25th INTERNATIONAL BIOLOGY OLYMPIAD

5 – 13 July, 2014

INDONESIA

THEORETICAL TEST

理論題 A

PART A

QUESTION PAPER

試卷

Total points: **48**

Duration: 180 minutes

COUNTRY:	.....
STUDENT ID:	.....

INSTRUCTIONS:說明

1. Fill in your STUDENT ID and your country in the Answer Sheet.
   在答案卷上填入 STUDENT ID 與 country

2. Each question contains four statements which you must indicate as True or False.
   每題都有四小題，都必須回答正確或是錯誤
   - If you answer correctly to all four statements, you will receive 1 point.
     四題全對給 1 分
   - If you answer correctly to only three statements, you will receive 0.6 point.
     對三題給 0.6 分
   - If you answer correctly to only two statements, you will receive 0.2 point.
     對二題給 0.2 分
   - If there is only one statement with the correct answer, you will not receive any points (0).
     對一題不得分
   - There is no minus system. 沒有倒扣

3. Tick (√) the correct answer in your Answer Sheet using a pen (in ink). If you need to change an answer, you should strikethrough the wrong answer and write in the new one (see the example below). In the table, T=True, F=False.
   在答案紙上以打勾 (√) 方式回答。如果要更改答案，必須將先前答案以雙線劃除後，重新選擇。參考下圖示範。T = 正確, F = 錯誤.

No.	Statement	T	F
1.	A		√
	B	~~√~~	√
	C	√	
	D	√	~~√~~

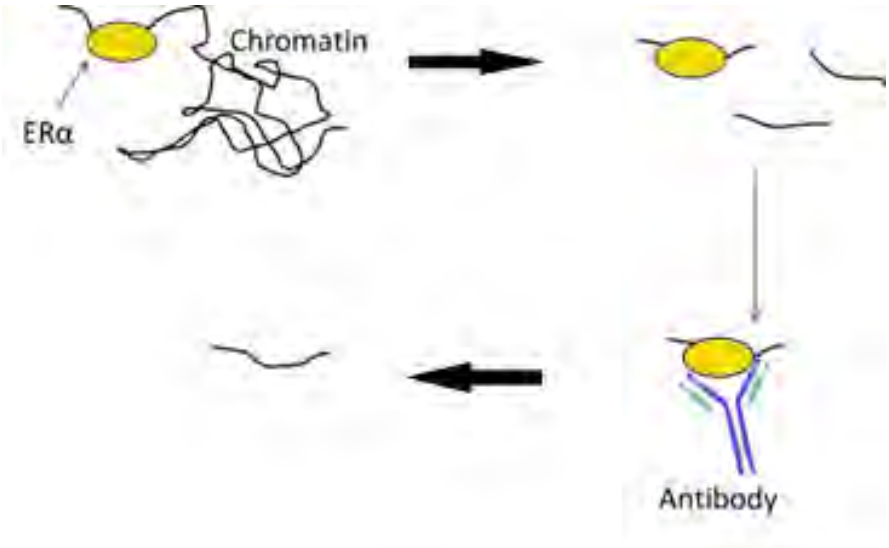
4. You may use a calculator in your exam.
   可以使用計算機

5. GOOD LUCK.
   祝好運

CELL AND MOLECULAR BIOLOGY 細胞與分子生物學

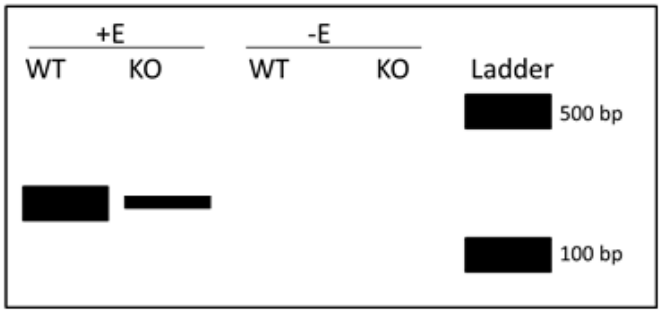
1. In the presence of estrogen, the estrogen receptor α (ERα) regulates expression of around 10,000 genes in humans. To study the interaction of protein X with ERα, you have generated cells that lack gene *x* (KO). You treat KO and wild type (WT) cells with estrogen (+E) or not (-E). You next perform Chromatin Immunoprecipitation (ChIP, see figure below) , in which ERα proteins are first recersibly cross-linked to their current binding location in the genome. The genome is fragmented and fragments containing Erα are extracted with polyclonal antibodies against ERα.

