

27th International Biology Olympiad

July 17-23, 2016

Hanoi, Vietnam



Theoretical Test

PART A

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 A consists of 50 questions:

- Q1-Q10: Cell Biology
- Q11-Q17: Plant Anatomy and Physiology
- Q18-Q30: Animal Anatomy and Physiology
- Q31-Q32: Ethology
- Q33-Q42: Genetics and Evolution
- Q43-Q47: Ecology
- Q48-Q50: 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 Paper** 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!!!

Q.1

The activities of Wee1 kinase and Cdc25 phosphatase determine the state of phosphorylation of tyrosine 15 in the Cdk1 component of M-Cdk. When tyrosine 15 is phosphorylated, M-Cdk is inactive; when tyrosine 15 is not phosphorylated, M-Cdk is active (**Figure Q.1A**). The activities of Wee1 kinase and Cdc25 phosphatase are also controlled by phosphorylation.

Wee1激酶和CDC25磷酸酶的活性可決定在M-Cdk的Cdk1組成分中的第15位點酪氨酸(酪氨酸15)磷酸化的狀態。當Cdk1的酪氨酸15被磷酸化時，M-Cdk是不具活性的;但當酪氨酸15沒有磷酸化時M-Cdk會具有活性（圖**Q.1A**）。Wee1激酶和磷酸酶Cdc25的活性也受其本身之磷酸化調控。

The regulation of these activities can be studied in extracts of frog oocytes. In such extracts, Wee1 kinase is active and Cdc25 phosphatase is inactive. As a result, M-Cdk is inactive because its Cdk1 component is phosphorylated on tyrosine 15. M-Cdk in these extracts can be rapidly activated by addition of okadaic acid, which is a potent inhibitor of serine/threonine protein phosphatases. Using antibodies specific for Cdk1, Wee1 kinase, and Cdc25 phosphatase, it is possible to examine their phosphorylation states by changes in mobility upon gel electrophoresis (**Figure Q.1B**). Phosphorylated forms of these proteins generally migrate more slowly than their nonphosphorylated counterparts.

這些蛋白活性的調節可以用蛙卵母細胞的萃取物來進行研究。在這種萃取物中，蛋白激酶Wee1是具活性的，而Cdc25磷酸酶則處於非活性狀態。其結果是，M-Cdk會因其Cdk1組成分的酪氨酸15被磷酸化而不具活性。這些萃取物中的M-Cdk可以在加入絲氨酸/蘇氨酸蛋白磷酸酶的強效抑制劑Okadaic acid被快速激活。使用Cdk1, Wee1激酶和Cdc25磷酸酶的抗體，可以檢測這些蛋白在電泳膠體中的泳動狀況而了解其磷酸化狀態,因為當蛋白磷酸化時可造成其在膠體電泳位置之改變（圖**Q.1B**）。蛋白磷酸化態通常比他們的非磷酸化態在膠體內的移動更慢。

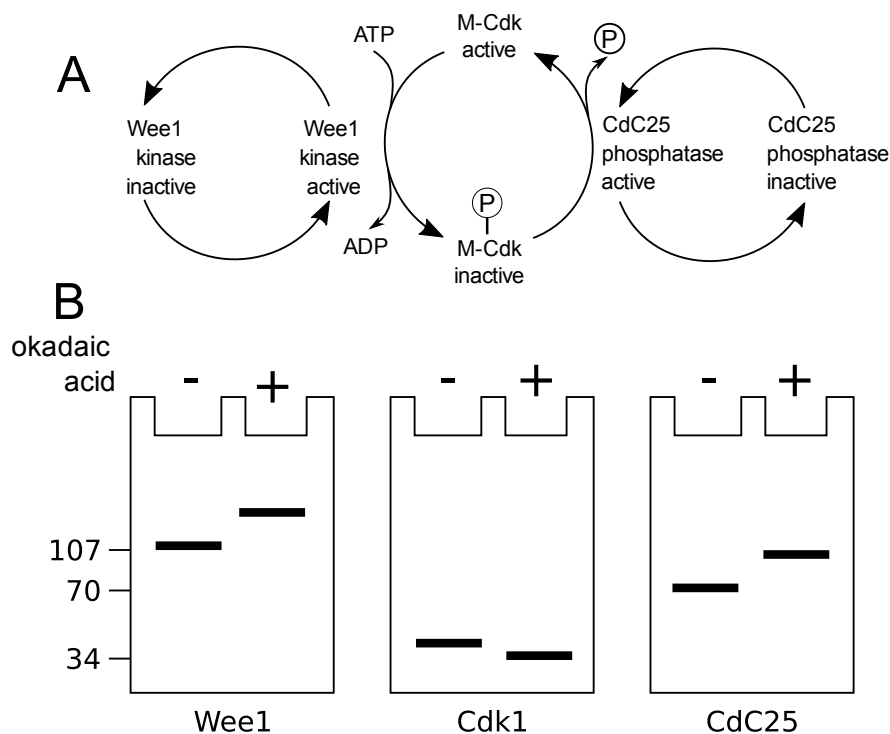


Fig.Q.1. (A) Control of M-Cdk activity by Wee1 kinase and Cdc25 phosphatase; (B) Effects of okadaic acid on the phosphorylation states of Cdk1, Wee1 kinase, and Cdc25 phosphatase

(A) Wee1激酶和CDC25磷酸酶控制 M-Cdk活性之示意圖
(B) Okadaic acid對Cdk1和Wee1激酶和CDC25磷酸酶的磷酸化狀態的影響

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.** Wee1 kinase is active if it is phosphorylated.
Wee1激酶如被磷酸化則具活性。
- B.** The phosphatases that control the phosphorylation of Wee1 kinase and Cdc25 phosphatase are specific for tyrosine side chains.
控制Wee1激酶和Cdc25磷酸酶的磷酸化的磷酸酶具有酪氨酸側鏈專一性。
- C.** Okadaic acid directly affects the activation of Cdk1.
Okadaic acid直接影響Cdk1的活化。
- D.** If M-Cdk is able to phosphorylate Wee1 kinase and Cdc25 phosphatase, a small amount of active M-Cdk would lead to its rapid and complete activation.
如果M-Cdk能夠磷酸化Wee1激酶和Cdc25磷酸酶，則只需少量活化態M-Cdk即會導致其快速和完全活化。

Q.2

Translational rate of a mRNA can be estimated from sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE). In this experiment, a tobacco mosaic virus (TMV) mRNA, which encodes a 116,000-dalton protein, was translated in a rabbit reticulocyte lysate in the presence of ^{35}S -methionine. The lysate contained all components of rabbit reticulocyte translational machinery. Samples were removed at 1-minute intervals and subjected to SDS-PAGE. The separated translation products were visualized by autoradiography. As can be seen in the figure below, the largest detectable polypeptides get larger with time, until the full-length protein appears at about 25 minutes.

一個mRNA的轉譯速率可以用十二烷基硫酸鈉聚丙烯醯胺凝膠電泳（SDS-PAGE）實驗結果來估算。在該實驗中，煙草鑲嵌病毒（TMV）的mRNA，其可製造出116000道爾頓(Dalton)蛋白，可將此mRNA放入兔網狀細胞(reticulocyte)裂解物中，在 ^{35}S 放射同位素標定的甲硫氨酸(methionine)的存在的環境下進行蛋白轉譯。此裂解物中含有進行轉譯作用的所有要件。反應樣品以每1分鐘的間隔取出後進行SDS-PAGE分析。分離的轉譯產物影像可通過放射自動顯影方式顯示如下圖，最大的可檢測的多肽大小會隨時間變大，直至全長蛋白質在大約25分鐘時出現。

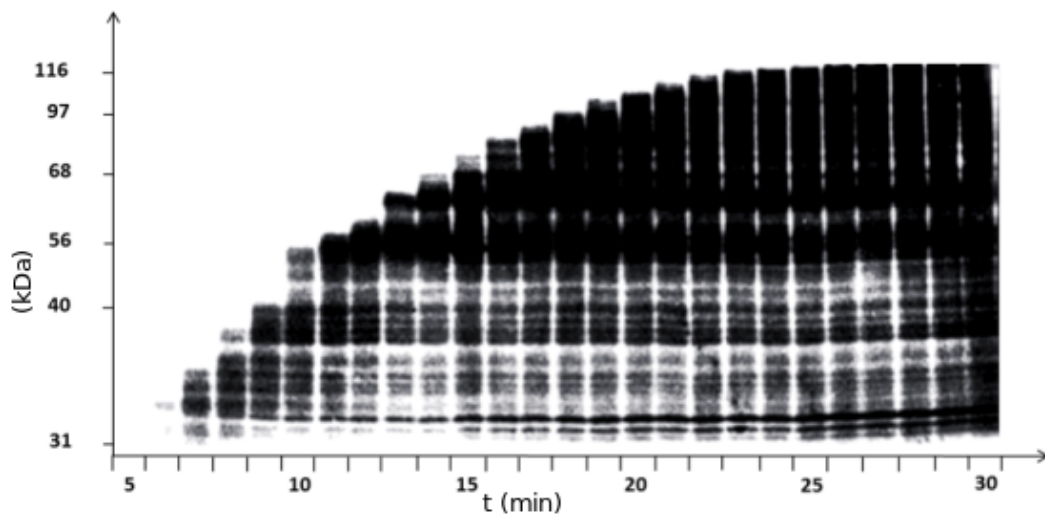


Fig.Q.2. Time course of synthesis of a TMV protein in a rabbit-reticulocyte lysate. Molecular weight (kDa) as a function of time t (min).

隨著時間變化在兔子網狀細胞裂解物中轉譯出的TMV蛋白合成的情況
蛋白質分子量(kDa)與時間(min)關係

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 rate of TMV protein synthesis is exponentially proportional to time. 煙草鑲嵌病毒(TMV)蛋白合成速率的對數與時間呈比例。
- B. With an average molecular mass of an amino acid of 110 daltons, the average rate of protein synthesis is approximately 35 to 40 amino acids per minute.
如果一個氨基酸的平均分子量為110 daltons，則蛋白合成的平均速率為每分鐘約35至40個氨基酸。
- C. The rabbit reticulocyte lysate contains methionyl-tRNA synthetase
在兔網狀細胞裂解物中含有甲硫氨醯tRNA合成酶(methionyl-tRNA synthetase)
- D. The mRNA may contain more than two rare codons in its sequence.
該mRNA可能其序列上含有兩個以上的罕見密碼子。

Q.3

Scientists have isolated three different strains of bacteria ProA^- , ProB^- , and ProC^- that require added proline for growth. One is cold-sensitive, one is heat-sensitive, and one has a gene deleted. Cross-feeding experiments were carried out by streaking the strains out on agar plates containing minimal medium supplemented with a very low level of proline. In cross-feeding experiments, metabolites leaking from one strain can feed a neighbouring strain. After growth at three temperatures, the results were shown in Figure Q.3.

科學家們已分離三種需在其培養基中添加脯氨酸(proline)才能生長的不同細菌株，有一株不耐冷，一株不耐熱及一株有基因缺損，當進行交叉饋送(cross-feeding)實驗時，將各菌株劃線於含有proline 的非常低的基本培養基瓊脂皿中培養時，代謝物從一株洩漏出可以養活鄰近的菌株。下圖Q.3顯示當三種菌株與野生菌株分別培養在三個不同溫度中生長狀況。

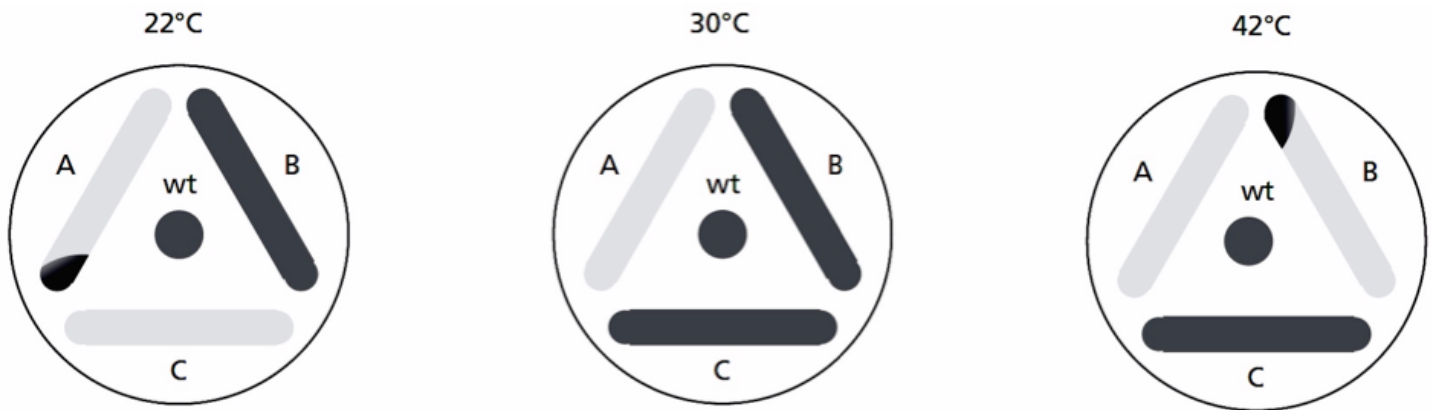


Fig.Q.3. Results of cross-feeding experiments with three strains defective in proline biosynthesis. Dark areas show high cell growth rate; grey areas show low cell growth rate; wt, wild type

圖Q.3. 三種proline生成缺陷菌株cross-feeding實驗結果
黑色區表示生長速率快菌落；灰色區表示生長速率慢菌落；wt, 野生型

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

- The intermediate that accumulates in the ProC^- strain comes after the block in the ProA^- strain.
ProC-菌株中累積的中間產物在合成途徑中位於ProA-菌株受阻步驟之後。
- The intermediate that accumulates in the ProB^- strain comes after the block in the ProA^- strain.
ProB-菌株中累積的中間產物在合成途徑中位於ProA-菌株受阻步驟之後。
- There are at least three different genes that affect proline biosynthesis.
至少有三個不同的基因影響脯氨酸(Proline)生成。
- Under at least one condition, the proline that is produced is rapidly used for protein synthesis and is prevented from being synthesized in excess of needs.
至少在其中一個，脯氨酸會很快速被用於蛋白質合成及避免合成過多超過需求量。

Q.4

When isolated mitochondria are suspended in a buffer containing ADP, P_i , and an oxidizable substrate, three easily measured processes occur: the substrate is oxidized; O_2 is consumed; and ATP is synthesized. Cyanide (CN^-) is an inhibitor of the passage of electrons to O_2 . Oligomycin inhibits ATP synthase by interacting with subunit F_0 . 2,4-dinitrophenol (DNP) can diffuse readily across mitochondrial membranes and release a proton into the matrix, thus dissipating the proton gradient.

當分離的粒線體懸浮在含有ADP, P_i 和可被氧化受質的緩衝液內, 有3種容易測定的反應過程會發生: 受質被氧化; O_2 被消耗; 及ATP合成。氰化物 (CN^-) 是電子傳送到 O_2 的通路抑製劑。Oligomycin因與 F_0 次單元交互作用而抑制ATP合成酶(ATP synthase)的活性。2,4-二硝基苯酚 (DNP) 可以擴散通過線粒體膜並釋放質子進入基質, 因而消散質子濃度梯度。

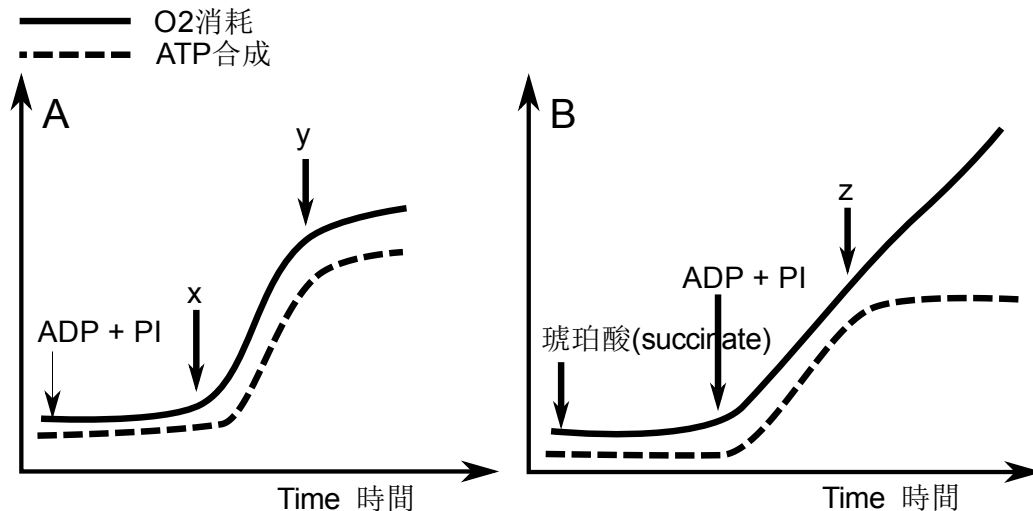


Fig.Q.4. Oxygen consumption and ATP synthesis in mitochondria. The solid lines indicate the amount of oxygen consumed and the dash lines indicate the amount of ATP synthesized
粒線體氧消耗和ATP的合成。實線表示所消耗的氧量, 虛線表示ATP的合成量

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

- x is the oxidizable substrate.
x 是可被氧化受質。
- y is either oligomycin or CN^- .
Y 是 oligomycin 或 CN^- 。
- z is DNP.
z 是 DNP。
- If z is a mixture of oligomycin and DNP, the ATP synthesis will not level off.
如果 z 是 oligomycin 和 DNP 的混合物, 則 ATP 的合成量將無法維持平穩。

Q.5

Imagine you are studying a membrane protein represented in the diagram below. You prepared artificial vesicles containing this protein only in the membrane. The vesicles were then treated with a protease cleaving close to the membrane (2) or permeabilised before protease treatment (3). Resulting peptides were subsequently separated using SDS-PAGE (sodium dodecyl sulfate polyacrylamide gel electrophoresis).

想像一下，你正在研究下圖中所表示的膜蛋白。您準備了其膜上含有這種蛋白質的人造囊泡。囊泡用蛋白酶切割處理消化膜蛋白（2）或蛋白酶處理前先經過通透(permeabilised)處理（3）。所得的胜肽隨後使用SDS-PAGE（十二烷基硫酸鈉聚丙烯醯胺凝膠電泳）分析。

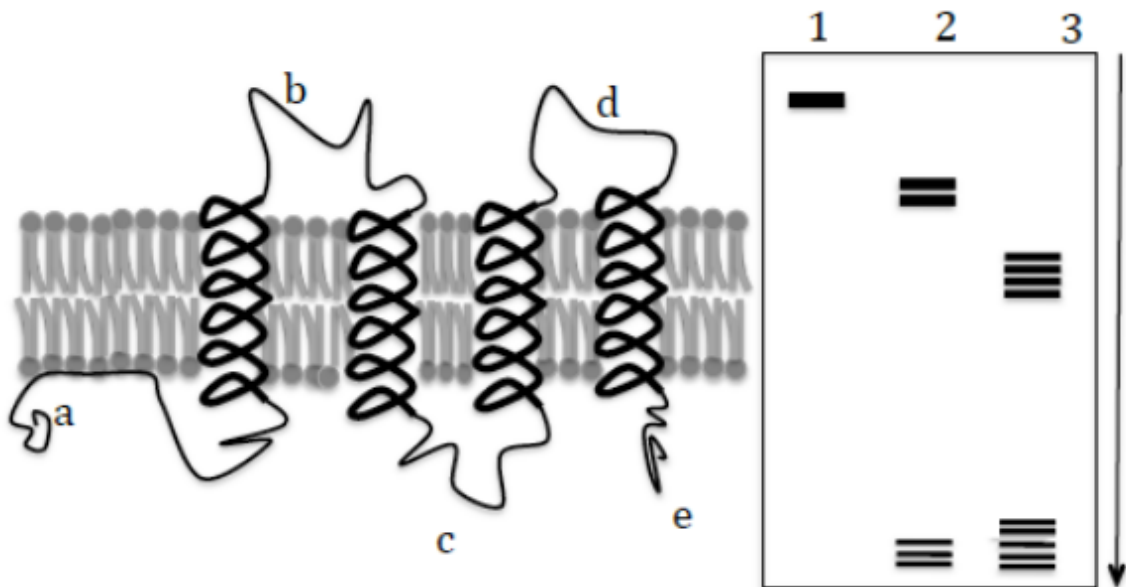


Fig.Q.5. Membrane protein (a, b, c, d, e: domains) and the SDS-PAGE gel

膜蛋白（a, b, c, d, e: 結構域）及SDS-PAGE電泳膠體影像

(1. untreated control, 2. peptides after protease cleavage, 3. peptides after permeabilisation and protease cleavage. The arrow indicates the direction of migration).

