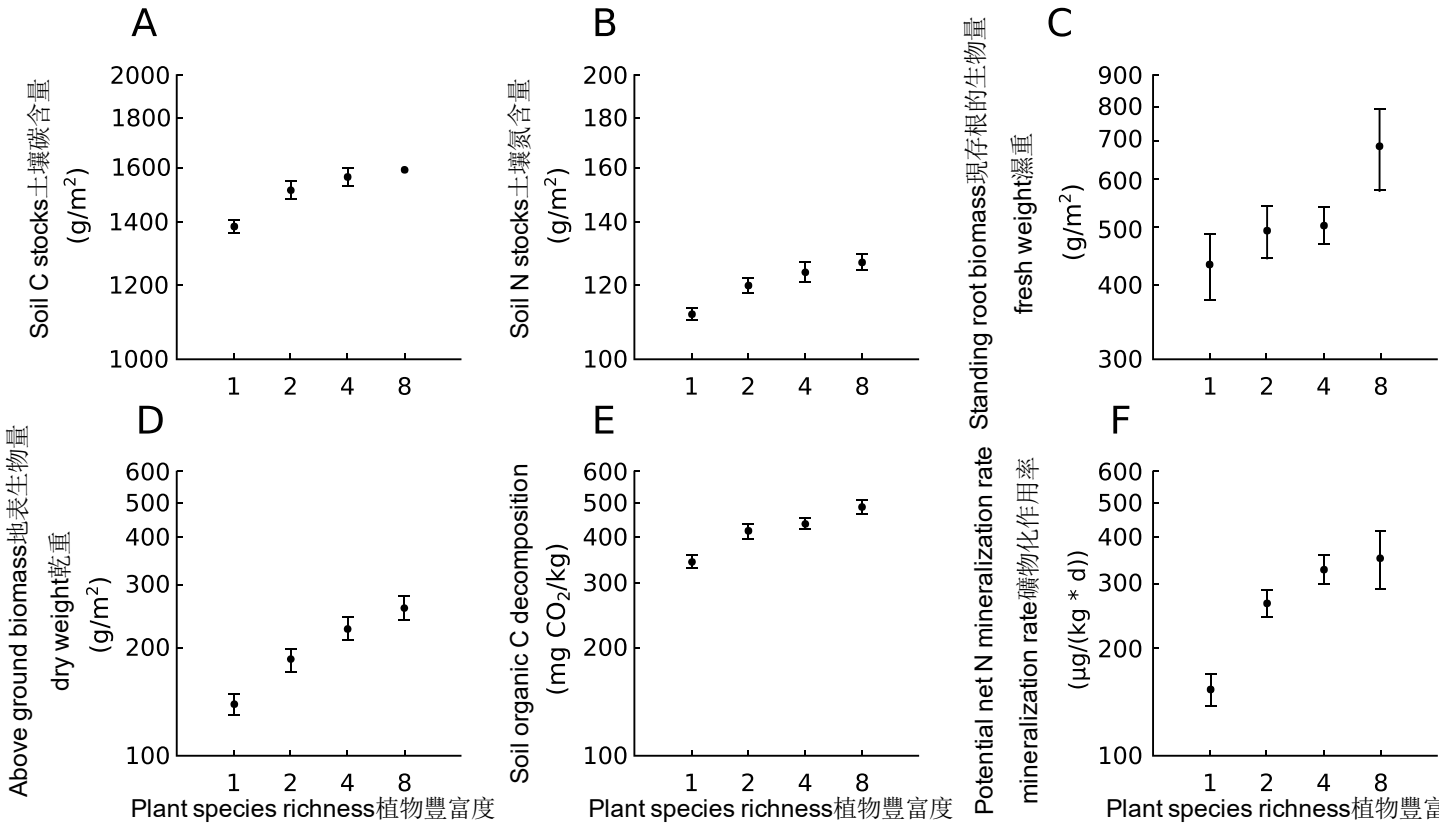


Figure Q.96

Indicate in the **Answer sheet** if each of the following statements is True or False.
在答案卷上指出下列各敘述何者正確或錯誤

A. Above ground biomass increases but root biomass decreases with the increase of species richness.
隨著物種豐富度的增加，在地表上的生物量會增加但根的生物量會減少

B. Plant species richness promotes soil C stocks mainly through enhanced plant productivity, despite accelerated soil organic C decomposition.
縱使在土壤有機碳加速分解的情況下，植物豐富度增加土壤中的碳含量，其碳含量的增加主要來自植物加強其生產量

C. Greater soil N stocks at higher species richness is mainly attributed to increased N retention, rather than N input, with enhanced plant productivity.
在植物豐富度高時，造成含有較高土壤含氮量的主因是增加土壤中氮存留的時間，及加強植物的生產力而非外在氮元的加入

D. More diverse ecosystems can increase the potential for C sequestration in terrestrial ecosystems.
較多樣化的生態系能增加陸域生態系碳封存的潛力