人體中，當雌激素存在時，雌激素受體 α (ERα) 能調控近 10,000 個基因。要研究X蛋白與 ERα 的交互作用時，你要先準備一個缺乏 *x* 基因的細胞 (KO)。下一步便是在 KO 細胞與野生型細胞 (WT) ，分別添加 (+E) 或移除 (-E) 雌激素的實驗。為了進一步了解 ERα 蛋白在基因體中可逆的結合位置，此時染色質沈澱法（ChIP，見下圖說明）便派上用場。首先將基因體打碎，再利用 ERα 的抗體將 ERα 黏附的染色質斷片萃取出來。



（Chromatin：染色質；Antibody：抗體）

After releasing Erα, the DNA fragments are isolated and amplified semiquantitatively with primers for the promoter region of a gene *a*, known to be upregulated by estrogen. Electrophoresis results are shown below.
此時，將 ERα 移除。使用 基因 *a* 的啟動子區域序列作為引子放大該基因片段，加以分離進行粗略定量純化出來的 DNA。已知，基因 *a* 被雌激素作用後會大量表現 。電泳結果如下。



Indicate if each of the following statements is true or false.
請分別回答下列有關敘述，是 正確 或 錯誤

This experiment suggests that protein X affects with the binding of ERα **to...:**
實驗結果顯示，X 蛋白會影響 ERα 結合到：

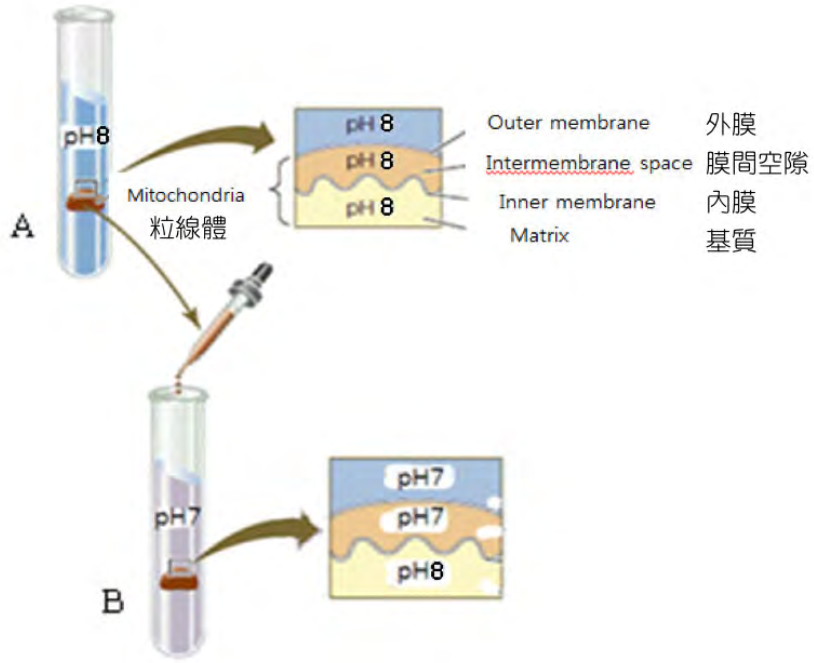
A. **...**the promoters of all gene regulated by ERα.
所有被 ERα 調控基因的啟動子

B. ...the promoter of gene *a*.
基因 *a* 的啟動子

C. ...all its possible protein partners
所有可能的相關蛋白

D. ...the protein product of gene *a* .
基因 *a* 的蛋白產物

2. An experiment was performed to study the relation between H^+ concentration and ATP synthesis in mitochondria. Mitochondria were isolated from the cell and placed into a pH 8 media (test tube A), then immediately transferred into a pH 7 media (test tube B). Later, ATP synthesis was verified in test tube B.
在一個研究粒線體中 H^+ 濃度與 ATP 合成關係的實驗中，粒線體自細胞中被分離出來，並置於 pH 8 的培養基中（A試管）。之後，立刻被移到 pH 7 的培養基中（B試管）。稍後，B試管中被檢驗出有 ATP 合成。