（1.未處理的對照組，2. 蛋白酶切割後的胜肽，3. 細胞膜通透處理後再經蛋白酶切割的胜肽。箭頭指示電泳泳動方向）。

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個敘述為真或假

- The bigger fragments in lane 3 are hydrophilic.
在泳道3中的較大的蛋白片段是親水性的。
- The smaller fragments in lane 2 represent protein domains protruding outside the membrane.
在泳道 2中的較小蛋白片段代表了向膜外突出的蛋白質結構區。
- Domain a is rich in leucine or isoleucine.
結構域a中富含Leucine或Isoleucine。
- Domains a, c and e protrude into the lumen of vesicles.
結構域a, c及e往囊泡的內腔方向突出。

Q.6

Ethanol inhibits microbial growth. Nevertheless, some strains of the yeast *Saccharomyces cerevisiae* can adapt to high concentrations of ethanol. Many studies have documented the alteration of cellular lipid composition in response to ethanol exposure.

乙醇抑制微生物的生長。然而，酵母的一些菌株釀酒酵母能適應高濃度的乙醇。許多研究已經證明細胞脂質組合物的改變響應於乙醇曝光。

In this investigation, we systematically altered the fatty acid composition in *S. cerevisiae* by knocking out OLE1 gene coding for integral membrane desaturase, responsible for the formation of monosaturated palmitoleic acid (Δ^9 -C16:1) and oleic acid (Δ^9 -C18:1). The knockout strain was then: (1) reconstituted with OLE1 gene by transformation with YEpOLE1 plasmid; (2) transformed with YEp- Δ^9 Hz, YEp- Δ^9 Tn, YEp- Δ^{11} Hz or YEp- Δ^{11} Tn plasmid containing Δ^9 or Δ^{11} desaturases of two lepidopteran insect (moths) *Helicoverpa zea* (Hz)or *Trichoplusia ni* (Tni). Fatty acid component and growth curves of each transformant were investigated and shown in table and figure below:

在本次調查中，我們通過剔除膜中去飽和酶(**desaturase**)編碼基因OLE1方式，系統性地改變了酵母菌的脂肪酸組成。此去飽和酶負責單飽和palmitoleic acid (Δ^9 -C_{16:1})和Oleic acid (Δ^9 -C_{18:1})之合成。基因剔除的菌株用以進行下列實驗：（1）轉殖YEpOLE1質體以重建OLE1基因；（2）轉殖YEp- Δ^9 Hz, YEp- Δ^9 Tn, YEp- Δ^{11} Hz or YEp- Δ^{11} Tn plasmid containing Δ^9 or Δ^{11} desaturases 質體使分別表現兩種飛蛾及夜蛾的Desaturase。每個轉型菌株的脂肪酸組成分和其生長曲線顯示在下表及圖中：

Table Q.6. Composition of major fatty acids in % of *S. cerevisiae* transformants at mid-log phase.
生長對數中期的各種酵母菌轉型菌株中主要脂肪酸組成百分比

Transformant	$C_{16:0}$	$C_{18:0}$	$C_{16:1}$	$C_{18:1}$
	<u>Saturated</u>	<u>Saturated</u>	<u>Monounsaturated</u>	<u>Monounsaturated</u>
OLE1	45.5 ± 2.2	4.7 ± 2.4	34.9 ± 0.8	14.9 ± 1.0
Δ^9 Hz	45.5 ± 5.5	7.9 ± 2.2	31.7 ± 5.6	11.0 ± 2.0
Δ^9 Tn	46.9 ± 4.0	8.6 ± 3.9	12.8 ± 1.9	31.7 ± 5.8
Δ^{11} Hz	45.6 ± 3.6	11.9 ± 2.8	42.6 ± 6.3	0
Δ^{11} Tn	49.7 ± 4.8	12.5 ± 0.1	41.8 ± 11.8	11.2 ± 1.5

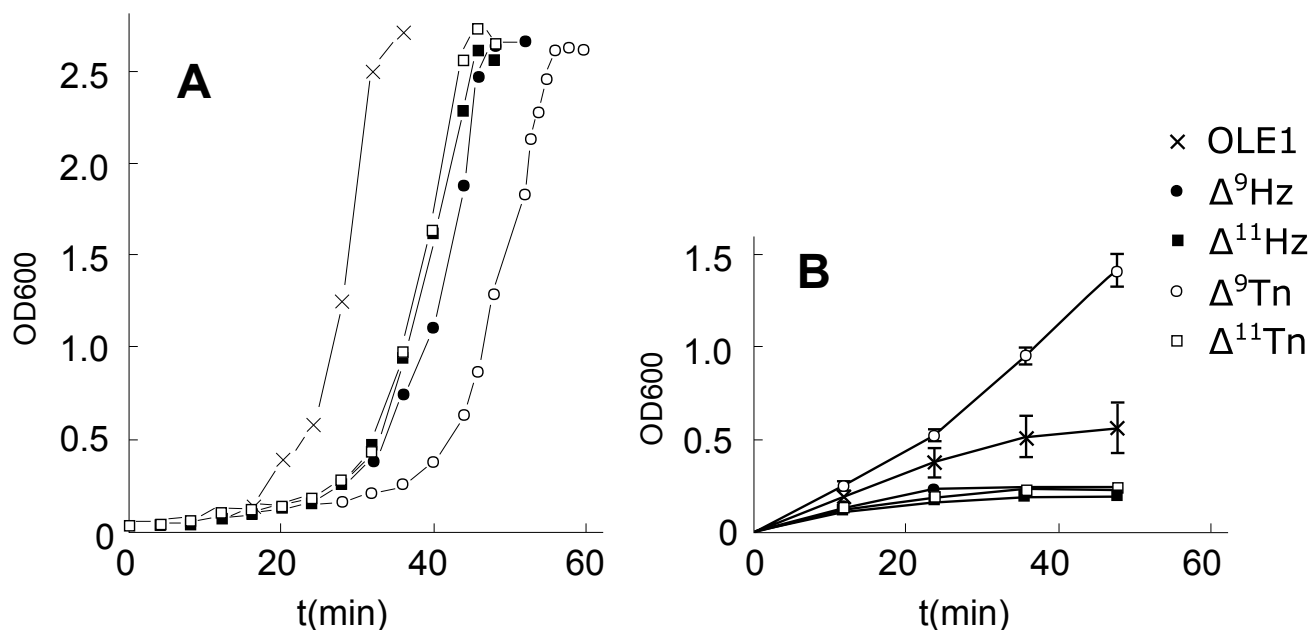


Fig.Q6. Growth curves of *S. cerevisiae* strains transformed with plasmid containing *OLE1* (x), Δ^9Hz (●), $\Delta^{11}Hz$ (■), Δ^9Tn (○) and $\Delta^{11}Tn$ (□) in YPD medium (A) and in YPD medium containing 5% ethanol (B)

各種酵母菌轉型菌株的生長曲線

將帶有OLE1 (x), Δ^9Hz (●), $\Delta^{11}Hz$ (■), Δ^9Tn (○) and $\Delta^{11}Tn$ (□) 表現質體轉型菌株培養在YPD培養基中(A), 或培養在含5%乙醇的YPD培養基中(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個敘述為真或假。

- The lag phase of transformant *OLE1* in YPD medium is shorter than those of Δ^9Hz , Δ^9Tn , $\Delta^{11}Hz$ and $\Delta^{11}Tn$ due to the presence of native desaturase in yeast cells.
在YPD培養基中培養的OLE1轉型菌株的生長遲滯期比 Δ^9Hz , Δ^9Tn , $\Delta^{11}Hz$ and $\Delta^{11}Tn$ 轉型菌株的為短, 是由於酵母細胞中具有天然去飽和酶(desaturase)。
- Desaturases are equally active in all transformants.
去飽和酶Desaturases在所有的轉型菌株中都同樣活躍。
- The content of mono-unsaturated fatty acids is a good indicator of the ethanol tolerance in *S. cerevisiae*.
單元不飽和脂肪酸的含量在酵母菌中是一個很好的乙醇耐受性指標。
- Higher ratio of $\Delta^9-C_{18:1}$ to $\Delta^9-C_{16:1}$ causes higher ethanol tolerance in *S. cerevisiae*.
較高的 $\Delta^9-C_{18:1}$ 與 $\Delta^9-C_{16:1}$ 比率使酵母菌對乙醇具有較高耐受性。

Q.7

Poly(3-hydroxybutyrate) (PHB) is a bacterial storage material which is accumulated by various bacteria, usually when grown under limitation of a nutrient such as oxygen, nitrogen, phosphate, sulphur, or magnesium and in the presence of excess carbon. Fig. Q7 shows the PHB synthesis pathway of *Ralstonia eutropha* from acetyl-CoA, which is regulated by feedback inhibition. In addition, acetyl-CoA can enter the citric acid cycle.

聚(3-羥基丁酸酯) (Poly(3-hydroxybutyrate), PHB) 是一種細菌儲藏物質，常在各種細菌中累積，尤其生長在營養物如氧，氮，磷，硫，或鎂受限的環境下，或過量的碳源存在之情況下會積累。圖 Q7 顯示 *Ralstonia eutropha* 細菌從乙醯輔酶A (acetyl-CoA) 合成PHB的路徑，此路徑會受到迴饋抑制調控。此外，乙醯輔酶A可進入檸檬酸循環 (citric acid cycle)。

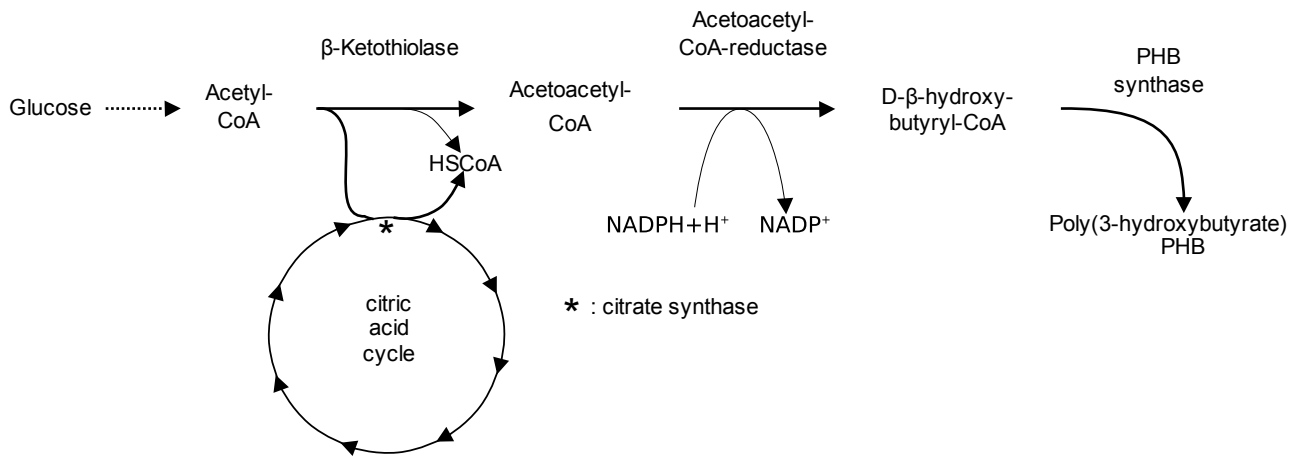


Fig. Q7. PHB synthesis pathway
PHB合成途徑

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

- The increase in activity of citrate synthase will reduce the production of PHB.
檸檬酸合成酶活性的增加將減少PHB的合成量。
- When the intracellular concentration of HSCoA is high, the rate of PHB synthesis will increase.
當細胞內HSCoA的濃度高時，PHB合成速率將增加。
- When the rate of PHB synthesis increases, the growth rate of *Ralstonia eutropha* cells will also increase.

當的PHB合成速率增加時， *Ralstonia eutropha* 細胞的生長速度也將增加。

- PHB synthesis is stimulated by low ratios of (NADPH+H⁺)/NADP
(NADPH + H⁺) / NADP的比率低時會促進PHB合成。

Q.8

A scientist has isolated five different peptides (1 to 5) containing five amino acids (named A, B, C, D, E). He determined the mass and the sequence of each peptide. The data which he obtained is shown on the table below
科學家已經分離出五種不同的胜肽（1~5），含有5種胺基酸（命名為A，B，C，D，E）。他測定其分子量與每種胜肽的胺基酸序列。他所獲得的數據顯示如下表

Peptide 胜肽	Amino Acids Sequence 胺基酸序列	Mass (Da) 分子量
1	BCDACCEDDCB	966
2	ABBCAEEDCEB	1099
3	BACDAEAECEA	1357
4	CACADBACAEB	1279
5	EDDCABBCCEE	1014

The mass of individual amino acids are shown in the table below
每個胺基酸的分子量如下表所示

Amino acids	Mass (Da)	Amino acids	Mass (Da)
Alanine	89	Leucine	131
Arginine	174	Lysine	146
Asparagine	132	Methionine	149
Aspartic Acid	133	Phenylalanine	165
Cysteine	121	Proline	115
Glutamic Acid	147	Serine	105
Glutamine	146	Threonine	119
Glycine	75	Tryptophan	204
Histidine	155	Tyrosine	181
Isoleucine	131	Valine	117

Note: The mass of a water molecule is 18 Da.

注意：一個水分子的分子量為18道爾頓。

Indicate if each of the following statements is True or False.

指出下列各敘述為真或假。

- A. Amino acid named C is serine
胺基酸C為絲胺酸(Serine)
- B. Amino acid named A is tyrosine
胺基酸A是酪胺酸(tyrosine)
- C. Amino acid named E is cysteine
胺基酸E是半胱胺酸(cysteine)
- D. Amino acid named B is glycine
胺基酸B是甘胺酸(glycine)

Q.9

Four different bacterial strains were isolated from the gut of a shrimp to study their probiotic potency through the decrease of their pathogenicity of *Vibrio harveyi*, a common bacteria infecting shrimp culture. In the first experiment, the four isolated bacteria were inoculated in cross-streak plates to observe inhibition zones against 4 bacterial strains (**Fig.9A**). In the second experiment, the shrimp survival rate in presence of *Vibrio harveyi* and each bacterial isolate after 5 days of incubation was measured (**Fig.9B**).

從蝦的腸道中分離到四種不同的細菌菌株,用以探討其降低哈維氏弧菌 致病性之效力, 以評估其作為益生菌之可能性。在第一個實驗中, 四個菌株畫在橫條紋板培養皿上觀察對四種細菌菌株的抑制區 (圖 9A)。在第二個實驗中, 在哈維氏弧菌及四種菌株同時接種後5天觀察蝦的存活率 (圖9B)。

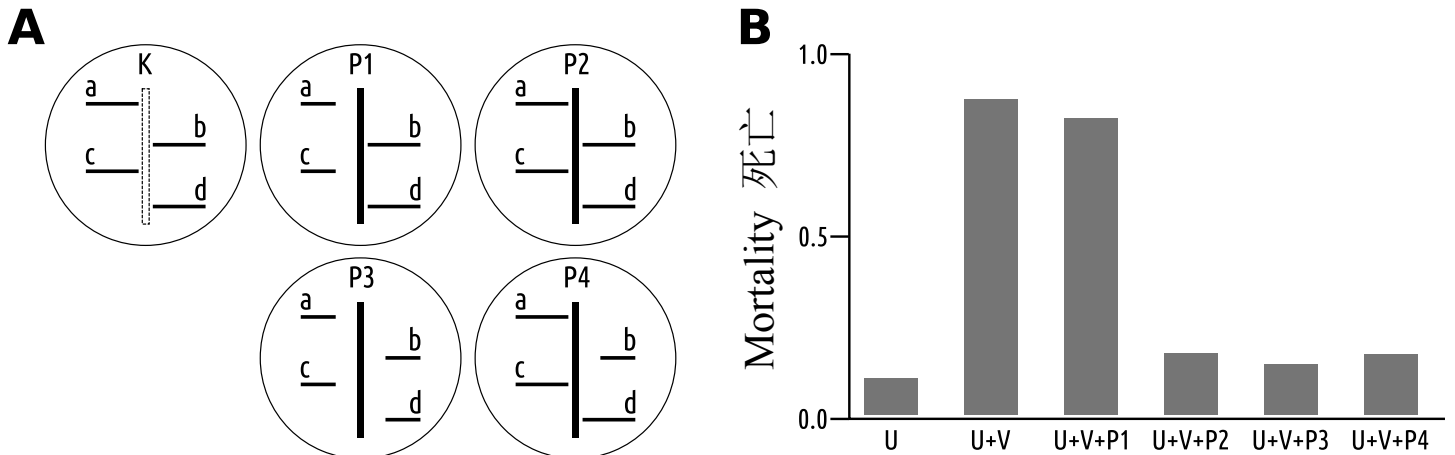


Fig.Q.9. (A) K = Control (no bacteria streaked on the dash box), P1-P4 = Probiotic candidates 1-4, a = *Streptococcus* sp. (Gram-positive), b = *Vibrio* sp. (Gram-negative), c = *Bacillus* sp. (Gram-positive), d = *Salmonella* sp. (Gram-negative). **(B)** U = shrimp culture alone, U+V = shrimp culture with addition of *Vibrio harveyi*, U+V+P1-4 = shrimp culture with addition of *Vibrio harveyi* and a specific probiotic candidate P1-4, respectively.

Fig.Q.9. (A) K = 控制組(無細菌劃線框), P1-P4 = 益生菌候選1-4, a = 鏈球菌(革蘭氏陽性), b = 弧菌(革蘭氏陰性) c = 芽孢桿菌(革蘭氏陽性), d = 沙門菌(革蘭氏陰性)。(B) U = 蝦單獨養殖, U + V = 蝦養殖與弧菌接種組, U + V + P1-4 = 蝦養殖與 弧菌及特定候選益生菌菌株(P1-4)分別接種)

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個敘述為真或假

- Candidate No.1 (P1) produced an antimicrobial compound that inhibited Gram negative and Gram positive bacteria.
益生菌候選1號 (P1) 產生一種抑制革蘭氏陰性和革蘭氏陽性菌的抗微生物化合物。
- Candidate No.2 (P2) was able to decrease *Vibrio* sp. pathogenicity without killing them.
益生菌候選2號 (P2) 能夠降低弧菌 *Vibrio* sp.的致病性但不會殺死他們。
- Candidate No.3 (P3) produced an antimicrobial compound targeting the outer membrane.
益生菌候選3號 (P3) 產生針對細菌外膜的抗微生物化合物。
- Candidate No.4 (P4) had good effect on the shrimp survival by inhibiting Gram-negative bacteria.
益生菌候選4號 (P4) 會藉由抑制革蘭氏陰性菌, 對蝦子存活有幫助。

Q.10

An experiment was set up to observe cell cycle length of a strain of yeast. Activated yeast cells were subcultured into a new medium with an initial concentration of 10^6 cells/mL. After 40 h, the number of cells increased to 4×10^6 cells/mL. A portion of the culture was taken for a separate experiment. In this experiment, cells were incubated for 15 min into a media containing radioactive thymidine before washing and re-grown on a new media containing non-radioactive thymidine. Cell samples were then taken periodically to measure the percentage of mitotic cells containing radioactive thymidine. **Fig.Q.10** shows the result obtained from the experiment. At each sampling, about 1% of the total cells sampled were undergoing mitosis.

某實驗設計用來觀察酵母菌株細胞週期的長度。活化的酵母菌在 10^6 個細胞/毫升的初始濃度下開始培養。40小時後，細胞數量增加至 4×10^6 個細胞/mL。培養物的一部分採樣後用以進行另一個單獨的實驗。在該實驗中，將細胞培養到含放射性標定的胸腺嘧啶(thymidine)培養基中15分鐘，清洗後再使其重新生長在不含放射標定的胸腺嘧啶之培養基中。然後細胞樣品再定時採樣收集，以測定含有放射性的胸腺嘧啶正在進行有絲分裂細胞之百分比。結果如圖**.Q.10**所示，實驗結果顯示。在每個採集樣品中約有1%的細胞正在進行有絲分裂。



Fig.Q.10, Fraction of mitotic cells that were labeled radioactively during the cell culture experiment.
細胞培養實驗中被放射性標記的有絲分裂細胞的比例。

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 synthesis rate of histone proteins is relatively high between 6 and 10 hours after radioactive labeled thymidine exposure.
暴露在放射性標記胸腺嘧啶後的6至10小時之間，組蛋白的合成速率相對較高。
- B.** S phase of the cell cycle takes about 5 hours.
細胞週期的S期大約為5小時。
- C.** M phase of the cell cycle takes longer than 1 hour
細胞週期的M期比1小時長。
- D.** Most of the radioactive thymidine is assimilated in the S phase of the cell cycle.
大多數的放射性胸腺嘧啶在細胞週期的S期被細胞同化作用所使用。

PLANT ANATOMY AND PHYSIOLOGY

植物解剖及生理學

Q.11

Cell walls provide plant cells with a substantial degree of volume homeostasis relative to the large changes in water potential that they experience as the everyday consequence of the transpirational water loss. Cell water potential (Ψ_w) of a plant cell is composed of solute potential (Ψ_s) and turgor pressure potential (Ψ_p). Relative cell volume is correlated with cell water potential and its components as described in the (Fig.Q11).