Q.97

A rocky shore contains many shallow rock pools dominated by macroalgae and grazing gastropods, comprising primarily *Patella ulyssiponensis* (P), *Littorina littore*a (L) and *Gibbula umbilicalis* (G).The experiment is designed to test the interaction between grazer species and the additive interaction with nutrient enrichment.Pools contained either none, one, two or all three of grazer species at realistic densities (Patella , Littorina and Gibbula).Another complete set of all the manipulation grazer treatments was also established concurrently where nutrient concentrations were enhanced to compare the simultaneous effects of grazer treatments at ambient and enriched nutrient conditions.Gross ecosystem productivity (GEP), number of algal taxa, and the biomass (dry weight) of all algal species were measured.
岩岸海灘上有很多潮池，主要優勢生物為大型海藻及啃食(草食)性腹足動物，啃食(草食)性腹足動物主要包括笠螺(P)*(Patella ulyssiponensis)*濱螺 (L)*(Littorina littorea)* 和鐘螺(G)*(Gibbula umbilicalis)* 。
本實驗是要測試啃食性物種間之交互作用，及在營養鹽增加的環境中會增加他們之間的交互作用。
實驗池中利用此3種啃食性物種的分別以0.1.2及3種等不同配置的組合進行實驗，並維持在適合的密度。
另一套有關啃食性物種的操作實驗也同時設立在此系統中，藉由調整營養鹽的濃度，用以比較正常及營養鹽豐富的環境中對啃食性物種所產生之同步效應。並進行對總生態生產力(GEP)，藻類分類群數及其所有藻類生物量(乾重)的測量

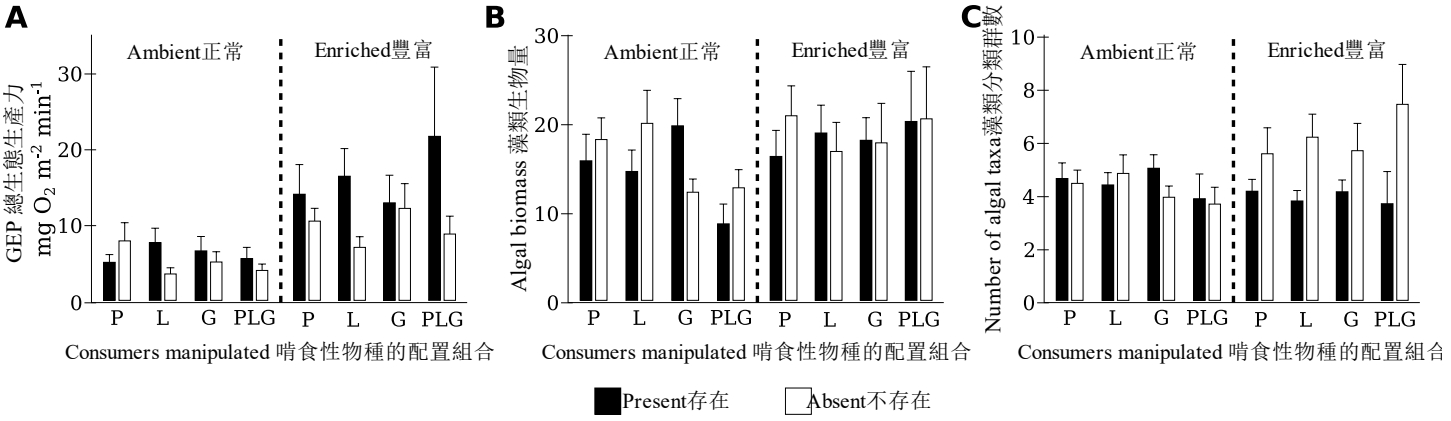


Figure Q.97

Indicate in the **Answer sheet** if each of the following statements is True or False.
在答案卷上指出下列各敘述何者正確或錯誤

A. Gross ecosystem productivity is enhanced by nutrient enrichment and is greater in pools where Littorina is present.
營養鹽豐富化可增加總生態生產力，其在有濱螺(Littorina)的池塘中更為明顯

B. The effects of grazer species loss on accumulated algal biomass are regulated by nutrient conditions, grazer identity and grazer diversity.
啃食性物種的消失對累積的藻類生物量的影響是受到營養鹽狀況、啃食性物種種類為何及啃食性物種的多樣性等調控

C. The effects of loss of grazer species on ecosystem functioning depend upon both the diversity and identity of the species present.
啃食性物種消失對生態系功能的影響，是取決於物種多樣性及存在之何種特定物種的種類

D. The presence of all grazers results in lower algal diversity and biomass in both nutrient conditions.
在兩種不同營養鹽的狀態下，所有啃食性物種同時存在時，會造成藻類多樣性及生物量較低