Indicate if each of the following statements is true or false.
請分別回答下列有關敘述，是 正確 或 錯誤

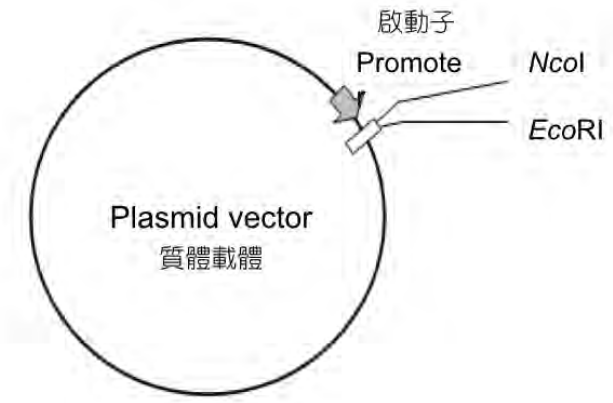
A. In tube B, ATP was synthesized in the matrix-facing side of the inner mitochondria.
B試管中，ATP 是在粒線體面對基質的內膜所合成的

B. In tube B, ATP was synthesized without the help of electron transport system.
B試管中，ATP 的合成，無需電子傳遞系統幫忙

C. If mitochondria in tube A was transferred into a pH 9 media, ATP synthesis will occur in the intermembrane space of mitochondria.
如果A試管中的粒線體被移到 pH 9 的培養基中，ATP 會在膜間空隙中合成

D. If mitochondria remains in tube A but glucose is added, there will be ATP synthesis.
若將粒線體置於A試管中，此時添加葡萄糖，會有 ATP 合成

3. You plan to insert the gene *PhoQ* from *Tobibacterium* sp into a plasmid vector containing an artificial promotor followed by a restriction site for *Nco*I (CCATGG) and a restriction site for *Eco*RI (GAATTC).
你計劃在一個人造的質體載體中插入來自 *Tobibacterium* sp 的 *PhoQ* 基因。這個質體具有一段人造啟動子，與兩個限制酶切位，分別為 *Nco*I (CCATGG) 與 *Eco*RI (GAATTC)，如下圖。



To conduct this experiment you are required to design forward (the sense strand) and reverse (antisense strand) primers. Part of the 561 nucleotide long coding sequence is shown below.
為了讓實驗順利進行，你必須分別設計一段 正向 (sense strand) 與 反向 (antisense strand) 引子。一段 561 個核苷酸長的編碼序列如下：

5’-ATGCGACAGTTCATCACCGA... _____....GCGGGACCGGACTGGGGTAA-3’

Indicate if each of the following statements is true or false.
請分別回答下列有關敘述，是 正確 或 錯誤

A. The use of two different restriction sites avoids wrong orientation of the inserted fragment
為了避免插入序列的方向性錯誤，因此設計兩個不同的限制酶切位

B. A possible forward primer for amplification and insertion of *PhoQ* gene will have the following sequence: 5’ – GATCCCATGGATGCGACAGTTC – 3’
可使 *PhoQ* 基因倍增所插入的 正向引子序列為
5’ –GATCCCATGGATGCGACAGTTC – 3’

C. A possible reverse primer for amplification and insertion of *PhoQ* gene will have the following sequence: 5’ – GATCGAATTCAATGGGGTCAGGCC – 3’
可使 *PhoQ* 基因倍增所插入的 反向引子序列為
5’ –GATCGAATTCAATGGGGTCAGGCC – 3’

D. The final gene product will consist of at least 189 amino acids.
基因的最終產物至少具有 189 個氨基酸

4. Indicate if each of the following statements about posttranslational modification of eukaryotic proteins.
請分別回答下列有關真核細胞後轉譯修飾的敘述，是 正確 或 錯誤