細胞壁幫助維持植物細胞體積的穩定，然而水勢則因每天蒸散作用所導致的水分喪失而呈現大幅變化。植物細胞的水勢 (Ψ_w) 包括溶質勢(Ψ_s) 及膨壓勢(Ψ_p)。細胞相對體積與細胞水勢以及其組成成分有關，如圖 Q11所述。

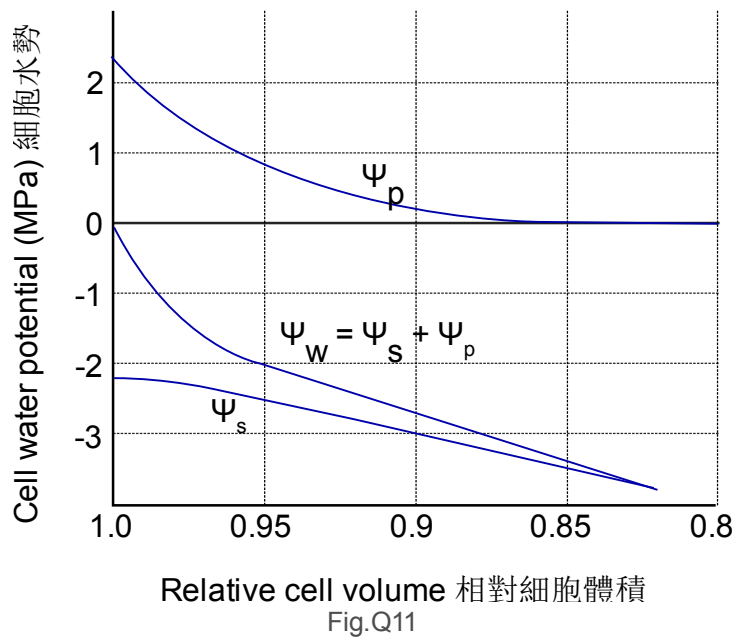


Fig.Q11

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. Alterations of plant cell water potential are generally accompanied by a large change in turgor pressure and in cell volume.
植物細胞水勢的改變通常伴隨膨壓及細胞體積的大幅變化。
- B. Disappearance of turgor pressure indicates the ending point of cell plasmolysis with reduction of approximately by 15% cell volume.
膨壓的消失表示細胞接近原生質離的終點，且使其體積減少約15%
- C. As the cell volume decreases by 10%, most of the change in cell water potential is caused by the drop in cell solute potential together with little change in turgor pressure.
當細胞體積降低10%，細胞水勢最大的變化是由於細胞溶質勢的下降，而膨壓幾乎沒有改變
- D. During cell rehydration, cell volume expansion stops when cell wall generates pressure equivalent to turgor pressure and the cell water potential reach zero
在細胞重新獲得水分期間，當細胞壁產生相當於膨壓的壓力時，細胞體積停止延伸，且細胞的水勢趨近於 0

Q.12

An experiment was carried out on sorghum (*Sorghum bicolor*) and soybean (*Glycine max*) plants in response to low temperature. Plants were grown at 25°C for several weeks and then at 10°C for three days, while day length and light intensity and ambient carbon dioxide concentration were kept constant throughout the experiment unless stated otherwise. The net photosynthesis of both plant species at 25°C are shown in Fig.Q12 below.

在高粱及大豆植株對低溫的反應實驗中，先將植株培養在25°C下生長數週，然後移至10°C下三天，且在實驗期間，日照時間、光強度及二氧化碳濃度維持恆定，除非特別註記。兩種植物在 25°C 下的淨光合作用結果如圖 Q12 所示。

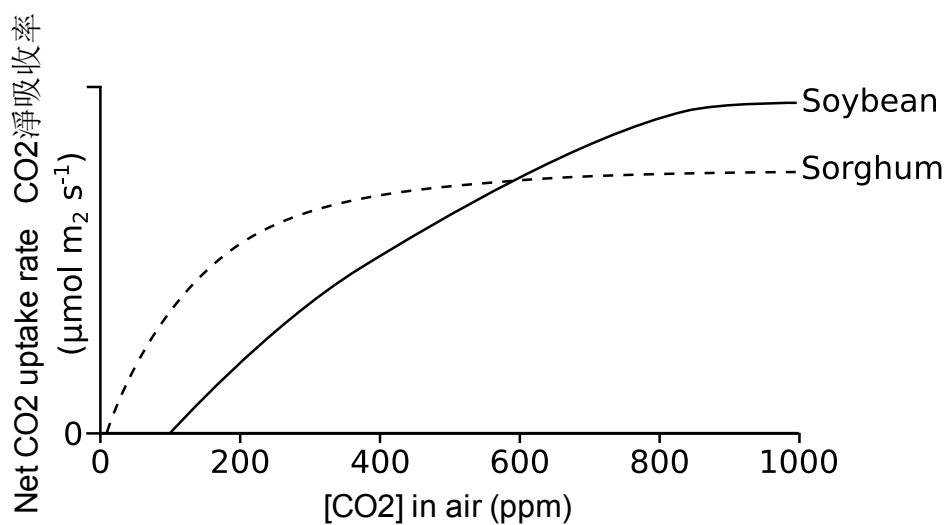


Fig.Q.12 圖 Q.12

Carbon dioxide uptake per leaf dry mass (mg CO₂g⁻¹)
每克葉乾重可吸收的二氧化碳量

Days	before	1	2	3	4-10
Temperature	25°C	10°C	10°C	10°C	25°C
Sorghum 高粱	48.2	5.5	2.9	1.2	1.5
Soybean 大豆	23.2	5.2	3.1	1.6	6.4

- 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. If put at 35°C, photosynthesis rate of soybean would decrease and that of sorghum would not change.
若在35°C下，大豆的光合作用速率會下降，但高粱則不變
 - B. In cool condition, the biomass of sorghum increases faster than that of soybean.
在涼爽環境下，高粱的生物量增加的較大豆快
 - C. Soybean plants are likely to have smaller photosynthetic water use efficiency than sorghum.
就光合作用之水分使用效率而言，大豆植株可能較高粱低
 - D. The reduction of the carbon dioxide uptake in sorghum is mainly due to the decrease of enzyme activity in low temperature.
高粱的CO₂吸收量降低主要是因為在低溫下酵素活性下降

Q.13

The bacterium *Bradyrhizobium japonicum* can infect soybean (*Glycine max*) roots and form nodules. The nitrogen fixation catalyzed by nitrogenase occurs in the nodules and the nitrogenase activity can be measured easily by acetylene reduction instead of nitrogen reduction. Scientists generated a defective mutation of NAD⁺-dependent malic enzyme (*dme* mutant), the enzyme that generates pyruvate and NADH, and infected soybean seedling roots with wildtype and mutant bacteria. The seedlings were grown in nitrogen-free media. After 14 and 28 days of inoculation, the number and weight of nodules in the seedlings and acetylene reduction activity were recorded.

細菌 *Bradyrhizobium japonicum* 可感染大豆根部並形成根瘤。在根瘤中，固氮作用由固氮酶來催化，且其活性可藉由測量乙炔的減少量而得，無須測量氮的降低量。學者生產一種 NAD⁺ 依賴型蘋果酸酶 (可生成丙酮酸及 NADH 的酵素) 的缺失突變菌株 (*dme* mutant)，並用野生型及突變型的細菌來感染大豆幼苗根部，然後在無氮源環境下培養幼苗，分別感染 14 天和 28 天後，記錄根瘤數目與重量，以及乙炔的減少量。

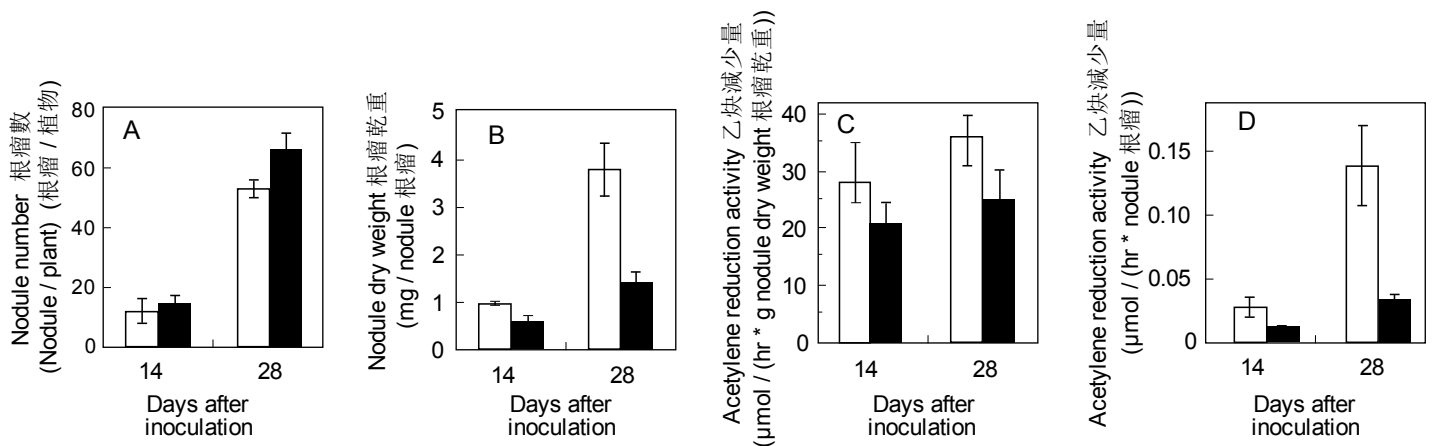


Fig.Q13. Nodule number and dry weight and acetylene reduction activity of soybean. Soybean nodules infected with wild-type *B. japonicum* (open bars) and the *dme* mutant (solid bars) are presented.

大豆之根瘤數目與乾重以及乙炔的減少量。大豆根瘤被細菌 *B. japonicum* 感染：野生型(空心直條)；*dme* 突變型(實心直條)

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

- Nitrogen fixation activity in nodules of the same treatment at 28 days after inoculation is higher than that at 14 days after inoculation.
相同處理下，根瘤的固氮作用在感染後 28 天較 14 天者高
- Both number and size of nodules increase with time from 14 to 28 days after inoculation with *B. japonicum*.
從感染後 14 天至 28 天，根瘤的數目及大小皆隨時間而增加
- The reduction in nitrogen-fixing activity of nodules infected by the mutant at 28 days after inoculation compared to those at 14 days after inoculation is due to the reduction of nitrogenase activity and nodule formation.
在根瘤的固氮作用能力方面，被突變型細菌感染後 28 天的根瘤相較於被感染後 14 天者為低，是因為固氮酶活性的降低以及根瘤形成的能力減弱
- Nitrogen fixation in *B. japonicum* -induced nodule is down-regulated by NAD⁺-dependent malic enzyme.
在 *B. japonicum* 菌誘導形成的根瘤中，固氮作用是受到 NAD⁺ 依賴型蘋果酸酶之向下調控

Q.14

Sucrose is produced in leaves and translocated short and long distance through veins to non-photosynthetic organs such as roots, stems, flowers and fruits. Two principal pathways include symplast and apoplast by which sucrose molecules are transported in phloems of leaves as shown in Fig.Q14.

蔗糖在葉片產生，並經由葉脈以短距離及長距離運送至不能行光合作用的器官，如根、莖、花及果實。在葉片韌皮部中，蔗糖的運送途徑有共質體與質體外兩種，如圖Q14所示

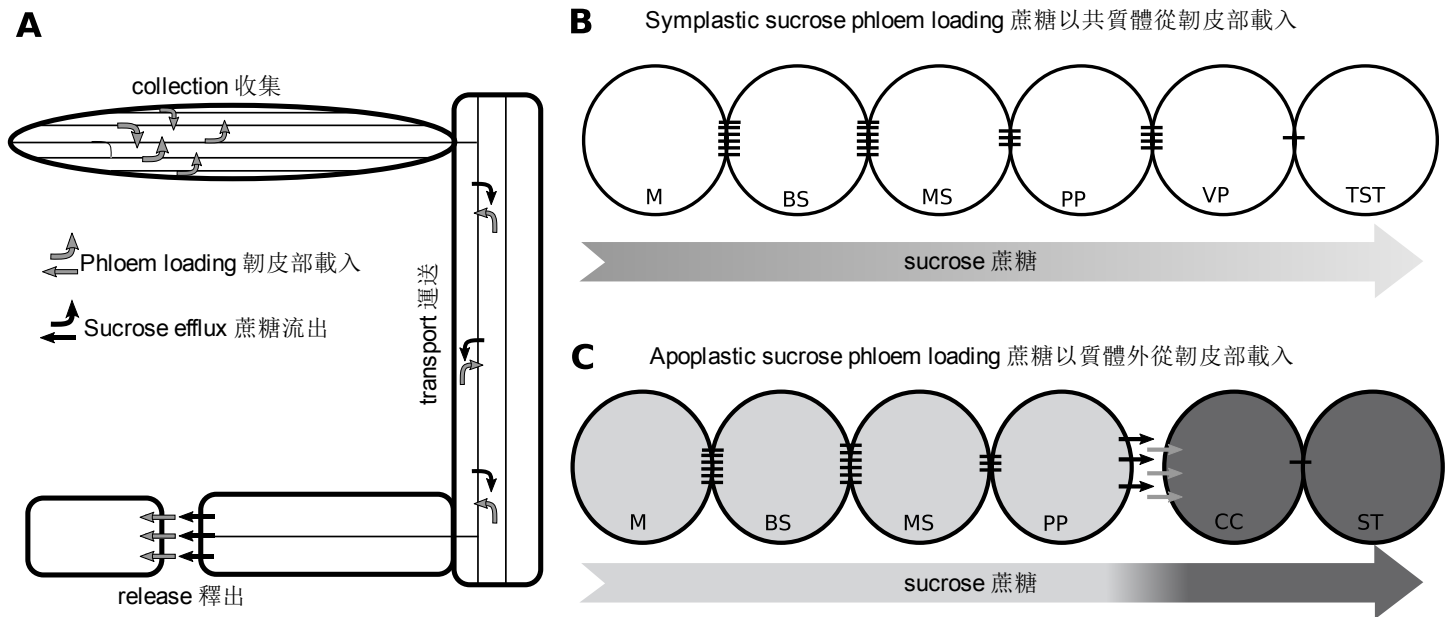


Fig.Q14. Diagram of the whole plant phloem network. M - Mesophyll, BS - Bundle sheath, MS - Mestome sheath, PP - Phloem parenchyma, VP - Vascular parenchyma, CC - Companion cell, TST - Thick walled sieve element, ST - Sieve element.

植物體內的韌皮部運送網示意圖。M - 葉肉細胞，BS - 維管束鞘，MS - 束鞘細胞，PP - 韌皮部薄壁細胞，VP - 維管束薄壁細胞，CC - 伴細胞，TST - 厚壁篩管細胞，ST - 篩管細胞

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

- Sucrose is synthesized in leaves and transported long distance through phloem to sinks under hydrostatic pressure gradient.
蔗糖在葉中生成，並經由韌皮部，藉靜水壓梯度，以長距離運送蔗糖至需求部位
- Loading sucrose in apoplastic pathway requires energy in several steps due to the movement across secondary wall of living cells.
藉質體外運輸途徑載入蔗糖時，有些步驟需要消耗能量，因為須通過活細胞的次生細胞壁
- In the symplastic pathway, sucrose molecules are passively loaded through plasmodesmata.
在共質體運輸的途徑中，蔗糖的移動是以被動載入方式通過原生質絲
- Unloading sucrose molecules at the sinks requires no energy release because of movement down a gradient concentration of sucrose.
在需求部位，蔗糖的卸載不需消耗能量，因為是藉蔗糖濃度漸減梯度來驅動

Q.15

Scientists measured length and height of rhizophores of mangrove plant (*Rhizophora mangle*, Fig.Q15A). They also made cross sections of rhizophores and observed their anatomical characteristics. The results are shown in Q15B and Q15C.

學者測量紅樹植物 *Rhizophora mangle* 的支持根之長與高，如圖.Q15A所示。另外也觀察支持根橫切面的解剖特徵，其結果如圖Q15B 及Q15C所示

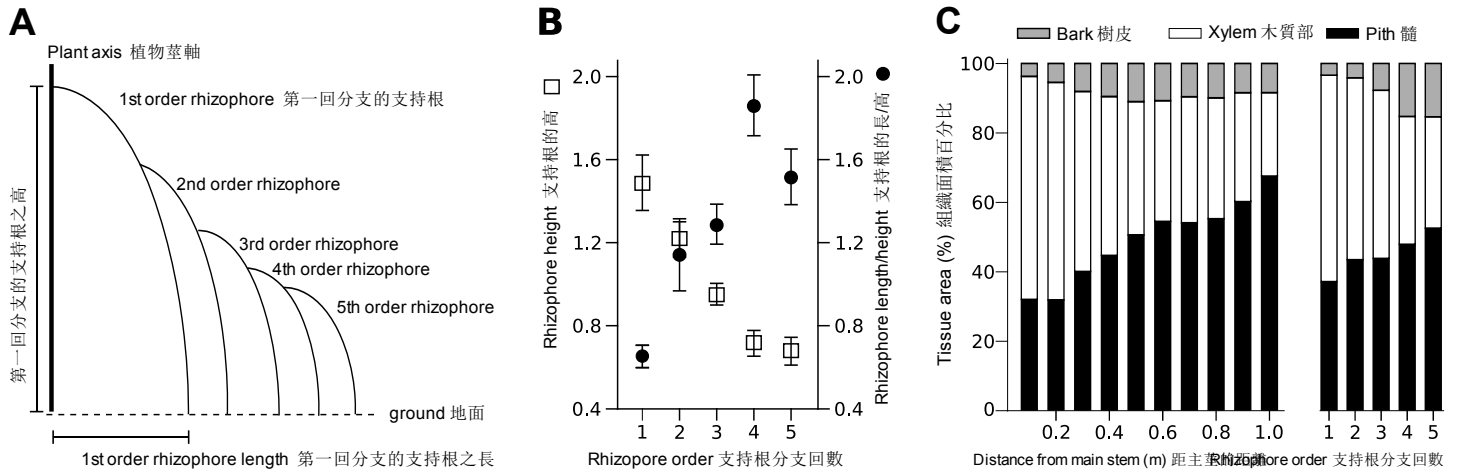


Fig.Q15. Rhizophores of *Rhizophora mangle* plants. **A:** Rhizophore height and length measurement. **B:** Change in height (empty square) and in length/height proportion (full circle) in five sequential orders of rhizophores. **C:** Relative proportions of bark (including aerenchyma), xylem and pith along the length of individual first-order rhizophores (left), and at the base of rhizophores of sequential orders (right).

圖.Q15. 紅樹植物的支持根。 **A:** 支持根之高與長的測量； **B:** 支持根連續 5 回分支的高(空心方格)以及長/高比例(實心圓)之變化； **C:** 第一回分支的支持根中的樹皮(包括通氣組織)、木質部及髓的相對組成比例(左側)；在支持根基部的分支回數(右側)

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

- There are monotonic decreases in rhizophore height and the length/height proportion in the rhizophores as a function of the rhizophore order.
支持根的高 以及長/高比例會隨支持根分支回數而遞減
- Within first-order rhizophores, the xylem proportion in the cross-section is larger when closer to the main stem, and decreases progressively as the rhizophore approached the ground while increasing the proportion of bark and pith.
在第一回分支的支持根橫切面中，愈接近主莖者其木質部所占比例愈大，且當支持根逐漸接觸地面，該比例漸減
- When rhizophore order changes from 1 to 5, bark and pith proportion decreases, while xylem proportion increases.
當支持根分支回數由1至5 改變，樹皮與髓的比例降低，然而木質部比例上升
- The supportive function is likely enhanced in the first-order rhizophores, with lower length/height proportion, and higher proportion of xylem compared with bark and pith.
在第一回分支的支持根中，支持功能可能增強，因為其長/高比例較低，且相較於樹皮與髓的比例，木質部所占比例較高

Q.16

Arsenic (As) in the soil has become an environmental concern worldwide because it is difficult to remediate and can adversely impact human health. The fern, *Athyrium yokoscense* is well known as a Cd hyperaccumulator as well as a Cu, Pb and Zn tolerant plant. However, no information is available on As accumulation by *A. yokoscense*, although it often grows in soils containing high levels of several heavy metals and As. To understand As accumulation in *A. yokoscense*, a student conducted an experiment in which young ferns collected from a mining area were grown in media containing As-spiked paddy soils or mine soil in a greenhouse for 21 weeks. Before transplanting fern biomass was $0.26 \pm 0.08 \text{ g plant}^{-1} \text{ DW}$ and As concentrations of young and old fronds were 7.8 ± 0.3 and $57.7 \pm 2.2 \text{ mg kg}^{-1}$, respectively.