Q.98

Gall aphids (*Pemphigus betae*) live in poplar plants. Adult females produce galls on poplar leaves. Some fraction of these galls will emerge and survive to adulthood. Female aphids complete their life cycle after laying eggs in the leaves. All the progeny of a single female aphid are contained in one gall. A student recorded observation on several aphid populations, shown in the table below. All environmental parameters are assumed constant.
蟲癭蚜蟲(*Pemphigus betae*)生長在楊樹(poplar)中。成年雌蟲在楊樹葉子中生產蟲癭，其中一些蟲癭將會孵化並成長至成蟲，雌蟲在葉中產卵後即完成他們生命週期，單一雌蟲所有的子代皆存在一個蟲癭中。研究人員紀錄幾個蚜蟲族群結果如下表。假設所有環境因子皆維持恆定。

Population 族群	Number of aborted galls 萎縮蟲癭數量	Number of successful galls 成功的蟲癭數量	Female/Male ratio in adult stage 達到成熟期雌/雄比例
1	35	70	1/1
2	25	75	1/2
3	21	63	Not given 無資料呈現
4	16	32	1/1

An equation representing number of female aphids in t^{th} generation is established as below:
下方為一方程式，顯示如何計算雌蚜蟲在第t^{th} 代的數量

$$N_t = [f \times r \times (1\text{-}m)]^t \times N_o$$

Whereas:而
N_t – number of adult female aphids in the t^{th} generation
N_t – 在第t^{th} 代雌性成蟲的數量
N_o – number of adult female aphids in the initial generation
N_o –在開始時最初的雌性成蟲的數量
m – fraction mortality of the young aphids
m – 幼蚜蟲死亡的比例
f – number of progeny per female aphid
f – 每一雌蟲產生之子代數
r – ratio of female aphids to total adult aphids.
r –所有成蟲中雌蟲的比例
Theoretically f, m and r are constant.
理論上f, m 及 r皆為常數(不變的定值)

Indicate in the **Answer sheet** if each of the following statements is True or False.
在答案卷上指出下列各敘述何者正確或錯誤

A. Population 1 has a constant number of adult females across generations when each female produces 4 progeny.
當每一雌蟲生4個子代時，族群1的蟲癭蚜蟲歷代皆有恆定的雌性成蟲數量。

B. When every female in population 2 produces 3 progeny, this population will have a constant number of adult females across generations.
在族群2當中，當每個雌性生3個子代時，此族群歷代可有恆定的雌性成蟲數量

C. When population 3 has a constant number of adult females across generations and each female aphid produces 4 progeny, the female/male ratio of the population in adult stage is 1/2.
當族群3在歷代皆有固定的雌性成蟲時，而且每一雌蟲都生4個子代，則族群中成蟲的雌/雄比例是1/2。

D. Given that each female in population 4 produces 6 aphids and taking the offspring of population 4 to be in the first generation, the number of adult females in the third generation will be 384.
在族群4，假設每一雌蟲生6個子代，如將其所產生的子代界定為第1代，則在第3代時，雌性成蟲的數量將達到384隻。

Q.99

Information about the relationships among organisms is a useful source of data for scientists investigating a wide variety of biological questions. Indicate in the answer sheet if each of the following statements about using the phylogenetic trees is true or false.
生物間的親緣關係可作為提供科學家探討不同範疇的生物相關問題時的有用資訊。在答案紙上，註明下列敘述正確或錯誤。

A. Phylogenetic trees can be used to determine how many times a particular trait independently evolved.
親緣關係樹可用來決定某特定特徵總共獨立演化了多少次。

B. Phylogenetic trees can suggest whether a particular trait is the ancestral one..
親緣關係樹可暗示某特定特徵是否為祖徵

C. Phylogenetic trees can be used to determine the timing of evolutionary lineage splits.
親緣關係樹可用來決定演化支系分岐的時間

D. Phylogenetic trees can be used to determine the virus's origins in human populations.
親緣關係樹可用來決定人類族群中的病毒之起源

Q.100

The analysis of DNA and protein sequences nowadays is widely used in constructing phylogenetic trees. Indicate if in the answer sheet each of the following statements is true or false.
現在DNA及蛋白質序列的分析被廣泛用於建構親緣關係樹。在答案紙上，註明下列敘述正確或錯誤。

A. The number of differences in a nucleotide sequence of two species increases with time that has passed since the species split from a common ancestor.
當物種從其共同祖先分岐出來後，兩物種的核甘酸序列差異數目會隨時間增加

B. If the same protein of two related species are different at only one amino acid, then multiple substitutions might have occurred since the two species split.
兩個親緣接近的物種之相同蛋白質中，只有一個胺基酸不同，則在此兩物種分岐後，可能會發生多次的取代

C. rRNA sequence analysis is useful for phylogenetic relationship among species within a genus.
rRNA的序列分析可用於探討同一屬的物種間之親緣關係

D. Pseudogenes can be used for constructing phylogenetic trees.
偽基因可用以建構親緣關係樹

END OF THEORY PART B 結束!!