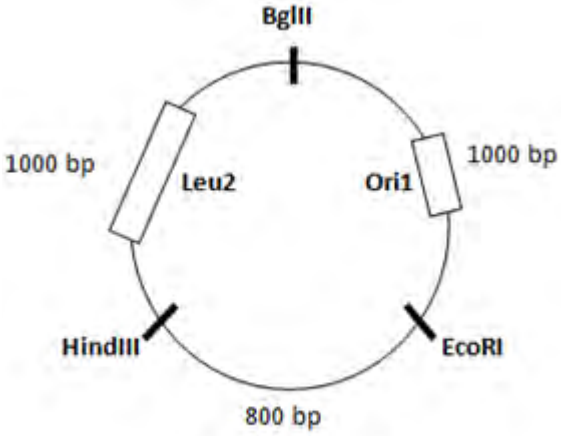
A. Disulfide bond formation on a protein occur in the endoplasmic reticulum.
蛋白質的雙硫鍵形成是於內質網進行

B. Glycoproteins may be found in viruses that infect human.
糖蛋白與病毒感染人類有關

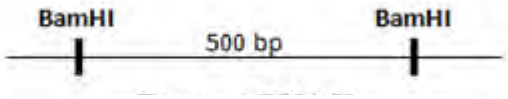
C. Oligosaccharide group addition to a protein may occur in both Golgi apparatus and , without involving any enzymes from endoplasmic reticulum.
蛋白質上寡醣的添加是在高基氏體中進行，與內質網的酵素無關

D. Palmitoylation of a protein can change its intracellular localization.
蛋白的棕櫚酰化能改變它在細胞內的定位點

5. An experiment was performed to create a recombinant DNA between plasmid X and DNA insert Y. Plasmid X contains *leu2* gene for leucine biosynthesis while DNA fragment Y contains kanamycin-resistance gene *KanR*. The diagram for X and Y are shown below.
製備Ｘ質體與 DNA 插入Ｙ片段的 DNA 重組實驗中，Ｘ質體上具有一個合成 leucine 的基因 *leu2*，Ｙ片段上具有抗 kanamycin 的基因 *KanR*，如下圖所示。



Plasmid X　Ｘ質體



DNA insert Y
(contains *KanR*)
含有 *KanR* 的 Ｙ片段

Plasmid X and DNA insert Y were added to a reaction mix containing restriction enzymes *Bgl*II (5'-A*GATCT-3'), *Bam*HI (5'-G*GATCC-3'), and the resulting fragments then transferred to a new reaction mix containing ligase. The resulting DNA was transformed into bacterial culture Z which is sensitive to kanamycin and unable to survive in leucine-deficient medium. Selection for transformed Z cells containing the recombinant plasmid (plasmid X with DNA insert Y) was performed by growing the culture on a selective medium containing kanamycin and no leucine. The recombinant plasmid was then isolated from the culture. Assume that all isolated plasmids are in circular conformation and there is no partial restriction reaction, all plasmids are cut completely by the restriction enzyme. (Note: (*) indicates the location of bond hydrolysis)

Ｘ質體與Ｙ片段分別置入含有限制酶 *Bgl*II (5'-A*GATCT-3'), *Bam*HI (5'-G*GATCC-3') 的混合液中。反應完成後，再移入有連接酶的混合液中繼續作用。將最後的 DNA 片段植入Ｚ細菌（該菌株對 kanamycin 敏感，並培養於缺乏 leucine 的培養基中），將已植入含有Ｙ片段的Ｘ質體之Ｚ細菌培養在無 kanamycin 與缺乏 leucine 的培養基中。將重組之質體自細菌中萃取出來。假設，分離出來的質體此時為環形且完整。最後，將此質體經由限制酶完全作用。（注意：**(*)** 指水解的位置）

Indicate if each of the following statements is true or false.
請分別回答下列有關敘述，是 正確 或 錯誤