土壤中的砷(As)污染已是全世界矚目的環境議題，因為它不易移除，且會嚴重影響人類健康。有一種蕨類 *Athyrium yokoscense* 因為可在體內超量累積鎘(Cd)而聞名，它同時也是銅(Cu)、鉛(Pb)及鋅(Zn)的耐受植物。然而對於此蕨類體內是否也可以累積砷，則無相關資訊可供參考。雖然此蕨類也常生長在含有高濃度之多種重金屬及砷的土壤中。為了解砷在此蕨類體內的累積情形，某學生進行了一項實驗：將從礦區採得的此蕨類幼株，以含有不同砷濃度的田間土壤或礦區土壤，在溫室中種植21週。在移植前，此蕨類的生物量(乾重)為 $0.26 \pm 0.08 \text{ g plant}^{-1} \text{ DW}$ ，且其新葉及老葉中的砷濃度分別為 7.8 ± 0.3 and $57.7 \pm 2.2 \text{ mg kg}^{-1}$ ，

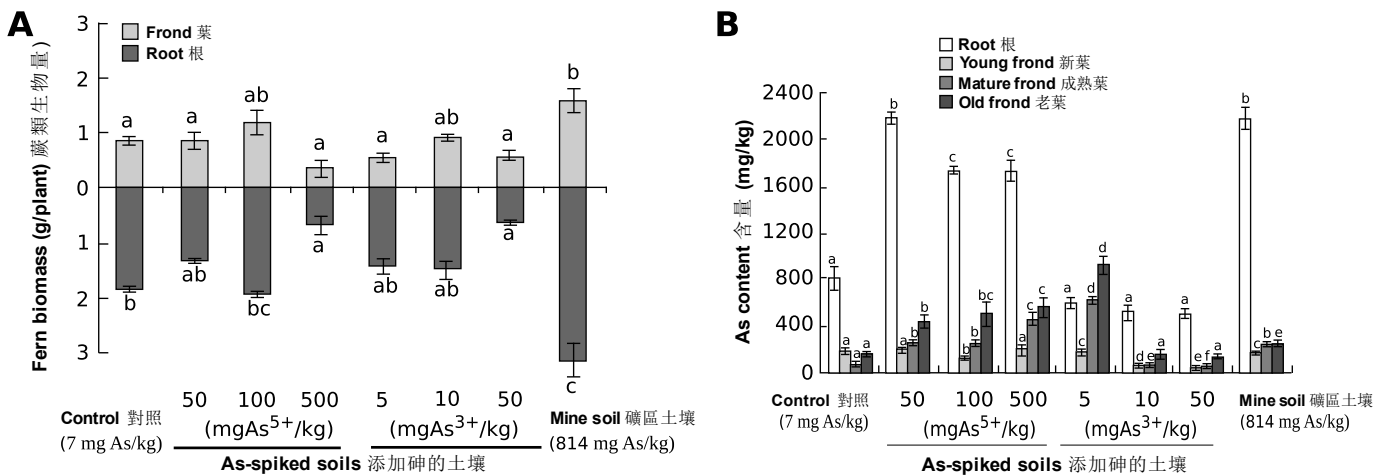


Fig.Q16. A: Dry biomass of *A. yokoscense* after 21 weeks of cultivation in a greenhouse. **B:** Arsenic concentration in different parts of *A. yokoscense* cultivated in As- spiked soils and mine soils. a,b,c letter above each bar indicate the significant difference of the same plant parts

圖Q16. A: 蕨類 *A. yokoscense* 在溫室生長 21 週後的生物量(乾重); B: 分別生長在添加不同砷濃度土壤或礦區土壤的蕨類個體，其不同部位的砷濃度的測量，直條上方的a,b,c 字母代表其具顯著差異。

Tukey's test, a multiple comparison procedure and statistical test was used. The statistical significance of the difference between treatments for a given organ, are shown using the letter a – f above the bar. The same letter means there is no statistical difference for that organ.

Tukey's 檢定是一種多項比較過程及統計檢定方法。對特定器官的處理間之差異具統計上的顯著性，在直條上方用a – f 字母來表示。若字母相同即代表對該器官沒有統計上的顯著差異

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.** Moderate As levels in soils promote the growth of ferns.
土壤中適度的砷濃度可促進此蕨類的生長
- B.** Concentration of As in root grown in arsenite-spiked media (As^{3+}) is lower than those in arsenate treatment(As^{5+}), resulting in the increase of total biomass.
植株生長在含有亞砷酸鹽的基質時，其根中的砷濃度相較於生長在砷酸鹽處理者為低，且造成植株的總生物量增加
- C.** Arsenic concentration increases from young to old fronds and is correlated to As levels in the soil
從新葉到老葉的砷濃度漸增，且與土壤中的砷含量有相關
- D.** The transfer of As from root to frond of *A. yokoscense* in mine soil over time is similar to that in arsenate-spiked soil.
在礦區土壤中生長的蕨類，其體內的砷由根轉移到葉的情形，與生長在砷酸鹽增強的土壤中結果相似

To study the effect of phytohormone on fruit maturation, researchers used abscisic acid (ABA) and ethephon to treat of sweet cherry fruits and afterward to evaluate the expression of *PacNCED1* gene which encodes 9-cis-epoxycarotenoid dioxygenase, a key enzyme in ABA biosynthesis. They also checked the expression of *PacACO1* gene encoding 1-aminocyclopropane-1-carboxylic acid oxidase enzyme that involves in ethylene biosynthesis. The transcript of *PacACT1* (one b-actin cDNA fragment was cloned and designated as *PacACT1*, accession number FJ560908) was used to standardize for all expression (Fig.Q17-D).

為了研究植物激素對果實成熟的影響，研究學者們利用離層酸 (ABA)及益收素(ethephon)來處理櫻桃果實，然後再測定*PacNCED1* 基因的表現量，此基因負責製造 9-cis-epoxycarotenoid dioxygenase，此酵素為ABA生合成過程中的關鍵酵素。學者也檢測 *PacACO1* 基因的表現，此基因負責製造1-aminocyclopropane-1-carboxylic acid oxidase enzyme，此酵素參與乙烯的生合成過程。編碼一種蛋白質 *PacACT1* 的 mRNA(一段從 b-actin cDNA 選殖出的基因片段.被命名為 *PacACT1*, 基因編號為 FJ560908)的量被當作所有基因的mRNA表現量的標準化參考 (圖Q17-D)。

Treatment 處理	Firmness of pulp 果肉紮實度	Soluble solids content/ titratable acidity 可溶固體含量 / 可滴定之酸度	Anthocyanin(U.g ⁻¹) 花青素含量
Control 對照	20.3a	14.4a	13.4a
Ethephon 益收素	19.6a	15.3a	14.4a
ABA 離層酸	11.9b	16.8b	23.8b

(a and b show values that are significantly different).

(a 及 b 顯示實驗數值具顯著差異)

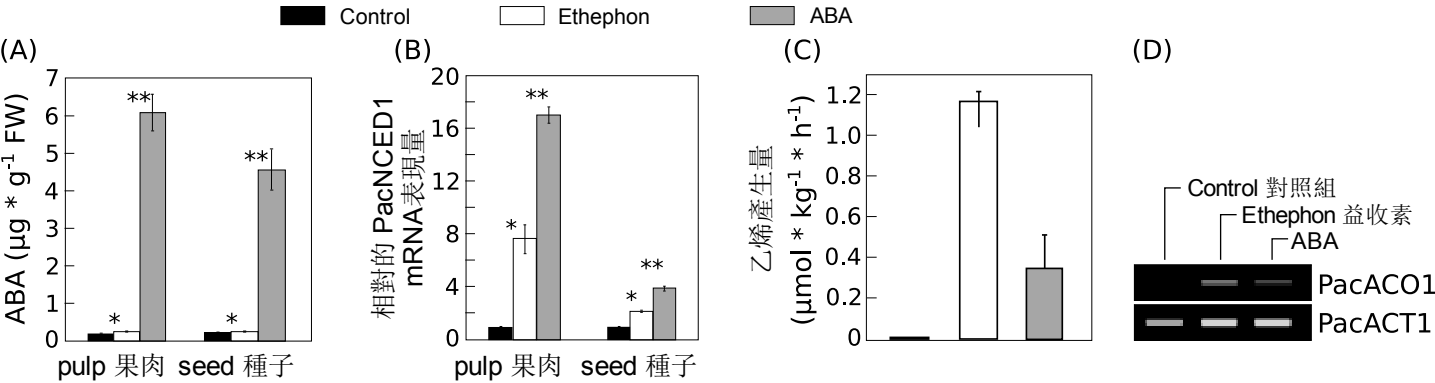


Fig. Q17. Effects of ABA and ethephon application on ABA content (A), accumulation of *PacNCED1* (B), ethylene production during ripening (C) and *PacACO1*(D). * and ** indicate significant differences compared to control. 圖Q17 ABA及益收素對 ABA 含量 (A)、*PacNCED1*的累積 (B)、成熟期間產生的乙烯量 (C) 以及*PacACO1*(D)的影響。* 和 ** 表示數據與對照組比較後具顯著差異。

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.** Both ABA and Ethephon stimulate the expression of *PacACO1* and *PacNCED1* genes in sweet cherry fruit.
ABA 和 Ethephon 兩者皆可促進櫻桃果實中*PacACO1* 和 *PacNCED1* 基因的表現
- B.** The expression of *PacNCED1* and ABA accumulation in pulp are higher than in the seed in the treatments of ABA
以 ABA 處理後，果肉內的 *PacNCED1* 的表現量和 ABA 的累積量均高於種子
- C.** ABA induces the maturation of sweet cherry fruit via stimulation of ethylene production.
ABA 誘導櫻桃果實的成熟，是經由促進乙烯的生合成來達成
- D.** Ethephon shows lower effect on anthocyanin and endogenous ABA production than exogenous ABA does.
相較於外加ABA處理，Ethephon 對於花青素和內生型 ABA 的合成的影響程度較低

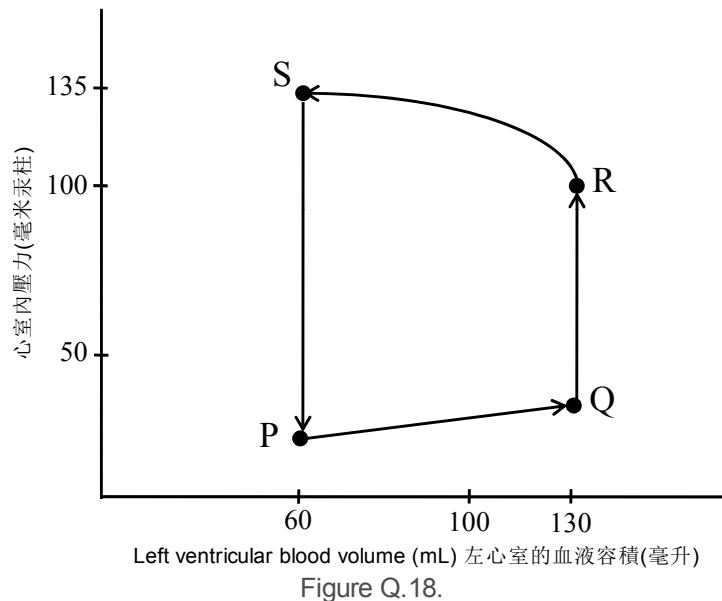
ANIMAL ANATOMY AND PHYSIOLOGY

動物解剖與生理

Q.18

A 55-year-old man has a resting cardiac output of 7000 mL/minute. His arterial pressure is 125/85 mmHg. His heart rate is 100 beats/min and his body temperature is normal. Figure Q.18 represents the changes in left ventricular pressure and blood volume during a cardiac cycle.

一位55歲男子休息時的心輸出量為7000毫升/分，動脈壓為125/85毫米汞柱，心跳是100次/分，體溫正常。圖Q.18表示在一個心搏週期中左心室壓力和血液容積的變化。



Indicate in the Answer sheet if each of the following statements is True or False.

在答案卷上寫出下列各敘述是 正確 或 錯誤。

- A. At Q, the left atrioventricular valve is opened.
在 Q 時，左房室瓣(二尖瓣)打開.
- B. Ventricular ejection ends at S.
S 時，心臟停止排出血液.
- C. The distance from S to P should be longer if there is a narrowing of the aortic valve .
如果有主動脈瓣狹窄，由 S 到 P 的距離應該更長.
- D. In period R-S, blood does not flow into both atria and ventricles.
在 R-S 期間，血液不會流入心房和心室.

Q.19

Cardiac output (CO) is the volume of blood pumped by the heart in one minute. Cardiac output is affected by the stroke volume (SV) and the heart rate (HR). Cardiac output can be measured indirectly using the Fick's equation: $CO = Q/(A-V)$, where Q is the rate of oxygen consumption (mL/min), A-V is the difference between oxygen concentration in the arterial blood (A) and in the venous blood (V). The data below were measured from a healthy person before and during physical exercise.

心輸出量(CO)是在一分鐘內由心臟泵出血液的體積，心輸出量大小受心搏出量(SV)和心跳速率(HR)的影響。心輸出量可間接以Fick's公式測量： $CO = Q/(A-V)$ ，其中Q是耗氧率(mL/min)，A-V是動脈血(A)和靜脈血(V)之間的氧濃度差異。以下資料是一個健康的人在運動前和運動期間所測得的。

Parameters 參數	Before Exercise 運動前	During Exercise 運動時
Rate of oxygen consumption (Q) 耗氧率	250 mL/min	1500 mL/min
Oxygen difference (A-V) 氧分壓的變化	50 mL/L blood	150 mL/L blood
Heart rate (HR) 心跳速率	60 beats/min	120 beats/min

Indicate in the Answer sheet if each of the following statements is True or False.

在答案卷上寫出下列各敘述是 正確 或 錯誤。

- A. Cardiac output increased by two-fold during exercise.
心輸出量在運動過程中增加了兩倍。
- B. Stroke volume during exercise was higher than that before exercise.
運動時心搏出量明顯高於運動前。
- C. Physical exercise caused a reduction in hemoglobin's binding for oxygen in tissues, resulting in a three-fold increase in the amount of oxygen released to tissues.
運動可導致組織中的血紅蛋白與氧的結合能力減少，造成氧氣釋放到組織的量增加三倍。
- D. The number of heart beats required to supply a tissue with 3000 mL of oxygen during exercise is 240.
若運動時要供應某一組織 3000 mL 的氧，則需要有240次的心跳。

Q.20

Figure Q.20 shows the models of four types of common human congenital heart defects.

圖Q.20顯示四種人類先天性的心臟缺失類型

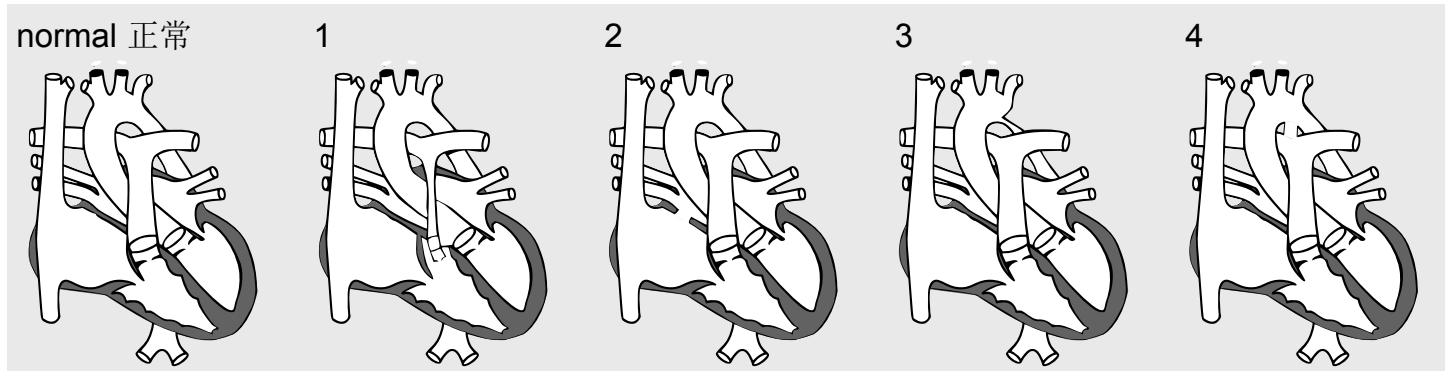


Figure Q.20.

Indicate in the Answer sheet if each of the following statements is True or False.

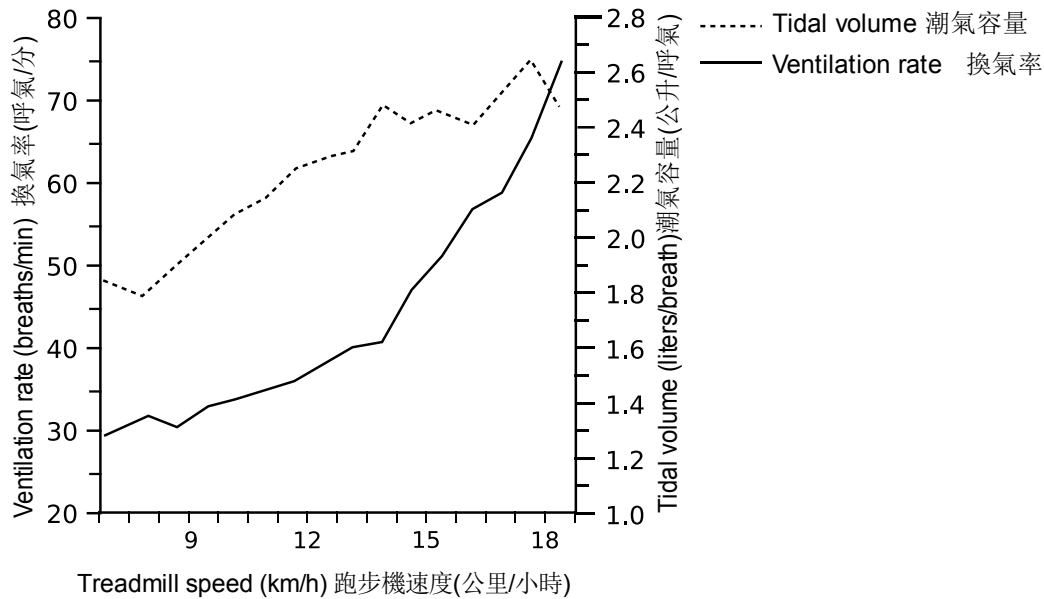
在答案卷上寫出下列各敘述是 正確 或 錯誤。

- A. In type 1, the blood volume going to the lungs is lower than normal.
在第一型中, 進入肺臟的血液較正常人為少
- B. In type 2, the stroke volume of the left ventricle is increased.
在第二型中, 左心室的心搏出量增加
- C. In type 3, the systolic blood pressure at the arms is higher than that in the normal type.
在第三型中, 在手臂測到的心縮壓較正常人為高
- D. In type 4, the pulmonary blood pressure is increased.
在第四型中, 肺臟血壓增加

Q.21

Figure Q.21 shows how lung ventilation is affected by physical activity. As the intensity of exercise increases, humans respond to the increased need for gas exchange in two ways: increase in ventilation rate and increase in tidal volume. The experimental data for a well-trained runner on a treadmill are shown in Figure Q.21.

圖Q.21顯示肺換氣如何受到運動的影響。隨著運動強度增加，人類對氣體交換的需要兩方面增強：即增加換氣率和增加潮氣容量。一個訓練有素的跑步者在跑步機上的實驗資料如圖Q.21所示。



Indicate in the Answer sheet if each of the following statements is True or False.

在答案卷上寫出下列各敘述是 正確 或 錯誤。

- The increase in ventilation rate is faster than the increase in tidal volume when the treadmill speed increases from 9 km/h to 12 km/h.
在跑步機速率為每小時9到12公里時，換氣率的增加比潮氣容量的增加為快
- In intense physical exercise (> 15 km/h treadmill speed), the increase in the ventilatory minute volume is mainly caused by increased ventilation rate.
在激烈運動時 (> 15 km/h 跑步機速率)，每分鐘換氣量的增加主要是由換氣率增加引起。
- At the treadmill speed of 15 km/h, the ventilatory volume per minute is approximately 120 L.
跑步速率在每小時15公里時，每分鐘換氣量約為120 公升。
- In an adult human, a tidal volume of 0.2 L and ventilation rate of 30 breaths per minute can provide equally effective gas exchange as a tidal volume of 0.6 L and a ventilation rate of 10 breaths per minute.

某一成人當其進行潮氣容量為0.2公升、換氣率為每分鐘30次的呼吸運動時所能提供的氣體交換效率，與進行潮氣容量0.6公升、換氣率每分鐘10次的深呼吸具有同樣效果。

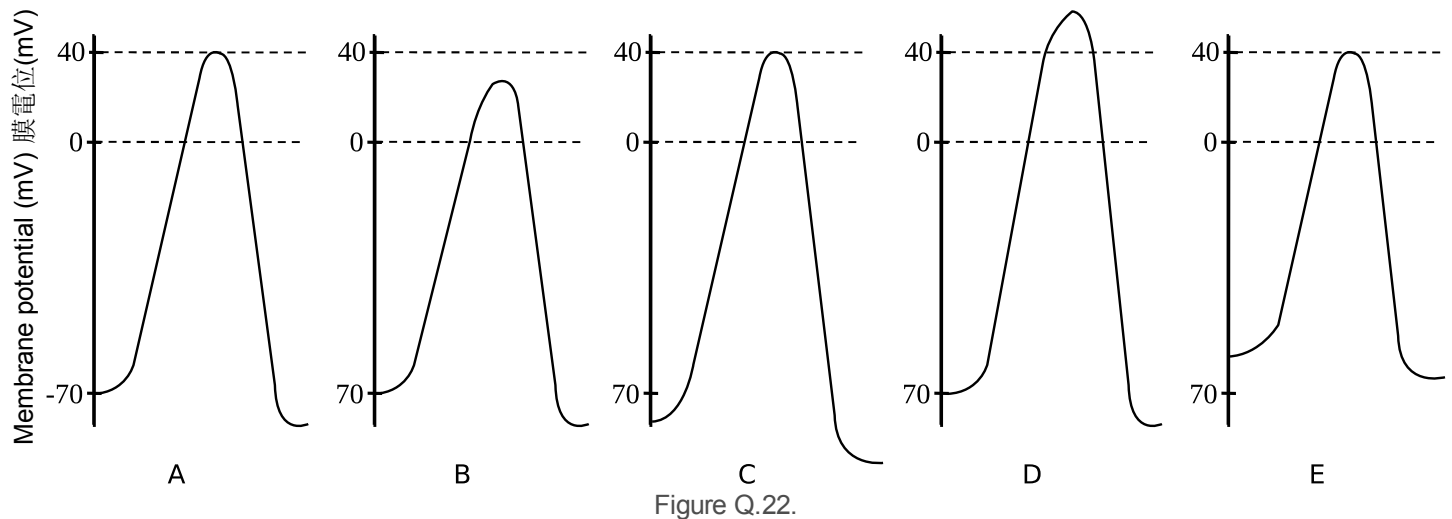
Q.22

In an experiment, a researcher isolated a neuron and placed it in the standard Ringer solution (isotonic physiological solution). He measured the resting membrane potential of the axon, then stimulated the axon and measured its action potential (Record A, Figure Q.22).

在一項實驗中，研究員分離一條神經元後，將其置於標準林格氏液（等滲生理溶液）中。他測量軸突的靜止膜電位，然後刺激軸突並測量其動作電位（圖Q.22記錄A）。

Subsequently, he repeated the experiment several times, each with a different modified Ringer solution. Figure Q.22 shows some of the results (Records B to E).

隨後，他重複做此實驗多次，每次使用不同修改的林格氏液。圖Q.22顯示其中的一些實驗結果（記錄B至E）。



Indicate in the Answer sheet if each of the following statements is True or False.

在答案卷上寫出下列各敘述是正確或錯誤。

- A. If the modified Ringer solution contained a lower concentration of Na^+ than the standard Ringer solution, the action potential is Record B.
如果修改的林格氏液所含的 Na^+ 濃度比標準的林格氏液低，則動作電位是記錄 B
- B. If the modified Ringer solution contained a lower concentration of K^+ than the standard Ringer solution, the action potential is Record C.
如果修改的林格氏液所含的 K^+ 濃度比標準的林格氏液低，則動作電位是記錄 C
- C. If the modified Ringer solution contained a substance that increased membrane permeability to K^+ , the action potential is Record D.
如果修改的林格氏液含有一種能增加膜對 K^+ 通透性的物質，則動作電位是記錄 D
- D. If the modified Ringer solution contained a substance that increased membrane permeability to Cl^- , the action potential is Record E.
如果修改的林格氏液含有一種能增加膜對 Cl^- 通透性的物質，則動作電位是記錄 E

Q.23

A group of researchers conducted an experiment to study the effects of phlorizin on some physiological indices in blood and urine of normal mice and diabetic mice. Phlorizin is an inhibitor of SGLT2 which is the channel of glucose reabsorption in the kidney.

一組研究人員進行的實驗，研究 phlorizin 對正常小鼠和糖尿病小鼠血液和尿液中的某些生理指標的影響。Phlorizin 是 SGLT2 的抑制劑，而 SGLT2 是葡萄糖在腎臟再吸收時的載體。

Mice were divided into four groups:

小鼠分為四組：

Group 1: Normal mice were injected with phlorizin

組 1：正常小鼠注射 phlorizin

Group 2: Mice were injected with streptozotocin to induce type 2 diabetes

組 2：小鼠注射鏈脲黴素誘導第 2 型糖尿病

Group 3: Streptozotocin induced-type 2 diabetic mice were injected with phlorizin

組 3：經鏈脲黴素誘導產生的第 2 型糖尿病小鼠再注射 phlorizin

Group 4: Normal mice as controls

組 4：正常小鼠作為控制組

After the four-week experiment, physiological indicators of blood, urine and renal SGLT2 expression of the mice were measured.

在實驗四個星期後，測定小鼠血液、尿液和腎臟 SGLT2 生理指標的表現。

Indicate in the Answer sheet if each of the following statements is True or False.

在答案卷上寫出下列各敘述是 正確 或 錯誤。

- A. The blood pressure of Group 3 mice was lower than that of Group 2 mice.
Group 3 老鼠的血壓比 Group 2 老鼠低
- B. The SGLT2 gene expression levels in the kidneys of Group 2 mice were lower than those of Group 4 mice.
Group 2 老鼠腎臟中 SGLT2 基因的表現量比 Group 4 老鼠為低
- C. The amount urine of Group 1 mice was higher than that of Group 4 mice.
Group 1 老鼠尿液的量比 Group 4 老鼠多
- D. The quantity of SGLT2 molecules in the kidney marrow is higher than that in the kidney cortex.
腎臟的髓質中 SGLT2 分子的數量比在皮質中的為高

Q.24

Polycystic ovarian syndrome (PCOS) is a common disorder of women characterized by increased levels of testosterone and by chronic failure in ovulation. The ovary can be stimulated to produce more testosterone when insulin levels in the blood are high.

多囊卵巢綜合症(PCOS)是一種常見的婦女疾病，特徵為睪固酮升高及慢性的無法正常排卵。當血液中的胰島素升高時，卵巢會受刺激而產生更多的睪固酮。

Indicate in the Answer sheet if each of the following statements is True or False.

在答案卷上寫出下列各敘述是 正確 或 錯誤

- A.** PCOS patients are more likely to have acne than healthy people.
PCOS患者比健康人更有可能得痤瘡
- B.** PCOS patients have progesterone level higher than healthy people.
PCOS患者的黃體激素高於健康人
- C.** Obese women have a higher risk of PCOS than normal-weight women.
肥胖婦女得多囊卵巢綜合症的風險比體重正常婦女更高。
- D.** Follicle-stimulating hormone (FSH) and Luteinizing hormone (LH) can be used to increase the probability of PCOS women to conceive.
濾泡刺激素(FSH)和促黃體生成素(LH)可用於增加PCOS婦女受孕機率

Q.25

In the gills of freshwater teleost fishes, the blood plasma is separated from the freshwater by a thin epithelium so that the blood plasma tends to lose ions such as Na^+ and Cl^- to the ambient water across the gill epithelium and H_2O tends to enter the plasma from the ambient water across the gill epithelium. There are transport mechanisms by which inorganic ions and water cross the gill epithelium and they help to maintain the difference in the ion composition between the plasma and the ambient water. Figure Q.25 shows the transportation of four ions across the gill epithelium.

在淡水硬骨魚的鰓的構造中，隔開淡水與血漿的上皮細胞很薄，血漿中的離子如 Na^+ 和 Cl^- 很容易經鰓上皮細胞而失去， H_2O 則跨越鰓上皮細胞從周圍環境進入血漿中。無機離子和 H_2O 跨越鰓上皮細胞的運輸機制有助於維持血漿和周圍環境水中離子成分的不同。圖Q.25.顯示四種不同離子跨越鰓上皮細胞的運輸情形。

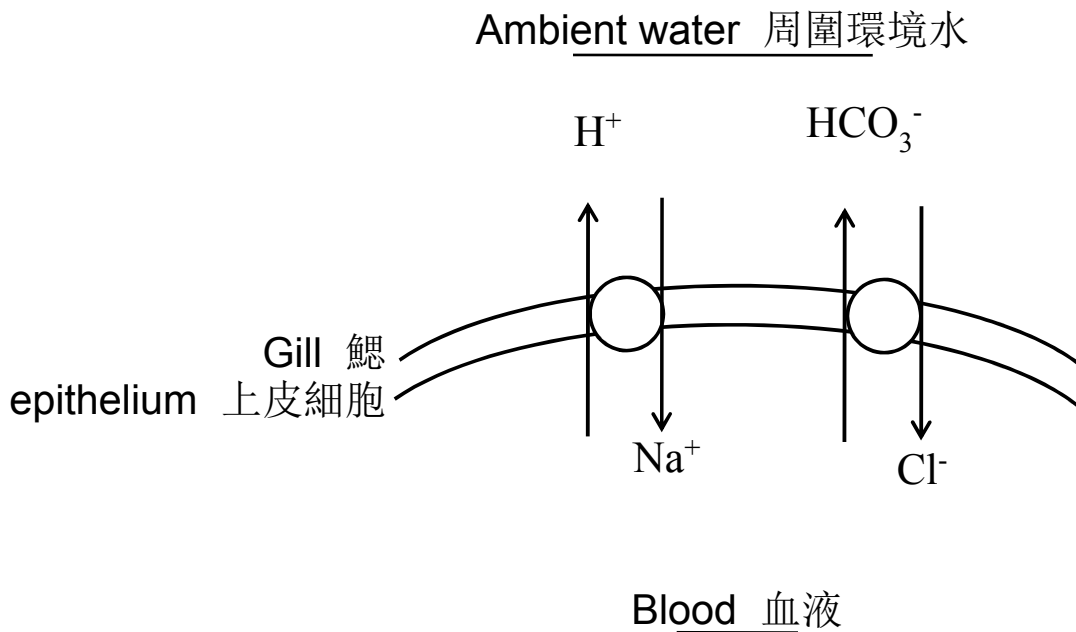


Figure Q.25.

Indicate in the Answer sheet if each of the following statements is True or False.

在答案卷上寫出下列各敘述是 正確 或 錯誤

- A. Inhibition of the Cl^- pump leads to an increase in blood pH.
抑制 Cl^- 幫浦蛋白將導致血液pH值增加
- B. An increase in CO_2 produced by catabolism leads to an increase in Na^+ and Cl^- transports across the epithelium cell.
當異化作用產生的 CO_2 增加時，會導致 Na^+ 和 Cl^- 跨越上皮細胞運輸增加。
- C. A substance blocking the electron transport chain causes a decrease of Na^+ influx, but does not affect HCO_3^- outflux at the gill epithelium.
一種阻斷電子傳遞鏈的物質可引起 Na^+ 的湧入量降低，但不影響 HCO_3^- 在鰓上皮細胞的湧出量
- D. During alkalosis, the epithelial cell increases the synthesis of a key $\text{Cl}^-/\text{HCO}_3^-$ countertransport protein.
當鹼中毒時，上皮細胞增加關鍵性 $\text{Cl}^-/\text{HCO}_3^-$ 反向運輸蛋白的合成

Q.26

Two groups of students separately performed an experiment on kidney function. Thirty minutes before the experiment, each student in one group was instructed to drink 500 mL of water, while each student in the other group was instructed to drink 100 mL of water. At $t = 0$ minute, each student in both groups was instructed to drink 750 mL of water. Each student was then asked to urinate as he or she would normally do without attempting to manipulate the speed or flow in any way at the different time points shown in Figure Q.26. An electronic uroflowmeter was used to measure the urine flow rate. The Cl^- concentration in each urine sample was measured. Figure Q.26 shows the data of the experiment.

兩組學生分別進行腎功能的實驗，在實驗前 30 分鐘，其中一組學生每人喝下 500 毫升的水，另一組學生則每人喝下 100 毫升的水。在 $t = 0$ 分鐘時，所有兩組學生均喝下 750 毫升的水，然後這些學生被要求在圖 Q.26 所示的不同時間點間，依照平常的小便習慣，不以任何方式操控尿流速率或流量、以電子尿流機(uroflowmeter)來測量尿流速率，並測量每個尿液樣本中的 Cl^- 濃度。實驗資料顯示在圖 Q.26。

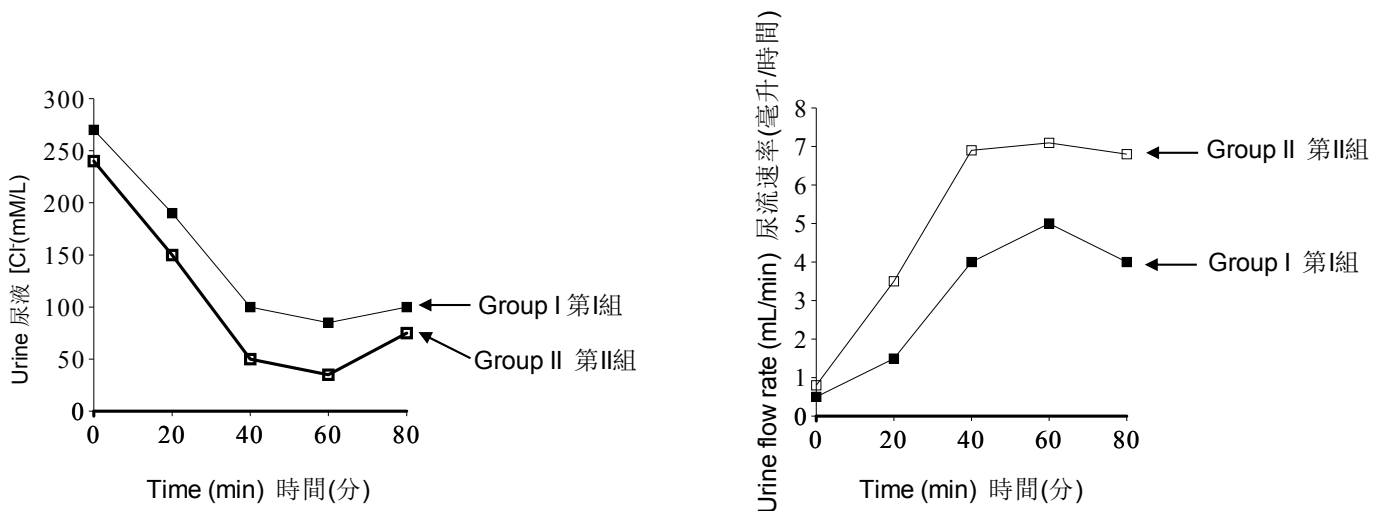


Figure Q.26.

Indicate in the Answer sheet if each of the following statements is True or False.

在答案卷上寫出下列各敘述是 正確 或 錯誤

- The absolute reabsorption of water by nephrons of the students in Group II at $t = 60$ min was lower than that of the students in Group I.
當 $t = 60$ min 時，第 II 組學生的腎元對水份絕對再吸收作用會比第 I 組學生低
- The plasma aldosterone concentration of the students in Group I was the highest at $t = 60$ min.
當 $t = 60$ min 時，以第 I 組學生血漿中的醛固酮濃度為最高
- The students in Group I drank 500 mL of water 30 minutes before the experiment.
在實驗前 30 分鐘，第 I 組學生喝了 500 毫升的水
- The students in Group II produced about 140 mL of urine during the period between $t = 40$ min and $t = 60$ min.
在時間 $t = 40$ 及 $t = 60$ min. 之間，第 II 組學生產生約 140 毫升的尿液

Q.27

Figure Q.27 shows the changes in metabolic rates of adult individuals of five animal species in response to temperature changes of the external environment (EM). The individual body weights of the five species were similar (about 30 grams). The data were measured from the animals when they were staying at rest.

圖Q.27顯示當外在環境溫度(EM)改變時五種動物成熟個體體內代謝率的變化，五種動物的個體體重相當(約30克)。圖中數據是在動物休息狀態下的測量結果。

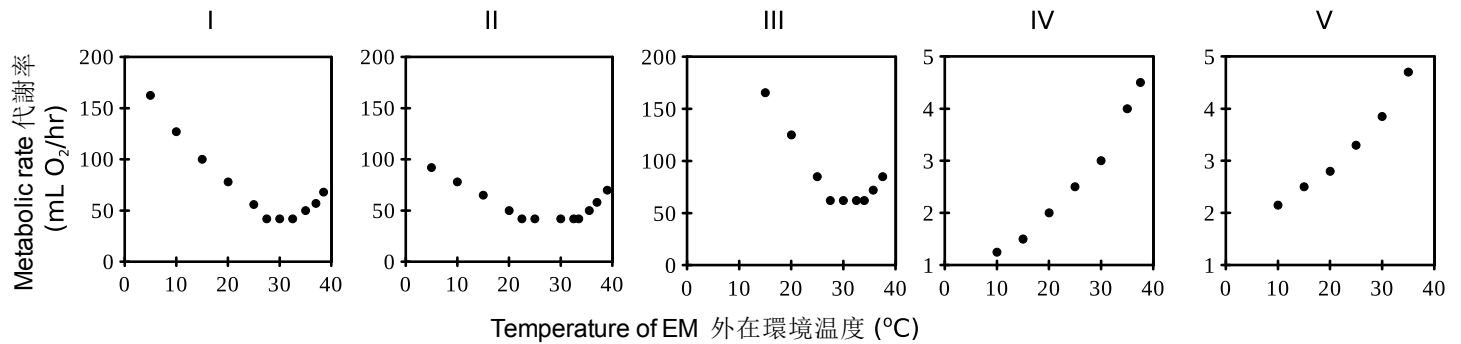


Fig. Q.27

Indicate in the Answer sheet if each of the following statements is True or False.

在答案卷上寫出下列各敘述是 正確 或 錯誤

- Species IV was an ectothermic animal.
物種 IV 是一種變溫動物
- Species II had the highest thermo-insulating ability among the five species.
五個物種中，物種 II 的絕熱能力最高
- Species III possessed the highest basal metabolic rate among the five species.
在五個物種中，物種 III 擁有最高的基礎代謝率
- Increase in body temperature in species V was mainly dependent on metabolism.
物種 V 體溫的增加，主要依賴代謝作用來提供

Q.28

BDNF, a brain protein, is crucial for neuron activities. BDNF is activated during the activation of neurons of the limbic system. An important function of BDNF in mammals is shown in Figure Q.28. The signal via the catecholamine receptor (β -AR) has a specific positive effect on the browning process and thermogenesis. BDNF是一種腦蛋白，對神經元的活動非常重要，BDNF的活性會在邊緣系統的神經元活化過程中被激發。圖Q.28顯示BDNF在哺乳動物中的一項重要功能，即經由兒茶酚胺受體(β -AR)相關的訊息傳遞途徑，專一性刺激棕色化過程及產熱。

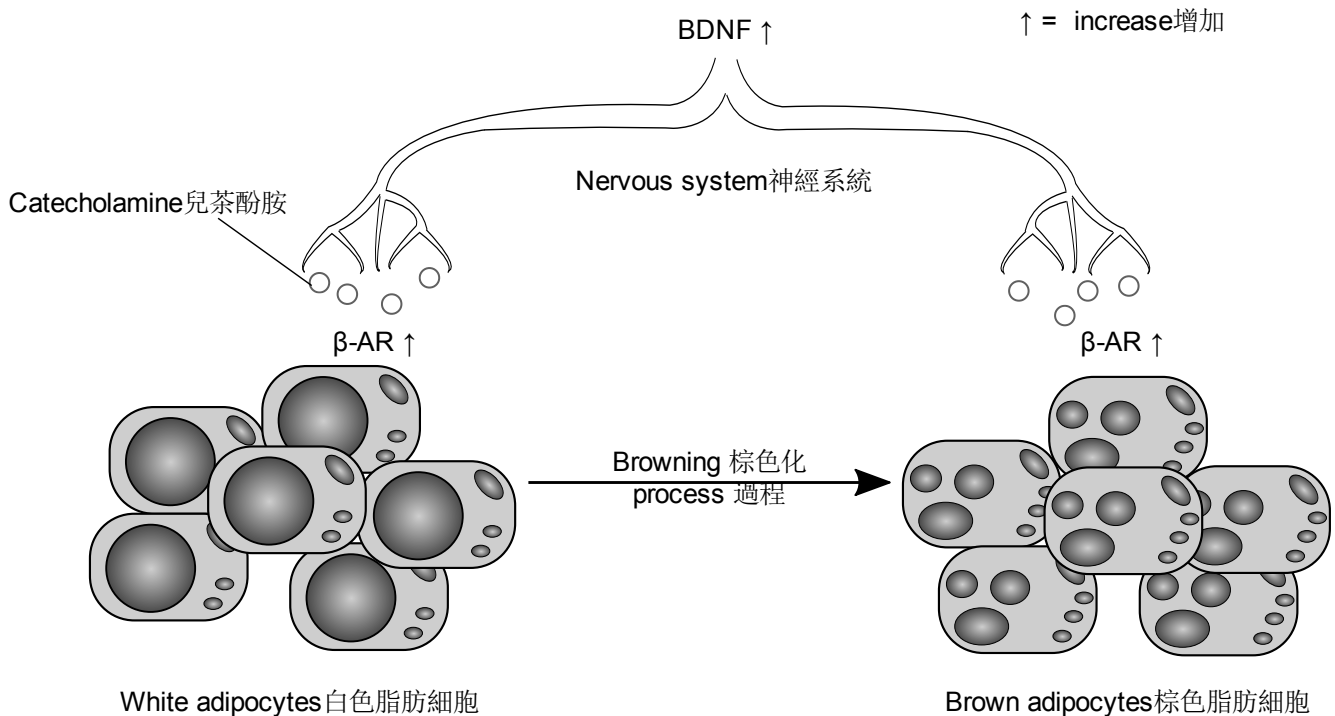


Fig. Q.28

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

- Regularly learning and memorizing activities help to increase the number of brown fat cells.
規律性學習及記憶活動可以幫助棕色脂肪細胞數目的增加
- Inhibition of BDNF expression reduces the size of white adipose tissue.
抑制BDNF的表現量，可以降低白色脂肪組織的體積大小
- Psychological anxiety increases the manifestation of the β -AR.
精神上的焦慮會增加 β -AR 的表現量
- β -AR gene-deleted mice will show higher sensitivity to cold.
 β -AR 基因剔除老鼠會有對寒冷更為敏感的表现

Q.29

The skeletal muscle fibers are divided into three types depending on the speed and energy sources of muscle contraction:

根據肌肉收縮的速率及能量來源，骨骼肌纖維可以分為三類

Type I: Slow twitch, oxidative muscle fibers.