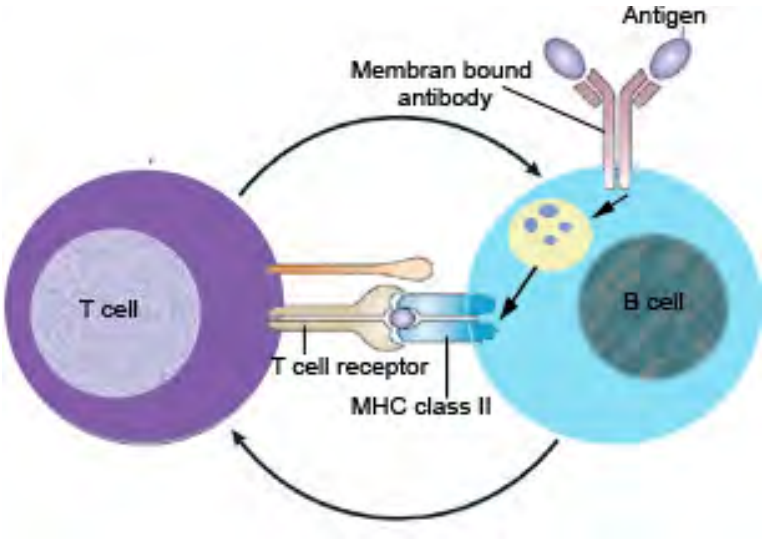
A. Cutting the plasmid after insertion of Y using *Eco*RI will result in single 2800 bp DNA fragment on the electrophoresis gel.
此重組的質體經 *Eco*RI 作用，電泳分離後，會得到一個 2800 bp 的DNA 片段

B. If in the reaction mix HindIII (5'-A*AGCTT-3') was used instead of BglII, the transformed bacteria are capable of growing on a medium containing Kanamycin.
使用 HindIII (5'-A*AGCTT-3') 取代原有的 BglII，基因轉殖細菌能生長在含有 Kanamycin 的培養基中

C. The 500 bp insert DNA can be removed from the recombinant plasmid by using restriction enzyme *Bgl*II.
使用 *Bgl*II 處理此重組的質體，會得到一個 500 bp 的外源 DNA

D. The migration pattern of the recombinant plasmid on an electrophoresis gel is different when it is treat with EcoRI or BamHI.
使用 EcoRI 或 BamHI 處理此重組的質體，會得到不同的電泳結果

6. Consider a protein containing four epitopes: an oligosacharide (O) and three peptides (P1, P2, P3). The following figure illustrates the interaction between B and T cells.
假設一個蛋白具有四種抗原決定位，分別是 O（寡糖構成），P1, P2, P3（多肽構成）。下圖為 B 細胞與 T 細胞的交互作用圖。



(modified from Edwards & Cambridge, 2006)

Indicate if each of the following statements is true or false.
請分別回答下列有關敘述，是 正確 或 錯誤

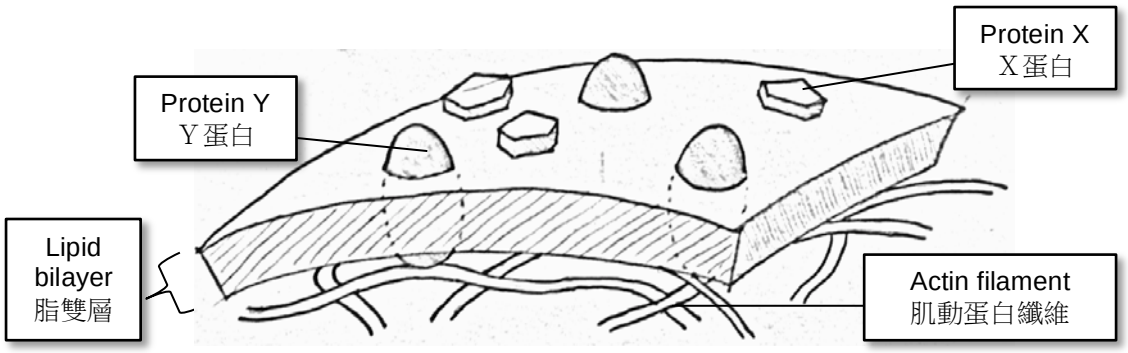
A. Antibody production for epitope O by B cells may occur only when the O epitope is presented by B cells to T cells.
當抗原決定位 O 經由 B 細胞呈獻給 T 細胞後，B 細胞才能產生辨認抗原決定位 O 的抗體