Type I: 抽動緩慢，氧化性肌纖維

Type IIa: Fast twitch, oxidative muscle fibers.

Type IIa: 抽動快速，氧化性肌纖維

Type IIb: Fast twitch, glycolytic muscle fibers.

Type IIb: 抽動快速，醣化性肌纖維

Figure Q.29 shows the correlation of mRNA expression levels of the genes *Myh7*, *Myh2*, and *Myh1* specific for muscle fiber types I, IIa, and IIb, respectively, in human skeletal muscles of legs: quadriceps, gastrocnemius, and soleus muscles.

圖Q.29顯示分別與人類Types I, IIa,及 IIb三種肌纖維內，相關的三種專一性基因*Myh7*, *Myh2*, 及 *Myh1* 的 mRNA 表現量

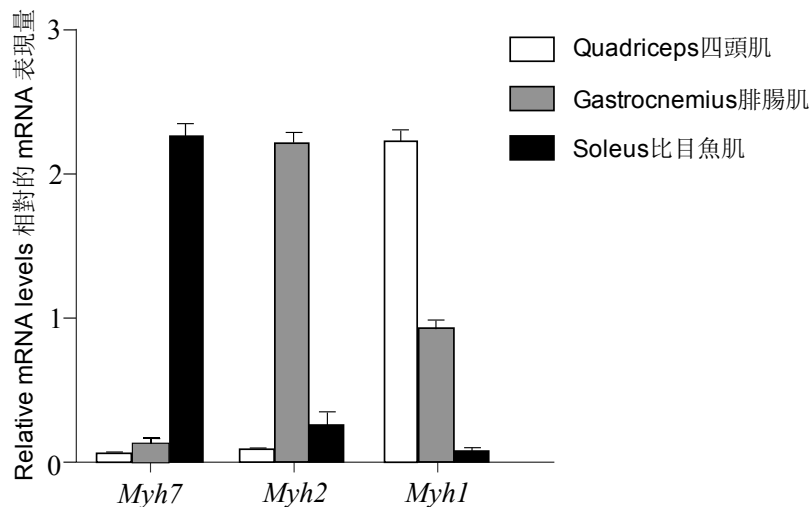


Figure Q.29.

Indicate in the Answer sheet if each of the following statements is True or False.

在答案卷上寫出下列各敘述是 正確 或 錯誤

- A. The soleus muscles of the sprinter athletes are prone to be more developed than those in the marathon athletes.
彈跳運動員的比目魚肌有比馬拉松選手發達的趨勢
- B. The ratio of mitochondria number per muscle mass in the quadriceps muscle is less than that in the gastrocnemius muscle.
每單位四頭肌中的粒線體數目的比腓腸肌中的少
- C. The soleus muscle contains less sarcoplasmic reticulum than the gastrocnemius muscle does.
比目魚肌所含的肌漿網數目的比腓腸肌中的少
- D. Regularly doing the endurance exercise for a long period of time can increase the number of glycolytic muscle fibers in the gastrocnemius muscles.
規律性的做一段長時期的耐力運動後，會增加腓腸肌中的醣化性肌纖維數目

Q.30

Figure Q.30A shows an insulin secretion and the mechanism by which insulin stimulates glucose absorption into cell. The mechanism includes four steps depicted by the four circled digits 1 to 4.

圖 Q.30A顯示胰島素的分泌及其刺激細胞吸收葡萄糖的機制，此機制包括 4 個步驟。

Four patients (E, F, G and H) had a defect each in a single step of the above mechanism. Patients E, F, G and H had defect in steps 1, 2, 3 and 4, respectively. These patients were given two tests:

四個病人(E, F, G and H)每個人分別有一項上述機制的缺陷。病人E, F, G 及 H依續分別為步驟1, 2, 3 及4的缺陷。

針對這些病人進行兩項測試：

- Test 1: Muscle cells from each patient were isolated and the percentage of insulin binding cells at different concentrations of insulin was determined (Figure Q.30B).

測試1：由每個病人分離出肌細胞，並在不同胰島素濃度下測定與胰島素結合的肌細胞的百分比(圖 Q.30B).

- Test 2: Each patient was injected with same insulin quantity related to their body mass and their plasma glucose concentrations were then measured at various times after injection (Figure Q.30C).

測試2：每個病人注射與體重比相同劑量的胰島素，並測量他們在注射後不同時間的血糖濃度

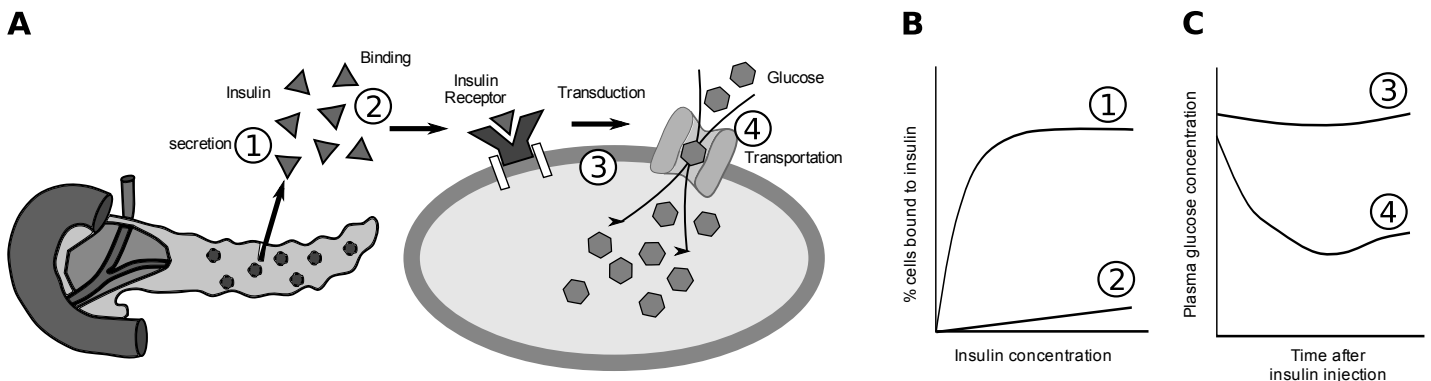


Figure Q.30

Indicate in the Answer sheet if each of the following statements is True or False.

在答案卷上寫出下列各敘述是 正確 或 錯誤

- The result of Test 1 of Patient G could be shown in Line 1.
Line 1 顯示病人G 進行測試 1 後的實驗結果
- Lines 2 and 3 show the results of Tests 1 and 2, respectively, of Patient F.
Lines 2 及 3 分別顯示病人F 進行測試 1 及測試 2 後的實驗結果
- Line 3 shows the tested result of Patient E.
Lines 3 顯示病人E 的測試結果
- Lines 1 and 4 show the results of Tests 1 and 2, respectively, of Patient H.
Lines 2 及 3 分別顯示病人H 進行測試 1 及測試 2 的實驗結果

ETHOLOGY

動物行為

Q.31

The territorial behavior of the red-whiskered bulbul (*Pycnonotus jocosus*) was studied during pre-nesting and nesting periods. Songs of decoys were played from ten different locations around a farmhouse, where the test birds lived, and the time taken to start displaying territorial behavior by the resident male measured at the different locations (Table Q.31). The resident bird defended the territory with aggressive calls, threat display and tried to attack the decoy.

針對紅鬚鵯 (*Pycnonotus jocosus*) 在繁殖前及繁殖期的領域行為進行研究。在這些受測鳥居住的一處農莊附近，研究人員選擇十個不同地點(站station)放置假鳥並播放鳴唱聲，紀錄雄鳥在到達不同地點時，到牠開始展現領域行為時所花費的時間（表Q.31）。領主以侵略性叫聲，威脅展示及嘗試攻擊假鳥模型的方式來防衛領域。

（表Q.31）

Station 站	C	I	K	G	H	B	F	J	D	E
Distance (m) 距離(公尺)	20	50	110	30	50	19	46	72	29	38
Direction 方向	N	N	N	S	S	E	E	E	W	W
Pre-nesting 繁殖前期										
Territory defense 領域防衛	+	+	-	+	-	+	+	-	+	-
Response time 反應時間	1	3	>10	5	>10	1	3	>10	4	>10
Nesting 繁殖期										
Territory defense 領域防衛	+	+	-	+	-	+	+	-	+	-
Response time 反應時間	0.2	1	>10	0.7	>10	0.3	2.5	>10	1	>10

Fig Q.31. Mean response time = time taken to start displaying territorial behavior (minute). (+) signifies territory defense whereas (-) stands for “no territory defense”. N= north, S= south, E= east and W = west.
圖 Q.31.平均反應時間=開始產生防衛領域行為時所花費的時間(分)。(+)表示有展現領域防衛行為而 (-) 表示無展現領域防衛行為
N= 北, S= 南, E= 東 及 W = 西

Based on this information, indicate in the answer sheet if each of the following statements about the behavior of the birds is true or false.

根據這些資料，在答案卷上指出下列有關此鳥行為的敘述，何者正確或錯誤

- A. The territory size during the pre-nesting period was smaller than that during the nesting period.
繁殖前期的領域範圍小於繁殖期
- B. The quadrangle made by stations G, D, I and F marks the territory size of the bird.
G,D,I及F 四站所形成的四邊形標示出此鳥的領域範圍
- C. The male responded more rapidly to the decoy within its territory during the nesting period.
在繁殖期時，雄鳥在牠的領域內對假鳥模型的反應較快
- D. The intensity of territorial behavior displayed is a dependent on seasonal fluctuation of hormones.
領域行為展現的強度是受到體內荷爾蒙季節性變動的影響

Q.32

Female vampire bats live in colonies made up of unrelated females and their offsprings, and they feed exclusively on blood of herbivores. The fully-fed bats often share some of the blood that they collected with bats that are starving, and are more likely to receive blood from these individuals when they themselves starve. 雌性吸血蝙蝠居住在群體中，由不具親緣關係的雌性個體及牠們的子代所組成。牠們完全依賴吸食草食動物的血液為生，吃飽的蝙蝠經常會將牠們所吸食的血液與其他飢餓的蝙蝠分享，並極有可能在牠們飢餓時會從這些曾分享的個體中獲得血液補充。

Indicate in the answer sheet if each of the following statements about this behavior of bats is mostly true or false.

在答案卷上指出下列有關此種蝙蝠行為的敘述，最有可能是正確或錯誤

- A. Kin selection has an important role to play in the evolution of sharing behavior.**
親緣天擇在分享行為中扮演一個重要的角色
- B. Vampire bats are likely to live in colonies only for short periods of time.**
吸血蝙蝠的群體居住行為極有可能是短期的
- C. The bats showing this behavior have higher indirect fitness than if they would not do so.**
具有此種行為的蝙蝠其間接適存度較無此種行為者要高
- D. Vampire bats are able to recognize and remember other individual bats.**
吸血蝙蝠有能力辨識及記憶其他蝙蝠個體

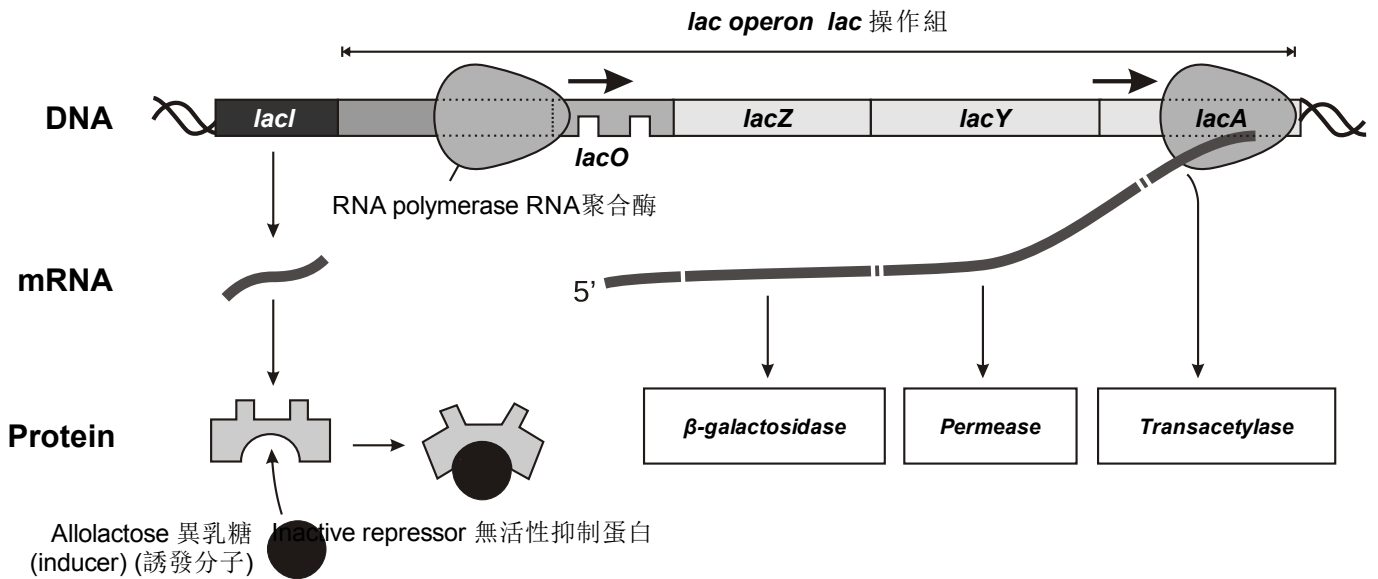
GENETICS AND EVOLUTION

遺傳學與演化

Q.33

Mr. Long had ten strains of *Escherichia coli* with different mutations in their *lac* operon. Analyzing their DNA, he found that each strain is one of five mutation types: *lacZ⁻*, *lacY⁻*, *lacI⁻*, *lacI^S* (the repressor *LacI^S* can bind to the operator but cannot bind to the inducer), or *lacO^c* (the mutated operator *lacO^c* cannot be bound by the repressor). Mr. Long also knew that strain number 6 is a *lacZ⁻* mutant. Operon *lac* is shown below.

龍先生有10個*E.coli*菌種，各帶有不同的*lac*操作組突變，分析它們的DNA，發現每一個菌種帶有以下五種突變之一：*lacZ⁻*, *lacY⁻*, *lacI⁻*, *lacI^S* (*LacI^S* 抑制蛋白可以與操縱子結合，但不能與誘導物結合), *lacO^c* (抑制蛋白無法附著於 *lacO^c* 突變操縱子)。龍先生也已知道6號菌種是 *lacZ⁻* 的突變體。*lac*操作組如下圖所示。



Mr. Long isolated DNA containing the *lac* operon from each strain (donor) and transformed it into other strains, thus making the strain merodiploid (recipient). Thereafter recipient strains were cultured on minimal medium that contained lactose as the only carbon source. Growth of the strains was recorded in the table below (+ means that the strain is growing, - means that the strain is not growing).

龍先生把從這些菌種中抽出的帶有*lac*操作組的DNA，將所得DNA互相轉殖到另一菌種中，每一個轉殖實驗中，提供DNA的菌種是donor，被轉入DNA的菌種是recipient。將轉殖後的recipient菌株培養在只提供乳糖為唯一碳源的培養基上，檢測其生長情形並記錄於下表中，"+"表示可生長，"-"表示無法生長。

Recipient strains	2	-							
	3	-	+						
	4	-	+	+					
	5	+	+	+	+				
	6	-	+	+	+	+			
	7	-	+	+	+	+	-		
	8	-	-	-	-	+	-	-	
	9	+	+	+	+	+	+	+	
	10	-	+	-	+	+	+	+	-
		1	2	3	4	5	6	7	8
Donor strains									

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. Strain number 7 is a *lac Z* mutant.
7號菌種是 *lac Z* 突變體
- B. Strain number 3 is a *lac Y* mutant.
3號菌種是 *lac Y* 突變體
- C. Strains number 2 and 4 are of the same mutation type.
2號菌種和4號菌種是同一種突變型
- D. If strain number 5 receives DNA from itself, the transformed bacteria cannot grow.
若5號菌種接受5號菌種自己的DNA，則此轉殖菌株不能生長

Q.34

Mr. Long analyzed DNA samples from three families using six loci of short tandem repeat (STR) on six different autosomal chromosomes. Each STR locus usually has many different alleles that are labeled by numbers e.g 3 and 5 for locus 1 of Huong sample, in the table. In the first family, the father is Hung, the mother is Huong and their son is Dung. In the second family, the father is Nhan and his two sons are Tin and Nghia. In the third family the father is Phu, and his son is Quy. Mr. Long also included a DNA sample from Dat who is unrelated to any of the three families. Samples were randomly encoded with numbers but the key was lost except for Huong’s sample.

龍先生研究6個不同的短重複序列(STR)基因座，這6個STR基因座位於6條不同的體染色體上，每一個STR基因座通常都有多個等位基因，以不同數字表示，例如 表中Huong的 基因座1 中的 3 和 5。龍先生分析了3個家庭的DNA樣品
家庭1：父是 Hung，母是 Huong，兒是 Dung
家庭二：父是 Nhan，二個兒子是 Tin 和 Nghia
家庭三：父是 Phu，兒是 Quy
另外1個DNA樣品來自和此三個家庭不相干的 Dat
這些DNA樣品以逢機數字標示，但登記資料遺失，只知道Huong的樣品。

		STR loci STR 基因座					
DNA samples DNA樣品		Locus 1	Locus 2	Locus 3	Locus 4	Locus 5	Locus 6
	Huong	3/5	2/2	5/6	3/3	1/2	2/6
	669	3/5	2/7	4/9	5/8	3/7	4/5
	297	1/5	3/3	3/3	6/9	2/7	4/8
	653	1/5	2/2	6/6	3/7	2/9	4/5
	735	5/7	2/4	5/5	3/4	2/2	1/2
	130	5/7	7/7	5/9	3/8	2/7	4/5
	860	1/6	2/3	3/5	6/7	1/7	2/8
	938	3/7	4/5	5/6	4/4	2/3	1/2
	264	3/7	7/7	1/4	5/9	7/9	3/4

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. Sample 735 is Dat's DNA.

樣品 735 是 Dat 的 DNA

B. Sample 669 is Nhan's DNA.

樣品 669 是 Nhan 的 DNA

C. Sample 938 is Hung's DNA.

樣品 938 是 Hung 的 DNA

D. Sample 297 can be Phu's DNA.

樣品 297 可能是 Phu 的 DNA

Q.35

Centromere position can be mapped using linear tetrads in some fungi. If there is no cross-over between gene E and the centromere, four spores are arranged in sequence of eeEE or EEee (Fig.Q.35A). If there is a cross-over between gene E and the centromere, four spores are arranged in sequence of eEeE or EeEe (Fig.Q.35B). There are many types of crossovers involving 2, 3 and 4 strands of chromatids as illustrated in Fig.Q.35C.

利用一些在減數分裂後會產生直線型排列4孢子的真菌，可以定出染色體中節的位置。如圖Q.35A所示，若E基因和中節間沒有發生互換，4個孢子的排列為 eeEE 或 EEee ；但如圖Q.35B所示，當E基因和中節間發生互換，則4個孢子的排列為 eEeE 或 EeEe 。如圖Q.35C所示，染色體互換有各種類型：可以包括二條、三條、或四條姐妹染色分體同時參與。

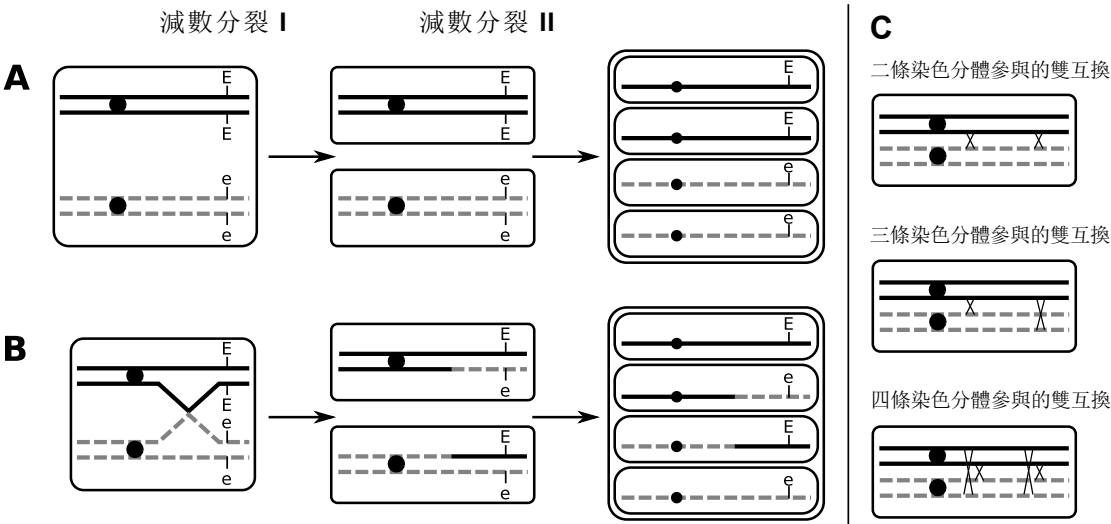


Figure Q.35

Strain ab was crossed to strain a⁺ b⁺ and 100 linear tetrads were isolated. Those tetrads were divided into six classes as shown in the following table:

ab品系 和 a⁺b⁺品系交配後，分析其產生的100組直線型排列四孢子，可將它們分為6種類型，如表所示：

Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
ab	ab	ab	ab	ab ⁺	ab
a ⁺ b	ab ⁺	ab	a ⁺ b ⁺	a ⁺ b	a ⁺ b ⁺
ab ⁺	a ⁺ b	a ⁺ b ⁺	ab	ab ⁺	ab ⁺
a ⁺ b ⁺	a ⁺ b ⁺	a ⁺ b ⁺	a ⁺ b ⁺	a ⁺ b	a ⁺ b
15	29	47	2	2	5

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. Locus a and b are located on the same arm of chromosome.

a 基因座 和 b 基因座 位於 染色體的同一臂上

B. Class 4 involves a 4-strand double crossover.

Class 4 是因為四條染色分體參與的雙互換

C. Class 6 involves a 3-strand double crossover, with one between gene a and the centromere and between the centromere and gene b.

Class 6 是因為三條染色分體參與的雙互換，其中一次在 a 基因 和 中節間，另一次在中節和 b 基因間。

D. Class 5 involves a 2-strand double crossover.

Class 5 是因為二條染色分體參與的雙互換。

Q.36

Heritability in broad sense (H^2) is the ratio of total genetic variance (V_g) to total phenotypic variance (V_p): $H^2 = V_g/V_p$. The phenotypic variance is often divided into three components: the genetic variance (V_g), environmental variance (V_e) and the interaction variance (V_i), $V_p = V_g + V_e + V_i$. The genetic variance is divided into three components: the additive genetic variance (V_a , cumulative effects of individual loci), the dominant genetic variance (V_d), and the genetic interaction variance (V_{gi}), $V_g = V_a + V_d + V_{gi}$. Heritability in narrow sense (h^2) = V_a/V_p .

廣義遺傳力(H^2)是總遺傳變方(V_g)與總表現型變方 (V_p)之比:

$H^2 = V_g/V_p$. 表現型變方包含三部分: 遺傳變方(V_g)、環境變方(V_e)、和交互作用變方(V_i), 即 $V_p = V_g + V_e + V_i$. 遺傳變異又可劃分稱三部分: 累加性遺傳變方 (V_a , 各基因座的累積效應), 顯性遺傳變方 (V_d), 和遺傳交互作用變方 (V_{gi}), $V_g = V_a + V_d + V_{gi}$. 狹義遺傳力 (h^2) = V_a/V_p .

Indicate in the answer sheet if each of the following statements about heritability is true or false

在答案卷上指出下列各敘述是對, 或錯

- A. A low H^2 value of a trait always indicates that the trait is determined mainly by the environment.
當一性狀的 H^2 很低時, 代表環境是決定此性狀的主要因子。
- B. Genetic variance depends on the environment to which the population is exposed.
遺傳變方會隨族群所處之環境而定。
- C. The artificial selection for a trait with higher h^2 is more successful than that for a trait with lower h^2 .
對於高 h^2 性狀的人擇比對低 h^2 性狀的人擇較成功
- D. Two pure strains of bean that produce seeds with different weights were crossed. The variances of seeds (V_p) from F_1 and F_2 plants are: 2.0 and 4.1, respectively. If we ignore interaction effects, H^2 of seeds is 0.51.
將二個會產生不同重量種子的純系豆子雜交, F_1 和 F_2 世代種子重量的變方 (V_p) 分別是 2.0 和 4.1。若忽略交互作用的效應, 則種子重量的 H^2 是 0.51

Q.37

F.D. Enfield selected for increased body size in the flour beetle *Tribolium castaneum*. He started with a population of beetles that had a mean weight of 2.4 g and variance of 4.0 g². For each generation, the selection differential (the difference between the mean of a generation subset selected for further breeding and the overall mean of that generation) was 0.022g. The initial value of h^2 (heritability in narrow sense- h^2 is the ratio of the additive variance to the total phenotypic variance) for body size in the original population was 0.3. For the first 50 generations, the mean weight of the selected population increased steadily. After 125 generations of selection, the mean weight had increased to 5.8g, more than twice the original mean, and additional selection did not result in a further increase in size. The lightest individuals in the selected population were heavier than the heaviest individuals in the original population. Enfield determined h^2 for the selected population after 125 generations and discovered that it was only slightly less than for the original population.

Enfield 對粉甲蟲 *Tribolium castaneum* 進行體型增加的選拔。起始的粉甲蟲族群平均體重 2.4 g，變方 4.0 g²，每一世代的選拔增量(被保留作為下一代親本的次族群平均值減去全族群平均值)是 0.022g，起始族群對體型的狹義遺傳力 h^2 是 0.3。在前 50 個世代，選拔族群的平均重量穩定增加。經過 125 個世代的選拔，平均重量已增加到 5.8g，二倍於起始族群均值，而之後的選拔不再有任何增加，此時族群中最輕的個體比起始族群中最重的個體還要重。Enfield 計算經過 125 個世代選拔的族群之 h^2 ，發現只略低於起始族群。

Based on above information, indicate in the answer sheet if each of the following statements is true or false.
依據上述資訊，在答案卷上指出下列各敘述是對，或錯

- A. The failure of the population to respond to further selection was because the population genetic variation is exhausted.
族群無法再對選拔有反應是因為其遺傳變方已不存在
- B. The reason why the mean of the population could be shifted to a value outside the original range of the population is that the selection for the increased the body size is a selection favoring heterozygotes.
選拔族群的平均增加到超過原起始族群的區間範圍，是因為對體型選拔會有利於異型合子
- C. After 125 generations of selection, additional selection can result in a further increase in size if we increase the selection differential (higher than 0.022g).
經過 125 代的選拔後，如果提高選拔差量(高於 0.022g)，進一步的選拔還可以再讓體型增加。
- D. If selection was stopped after 125 generations of selection then the body size would decrease.
如果經過 125 代選拔後，停止選拔，則體型會下降

Q.38

A mutated male mouse that is phenotypically normal shows reproductive anomalies when compared with a normal male in terms of mean number of embryos, as shown in Table Q.38.

The anomaly manifests itself after fertilization.

一隻突變的公鼠在外表上無異狀，但與一般公鼠比較其所能產生的胚胎數目時(如表Q.38)，可發現其生育能力受影響。此異常出現在受精之後

Mean number of embryos 平均胚胎數

Mating	Implanted in uterine wall 移植於子宮壁	Degeneration after implantation 移植後退化	Normal 正常	Degeneration (%) 退化比例
mutated♂ X normal ♀	8.7	5.0	3.7	57.5
normal♂ X normal ♀	9.5	0.6	8.9	6.5

Study carefully data given in the table and indicate in the answer sheet if each of the following statements is true or false.

小心研究表中資料，在答案卷上指出下列各敘述是對，或錯

- A.** The mutated male mouse can have a chromosome deletion
這隻突變公鼠可能有染色體缺失
- B.** The mutated male mouse can be a chromosomal translocation heterozygote.
這隻突變公鼠可能是染色體易位的異型合子
- C.** The mutated male mouse can be a chromosomal inversion heterozygote.
這隻突變公鼠可能是染色體倒位的異型合子
- D.** The genetic defect in mutated male could be verified by cytological observation of meiotic cells in the mouse.
突變公鼠的遺傳缺失可以藉由對減數分裂細胞進行細胞學觀察而得到驗證

Q.39

Speciation rates are variable in different lineages of organisms. Some lineages have many species; others have only a few.

在生物不同的演化譜系間，種化速率是變動的，有些會產生有許多物種，有些只能產生少數物種

Indicate in the answer sheet if each of the following statements about the factors influencing speciation rates is true or false

在答案卷上指出下列各有關影響種化速率因子的敘述是對，或錯。

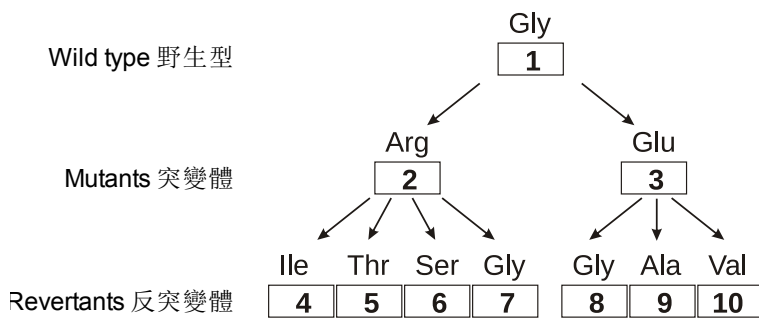
- A.** The larger the number of species in some lineages, the larger number of opportunities for new species to form.
在一些譜系中的物種數愈多，形成新種的機會愈大
- B.** Animal-pollinated plant families have, on average, more species than closely related families pollinated by wind.
藉由動物傳粉的植物科屬，平均而言，比親緣相近的風媒植物有更多的物種數目
- C.** Animals with complex mating behavior are likely to form new species at a low rate.
具有複雜交配行為的動物可能有較低的種化速率
- D.** Oscillations of climates may increase the speciation rate.
氣候的變動可增加種化速率

Q.40

About 50 years ago, Charles Yanofsky studied the sequence of the tryptophan synthetase of *E. coli*. The wild type protein (1) has a glycine in position 38. Yanofsky isolated two inactive *trp* mutants: 2 and 3. Mutant 2 had Arg instead of Gly at position 38, and mutant 3 had Glu at position 38. Mutants 2 and 3 were plated on minimal medium (without tryptophan). Colonies appearing correspond to spontaneous mutations that restored tryptophan synthetase function. The amino acid at position 38 was identified as described in figure A. Assume that each amino acid replacement results from a single base-pair change.

大約50年前，Charles Yanofsky研究 *E. coli* 的 tryptophan 合成酶之序列，野生型蛋白(1)的第38號位置是 glycine。Yanofsky發現了2個無活性的 *trp* 突變體 2 和 3，突變體2 的第38號位置是Arg，取代原有的 Gly，突變體 3 的第38號位置是Glu。將突變體 2 和 3 塗在沒有tryptophan的最低限度培養基上，長出的菌落代表其發生自發性的突變，回復tryptophan 合成酶的功能，檢定這些新突變體的第38個位置的胺基酸，結果如圖A所示。假設每一個胺基酸的置換都只是因為單一個鹼基對的改變。

A



B

		Second base				
		U	C	A	G	
First base	U	UUU Phe UUC UUA Leu UUG	UCU UCC Ser UCA UCG	UAU Tyr UAC UAA Stop UAG Stop	UGU Cys UGC UGA Stop UGG Trp	U C A G
	C	CUU CUC Leu CUA CUG	CCU CCC Pro CCA CCG	CAU His CAC CAA Gln CAG	CGU Arg CGC CGA CGG	U C A G
	A	AUU AUC Ile AUA AUG Met	ACU ACC Thr ACA ACG	AAU Asn AAC AAA Lys AAG	AGU Ser AGC AGA Arg AGG	U C A G
	G	GUU GUC Val GUA GUG	GCU GCC Ala GCA GCG	GAU Asp GAC GAA Glu GAG	GGU Gly GGC GGA GGG	U C A G
		Third base				

Indicate in the answer sheet if each of following statements about codon 38 of tryptophan synthetase is true or false.

在答案卷上指出下列各敘述是對，或錯

- Mutant 2 results from a base substitution at the first position of the codon .
突變體2 是因為在此密碼子的第一個位置發生置換
- Strains 7 and 8 likely have the same sequence as the wild type strain.
菌種 7 和 8 可能具有和野生型一樣的序列
- The codon in strain 10 is 5'GUA3'
菌種 10 的密碼子是 5'GUA3'
- The codon in strain 6 is 5'AGC3'.
菌種 6 的密碼子是 5'AGC3'

Q.41

Frequencies of the human ABO blood group alleles in a population are $p(I^A) = 40\%$, $p(I^B) = 40\%$ and $p(i) = 20\%$.
在一族群中ABO血型的等位基因頻率為
 $p(I^A) = 40\%$, $p(I^B) = 40\%$, $p(i) = 20\%$

Assuming that the population is in Hardy-Weinberg equilibrium, indicate in the answer sheet if each of the following statements is true or false.

假定此族群處於哈-溫平衡狀態，在答案卷上指出下列各敘述是對，或錯

- A. In this population, the number of persons with the blood groups A and B should be equal.
此族群中，A血型和B血型的人數應當相等
- B. In this population, the number of persons with the blood groups A and AB should be equal.
此族群中，A血型和AB血型的人數應當相等
- C. In this population the frequency of persons with anti-B antibodies is 64%.
此族群中具抗B抗體的人數占64%
- D. Locus ABO is localized on an autosomal chromosome because the blood group frequencies are the same for men and women.
ABO血型基因座位於體染色體上，因為血型頻率在男性和女性中是一樣的

Q.42

Frequency-dependent selection is an evolutionary process where the fitness of a phenotype depends on its frequency relative to other phenotypes in a given population. In **positive** frequency-dependent selection, the fitness of a phenotype increases as it becomes more common. And in **negative** frequency-dependent selection, the fitness of a phenotype decreases as it becomes more common.

頻率相依的天擇是演化的重要過程，一種表現型的適應度與它的頻率相對於族群中其它表現型有關。在正向的頻率相依天擇中，一表現型的適應度隨其頻率增加而增加。在負向的頻率相依天擇中，一表現型的適應度隨其頻率增加而減少

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. Plant self-incompatibility alleles are an example of negative frequency-dependent selection.
植物自交不親和等位基因是負向頻率相依天擇的例子
- B. Spreading of a newly emerged virus in a human population is controlled by negative frequency-dependent selection.
人類族群中新興病毒的傳播受到負向頻率相依天擇
- C. Prevalence of *Papilio memnon* whose females resemble distasteful *Papilio coon* is an example of positive frequency-dependent selection.
大鳳蝶的大量出現因其雌性和難吃的*Papilio coon* 相似，這是正向頻率相依天擇的例子
- D. Spread of genes responsible for warning coloration in toxic organisms in population is controlled by positive frequency-dependent selection.
有毒生物產生警戒色的基因在族群中傳布，是受到正向頻率相依天擇控制

Q.43

A population of dragonfly larvae (*Leucorrhinia intacta*) is separated into two groups. In both groups, larvae populations are put inside a cage with no food limitation. The first group is exposed to a fish predator that can swim freely, but cannot enter the cage. The second group is a control with no fish. The proportion of larvae surviving and the proportion of live larvae failing to metamorphose in the two groups are shown below:

將一個蜻蜓幼蟲 (*Leucorrhinia intacta*) 的族群分成兩組，將兩組幼蟲族群放入容器中，提供充足的食物。其中，將第一組幼蟲曝露在有一隻天敵魚的環境中，天敵魚可自由游動但無法進入容器，第二組無魚為控制組。

兩組幼蟲存活率以及存活幼蟲無法進入變態的比例，顯示在下圖。

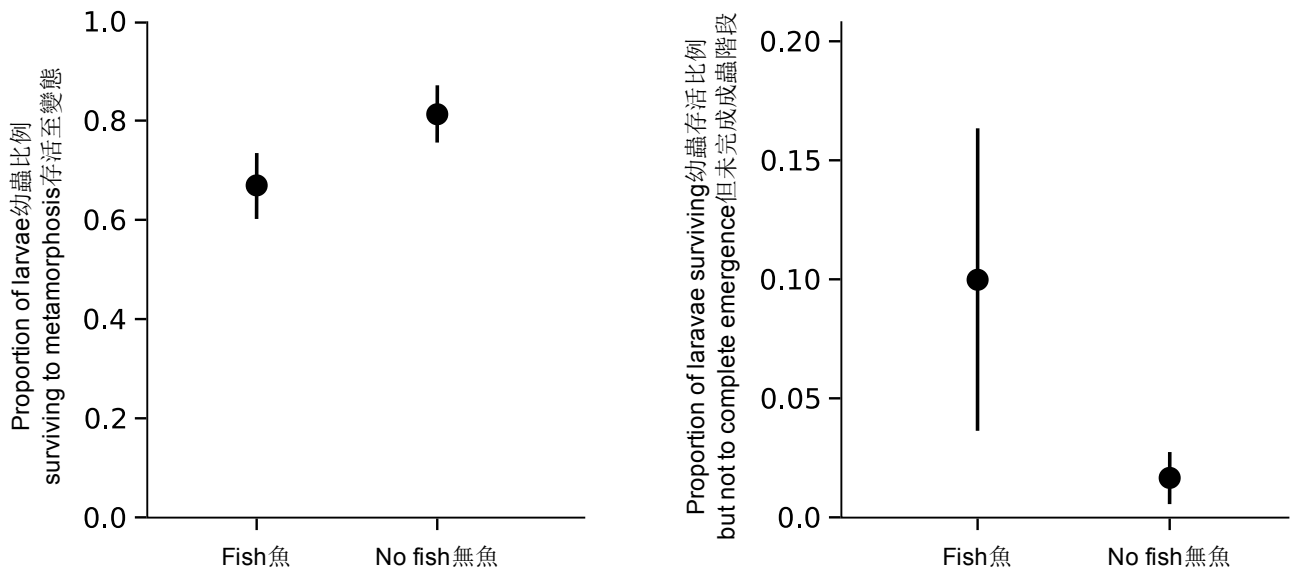


Figure Q.43

Indicate in the **Answer sheet** if each of the following statements is True or False.

在答案卷指出下列敘述是正確或錯誤。

- One of the causes of high failure rate of metamorphosis of the larvae upon exposure to a non-lethal predator is cannibalism.
環境中有非致命天敵存在之幼蟲組，其變態失敗率較高的原因之一為同類相殘
- The high mortality of larvae in the first group is due to predator-induced stress.
第一組幼蟲的高死亡率可歸因於天敵所引起之壓力
- In the predator treatment, the percentage of individuals that survived the larval stage completed emergence to the adult stage is lower than the percentage of those in the fishless treatment.
在環境中有天敵的試驗組中，個體從幼蟲存活至完全變態成蟲的比例較無魚的控制組為低
- The survival of dragonfly before metamorphosis is dependent on the predator while those during metamorphosis is not.
蜻蜓在變態前之存活率與天敵存在與否有關，而在變態期間則與天敵無關

Q.44

Laboratory experiments were conducted to examine the effects of temperature on interspecific competition between two stream salmonid fishes, *Salvelinus malma* and *S. leucomaenis*, with largely allopatric altitudinal distribution. Three combinations of species population, including allopatric populations of *S. malma* and *S. leucomaenis*, and sympatric populations of both species, were treated with low temperature (6°C) and high temperature (12°C), in which thriving allopatric populations of *S. malma* (6°C) and *S. leucomaenis* (12°C) are commonly found.

在實驗室中針對兩種溪流中的鮭魚 *Salvelinus malma* 和 *S. leucomaenis*，受溫度效應影響所產生的種間競爭進行研究，大體上此兩種魚為海拔分佈不重疊的物種。

三種組合包括 *Salvelinus malma* 和 *S. leucomaenis* 兩種魚的異域種群及兩者組合的同域種群，分別飼養在 6°C 及 12°C 的環境中。

兩種溫度是此兩種魚在野外生存環境中常見的溫度，分別是 *S. malma* (6°C) 及 *S. leucomaenis* (12°C)。

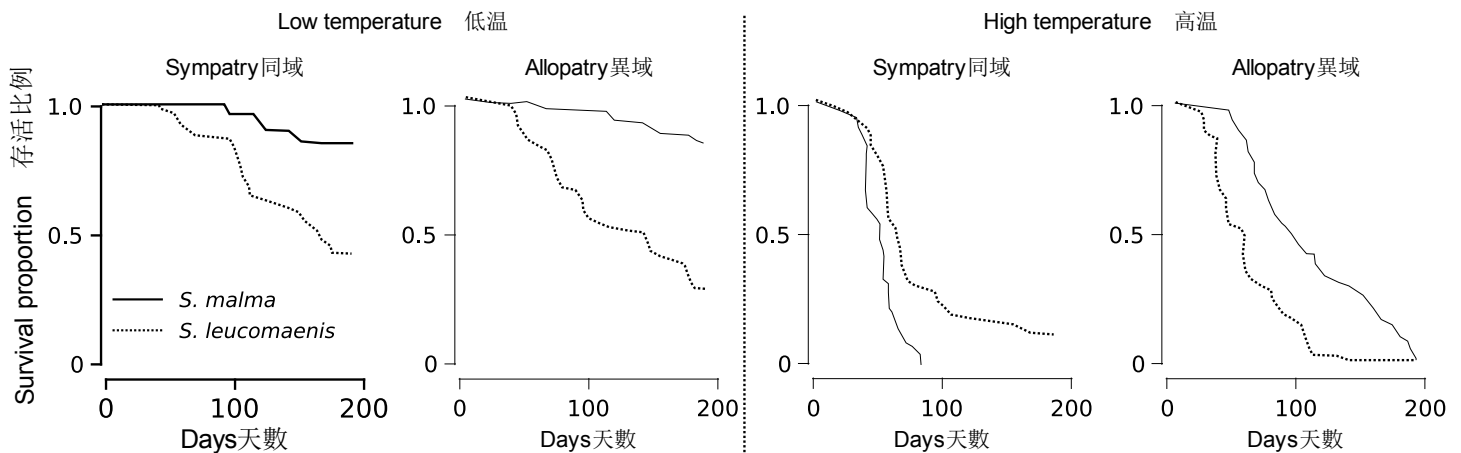


Figure Q.44

Indicate in the **Answer sheet** if each of the following statements is True or False.

在答案卷指出下列敘述何者為正確或錯誤

- Competition of these two species is likely to have been affected by temperature and altitude
此兩種魚的競爭可能受到溫度及海拔高度的影響
- S. Malma* may be distributed at higher altitudinal ranges than is *S. leucomaenis*
S. Mama 可以生存分佈的海拔高度範圍比 *S. leucomaenis* 大
- S. leucomaenis* is likely to be more low-temperature stress-resistant than *S. malma*
S. leucomaenis 有可能較 *S. malma* 對低溫的抵抗性要好
- S. malma* has a narrower fundamental niche than does *S. leucomaenis*
S. malma 較 *S. leucomaenis* 所具有的基礎生態區位要窄

Q.45

Male guppies (*Poecilia reticulata*) show a complex color pattern polymorphism that varies with predation pressure, reflecting a balance between selection for crypsis by predators and selection for conspicuousness by sexual selection. Three experimental ponds were used to study this phenomenon, mimicking the real condition on the native habitat of the guppies and its predators, *Rivulus hartii* and *Crenicichla alta*. One pond has the control group while the other two ponds were added with one of the two predators. In the field, *C. alta* was observed to be more dangerous than *R. hartii*.

雄性孔雀魚(*Poecilia reticulata*) 具有非常複雜多變的體色型，他會隨著天敵的壓力而變的隱晦或暗淡，及受性擇的壓力而呈現鮮明的體色。

為了解此現象，利用三個實驗的池塘，模擬孔雀魚和兩種天敵哈氏溪鱗(*Rivulus hartii*)及矛麗鯛(*Crenicichla alta*)所生存的環境。其中一個池塘為控制組，另外兩個池塘分別再引入兩種天敵的一種。在野外矛麗鯛(*C. alta*) 較哈氏溪鱗(*R. hartii*)對孔雀魚的威脅程度要大。

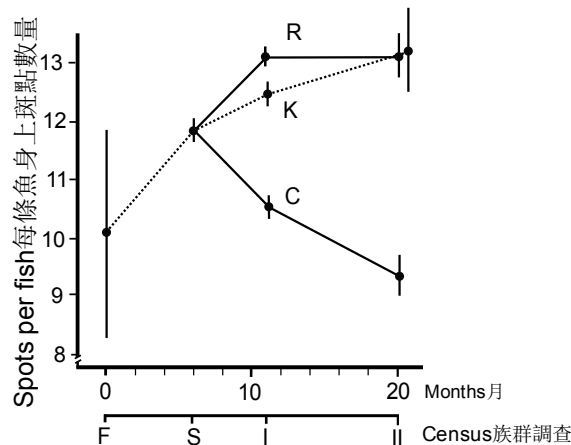


Figure Q.45. Changes in the number of spots per fish during the course of the experiment. Line 'K' stands for pond without predator, 'R' for pond with *R. hartii*, and 'C' for pond with *C. alta*. In the X-axis, 'F' stands for the time when the foundation population was started, 'S' stands for the time when the predators were added, then 'I' and 'II' stands for the numbering of the following censuses.

圖Q.45. 實驗過程中每條魚身體斑點數量的變化，'K'表示沒有天敵的池塘，'R'代表有天敵哈氏溪鱗(*R. hartii*)池塘，'C'代表有天敵矛麗鯛(*C. alta*)的池塘，在圖形的X軸中，'F'表示開始放入魚群的時間，'S'表示天敵加入的時間，'I'及'II'代表兩次魚群數量調查的時間。

Indicate in the **Answer sheet** if each of the following statements is True or False.

在答案卷指出下列敘述何者為正確或錯誤

- The color pattern is responsible for the reduced fitness of *P. reticulata*.
體色型態是造成孔雀魚(*P. reticulata*)適存度減少的原因
- Sexual selection for color pattern of the *P. reticulata* cannot be inferred from the data.
關於性擇對孔雀魚(*P. reticulata*)體色型態的影響，無法由所提供的資料來推論
- The color pattern of the *P. reticulata* may be advantageous in escaping *R. hartii*.
孔雀魚(*P. reticulata*) 體色型態有利於對天敵魚哈氏溪鱗(*R. hartii*)的逃避
- The two predators possibly use two different mechanisms to detect *P. reticulata*.
兩種不同的天敵可能使用不同的方式來找到孔雀魚(*P. reticulata*)

Q.46

The dioecious perennial *Poa* grass coexists with *Stipa* grass in the steppes. The former is highly preferred by domestic and wild herbivores, while the latter is relatively unpalatable. Scientists grew *Poa* plants in different distances to *Stipa* plants, with or without root barrier, in different grazing levels, and then recorded the growth of *Poa* plants.

雌雄異株多年生的草種早熟禾*Poa*與醉馬草*Stipa* 共存於旱地高原，前者是當地畜養及野生草食獸所偏好的食物，後者為相當遭排斥的食物。

科學家種植早熟禾*Poa*紀錄其在不同情況下生長狀況包括醉馬草*Stipa* 在不同距離，有無根系阻隔及不同的啃食壓力等的影響。

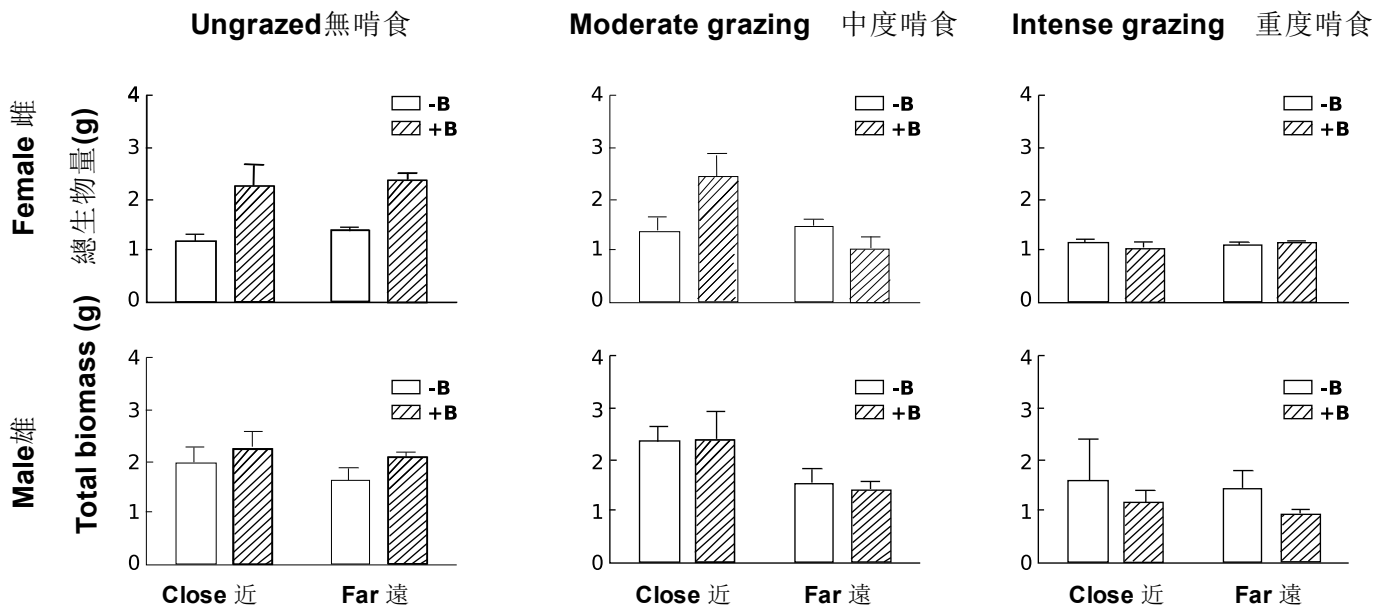


Figure Q.46-1. Effects of distance (close and far) and barrier (without barrier (-B) and with the barrier present (+B) to root competition manipulations on *Poa* female (top panels) and male plants (bottom panels) total biomass, at each grazing intensity level.

圖Q.46-1.在不同啃食壓力下，距離(近及遠)及阻隔(無(-B)及有(+B))，對於早熟禾*Poa*雌性(上排圖)及雄性植株(下排圖)根系間競爭的操作，及對其總生物量的影響。

In another experiment, they recorded the density of *Poa* male and female plants under different grazing levels. 在另一個實驗，他們紀錄了早熟禾(*Poa*)雄性及雌性植株在不同啃食壓力下的密度

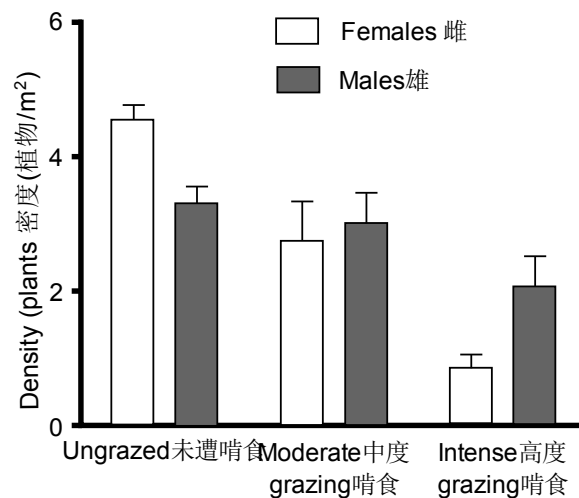


Fig.Q.46-2

Indicate in the **Answer sheet** if each of the following statements is True or False.

在答案卷指出下列敘述何者為正確或錯誤

- A.** Distance to the less palatable *Stipa* neighbours affects the *Poa* biomass of females and males at the ungrazed site.
早熟禾*Poa*在沒有啃食壓力的地區，其與不受歡迎馬醉草*Stipa* 的距離，會影響到早熟禾*Poa*雌性及雄性植株的生物量
- B.** Plants at the moderate grazing site, whether male or female, generally perform better near *Stipa* tussocks than far from them, demonstrating a positive effect of *Stipa* canopies on both genders.
在有中等啃食壓力的地區，無論是雌或雄性早熟禾植株，其靠近馬醉草(*Stipa*)的草叢者一般表現較遠離者好，此現象証實馬醉草的叢冠對早熟禾雌及雄性植株有正面效應
- C.** There is a strong below-ground competition between *Poa* females and *Stipa* neighbours at the ungrazed site.
在未啃食的地區，早熟禾(*Poa*) 雌性植株與馬醉草(*Stipa*)鄰居間呈現一種強大的地下競爭
- D.** Population sex ratio drift between female and male bias is influenced by domestic grazing intensity.
早熟禾族群雌雄性比差異之漂變，是受到放牧草食動物啃食強度的影響

Q.47

Goats are fed with alfalfa and corn stubble. At time 0, they were also fed with *Mimosa* seeds. The presence of viable *Mimosa* seeds in goat faeces was recorded with a germination experiment with egested and control seeds.

餵食山羊苜蓿及玉米桿，在一開始(At time 0)，他們也吃含羞草(*Mimosa*)的種子。利用從糞便排出及對照組的種子進行萌發實驗，紀錄山羊糞便中具存活力的含羞草種子的數量。

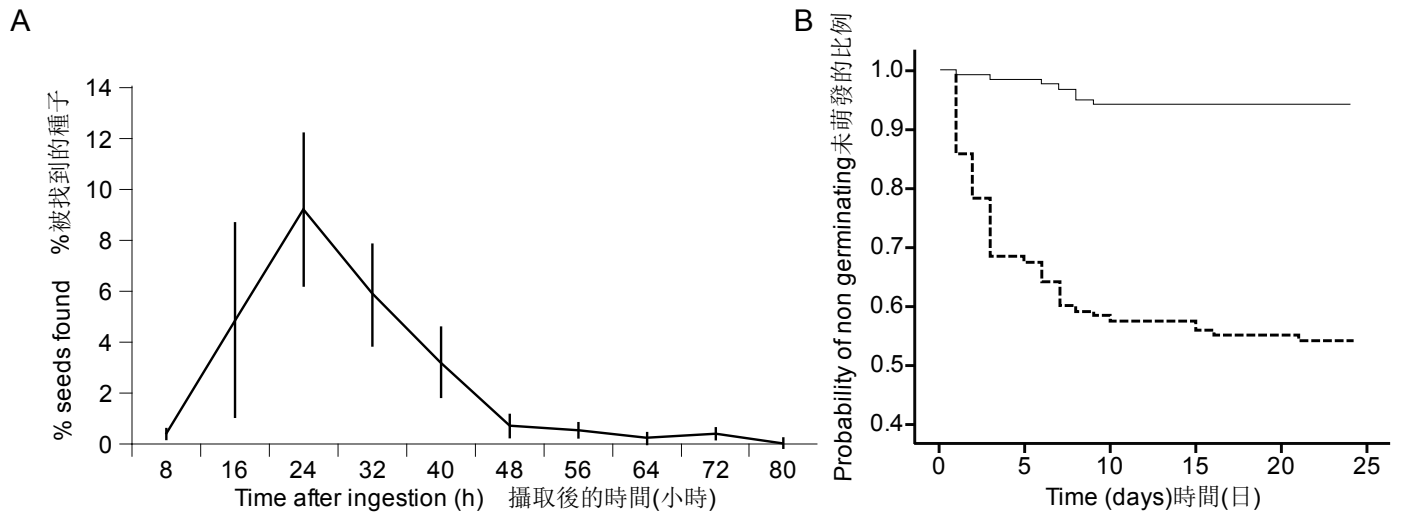


Figure Q.47 A: Percent of *Mimosa* seeds found in goat faeces as a function of time after ingestion. Goat pellets were collected every 8 hours over a period of 80 hours after ingestion. **B:** Probability of non germinating of egested (stippled line) and control (solid line) *Mimosa* seeds.

圖 Q.47 A: 山羊糞便中含有含羞草種子的百分比與攝取時間的關係。在攝食種子後80小時內，每8小時採集糞便一次。 B: 攝食後排出的(虛線)及對照組的 (實線) 含羞草(*Mimosa*)種子未能萌發的比例。

Indicate in the **Answer sheet** if each of the following statements is True or False.

在答案卷指出下列敘述何者為正確或錯誤

- Mimosa* seed can survive up to 3 days in the goat digestive system.
含羞草(*Mimosa*)種子在山羊的消化系統中最多能存活3天
- The passage through the goat digestive system decreases seed germination.
經過山羊消化道的種子其萌發率降低
- Number of seeds egested after ingestion is highest after 24 hours.
糞便中排出種子的數量，在攝食種子後24小時後達到最高
- Goats could act as legitimate disperser of *Mimosa* seeds.
山羊可以被當做是合適的含羞草種子傳播者

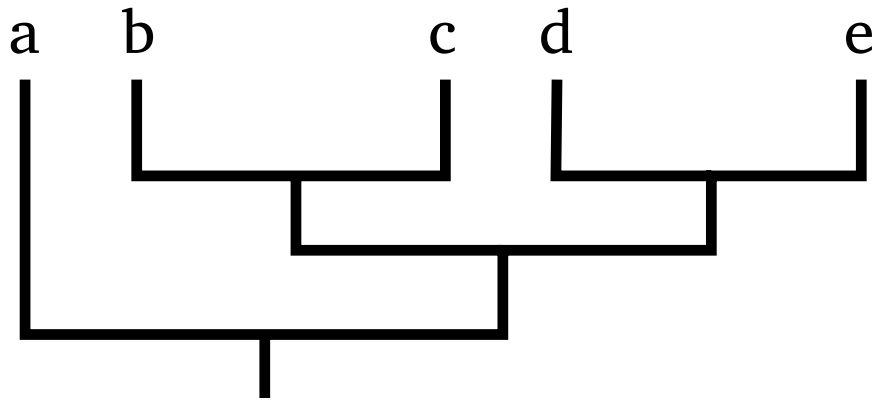
BIOSYSTEMATICS

生物系統分類

Q.48

Study the cladogram given below and indicate if each of the following statements is true or false.

檢視下列支序圖，並註明下列敘述正確或錯誤



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 clade containing (d) and (e) is a sister group to the taxon consisting of (a), (b) and (c).
包括 d 及 e 的分支是分類群(a, b, c)的姊妹群
- B. The last common ancestor of (b) and (c) descended from the last common ancestor of (c) and (d).
b 及 c 的最近共同祖先是從 c 及 d 的最近共同祖先 衍生而來
- C. Taxon (b) is more closely related to taxon (a) than to taxon (e).
對分類群 e 而言，分類群 b 與分類群 a 的親緣更近
- D. The lineage leading to taxon (a) was the first to diverge from the other lineages.
分類群 a 的族系是第一個從其他族系分歧出來者

Q.49

Most taxonomists today believe that biological classification systems should reflect the evolutionary relationships of organisms and taxonomic groups should be monophyletic. However, the classification used today still contains many polyphyletic and paraphyletic taxonomic groups.

現今大部分分類學家相信生物分類系統應該反映生物的演化關係，而且分類群應該是單源系。然而現今用的分類仍然包含許許多源系及平源系的分類群。

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. Polyphyletic taxa can arise when taxa that are not directly related share similar character states due to convergence.

當一些並非直接親近的分類群，因趨同演化而共享相似的特徵狀態時，則會產生多源系分類群

B. If a classification is based on phenotypic similarity, paraphyletic taxonomic groups may result

若一分類關係是奠基於表徵之相似性，則會導致有平源系的分類群

C. Some taxa in a paraphyletic taxonomic group have phenotypically evolved at different rates compared to closely related taxa that are not included in the group.

相較於親源相近但未包含在此平源系中的分類群，平源系中的一些分類群會在不同速率下進行表徵演化

D. All molecular data support gymnosperms as a monophyletic taxon.

所有分子數據都支持裸子植物是一個單源系分類群

Q.50

Using sequence differences to establish phylogenies has some advantages and possible dangers. An inappropriate choice of molecule could result in molecular trees that greatly distort true phylogenetic relationships. Hence, care must be taken in using this approach.

利用序列差異來建構親緣關係的方法有一些益處及可能的危險。分子的選擇若不適當，則可導致大幅曲解真正親緣關係的分子樹之結果，所以，必須小心使用此研究方式。

Indicate in the answer sheet if each of following statements is true or false.

在答案紙上，註明下列敘述正確或錯誤

- A.** Polypeptide sequences of cytochrome c are very useful for establishing evolutionary relationships between closely related species.
在建立親緣較近的物種間之演化關係，細胞色素 c 的多肽序列非常好用
- B.** For phylogenetic analysis, comparing partial sequences from many different genes is better than comparing full-length sequences of several genes.
為親緣關係分析，比較來自許多不同基因的部分片段序列，比起比較一些基因的全長序列來得好
- C.** Rates of nucleotide substitution per unit of time are faster in organisms with short generation times than in organisms with long generation times.
單位時間內的核苷酸取代速率在具有短的世代週期之生物體中比具長世代週期者快
- D.** The Neutral Theory requires that all polypeptide and DNA sequences evolve at the same rate.
中性理論是指所有多肽及DNA 序列的演化速率相同

END OF THEORY PART A 結束!!