B. All of the four epitopes could be recognized by the population of B cells.
四種抗原決定位均能被 B 細胞群所辨認

C. A single B cell produces antibodies recognizing only one of the four epitopes.
單一個 B 細胞只能辨識四種抗原決定位中的一個

D. Via MHC II proteins, a single B cell can present diverse protein fragments to the T cells.
借由 MHC II 蛋白，單一個 B 細胞能呈獻多種蛋白質片段給 T 細胞

7. The diagram below shows the distribution of proteins X and Y on a small area on outer surface of cell membrane.
下圖為Ｘ蛋白與Ｙ蛋白在細胞膜表面小區域的示意圖



Protein Y is bound to immobile actin filaments on the inner surface of cell membrane. There is no similar domain found in protein X. An experiment is conducted to show the mobility of Protein X and Y in cell membranes. Those proteins are labeled by different fluorescent dye (red for protein X and green for protein Y with only one fluorescent molecule for each protein) and a small region of the surface is irradiated to bleach the dye molecules, and the intensity of fluorescence is followed over time.
Ｙ蛋白，會與細胞膜內側的固定的肌動蛋白纖維連結，而且與Ｘ蛋白無相似功能 。本實驗想了解Ｘ蛋白與Ｙ蛋白在細胞表面上的運動情形。分別將Ｘ蛋白染成紅色螢光，Ｙ蛋白染成綠色。在小範圍內，先用強光將已經染色的螢光去除（漂白），再隨著時間的增加，觀察該區域螢光強度的變化。

Indicate if each of the following statements is true or false.
請分別回答下列有關敘述，是 正確 或 錯誤

A. After long term irradiation, the cell will only show green fluorescenc.e
經過長時間的照射，只有綠色螢光會被觀察到

B. If the short time irradiation is conducted, the fluorescence of both colors will recover to their initial state in the bleached region.
短時間的照射後，在漂白區域的螢光都能恢復成初始狀態

C. If the actin cytoskeleton was disrupted with cytochalasin, the fluorescence of the cell is bleached completely after long term irradiation.
使用 cytochalasin 將肌動蛋白的細胞骨架破壞，在經過長時間照射後，細胞螢光都會被完全漂白

D. Cooling down the cells to 20^{o}C will accelerate the bleaching of the red fluorescence on the cell surface.
細胞培養溫度降到 20^{o}C 時，將會加速細胞表面紅色螢光的漂白

8. Six isolates of anaerobic soil bacteria (A-F) were analyzed to study their role in the nitrogen cycle. Each isolates were grown on four different broths: (1) Peptone (short polypeptides), (2) Ammonium, (3) Nitrate, and (4) Nitrite. Only the nitrate broth contained carbohydrate as a carbon source. After 7 days of incubation, the bacterial culture were biochemically tested to observe changes in the medium and the results are shown below:
有六株土壤厭氧菌 (A-F) 被用來作為氮循環研究之用。每株細菌分別培養在下列四種不同的培養基：(1) 蛋白胨（短聚胜肽）、(2) 氨、(3) 硝酸鹽 與 (4) 亞硝酸鹽。其中只有硝酸鹽培養基中添加醣類作為碳源。經過 7 天的培養後，培養過細菌的培養基經由生化測試並觀察結果，得到的結果，整理如下表：

No	Growth medium	Isolates					
		A	B	C	D	E	F
1	Peptone broth 蛋白胨	+, pH+	+, pH+	-	+, pH+	-	+, pH+
2	Ammonium broth 氨	-	-	+, NO_2^-	-	-	-
3	Nitrate broth 硝酸鹽	+, gas	+	-	+	-	+, gas
4	Nitrite broth 亞硝酸鹽	-	-	-	-	+, NO_3^-	-

\+ = bacterial growth was observed 有生長

\- = bacterial growth was not observed 無生長

pH+ = Increased pH of the medium pH 上升
NO_2^- = Positive result of nitrite test 亞硝酸陽性
NO_3^- = Positive result of nitrate test 硝酸鹽陽性
Gas = Gas production in the medium (detected by using durham tube) 會產氣

Indicate if each of the following statements is true or false.
請分別回答下列有關敘述，是 正確 或 錯誤

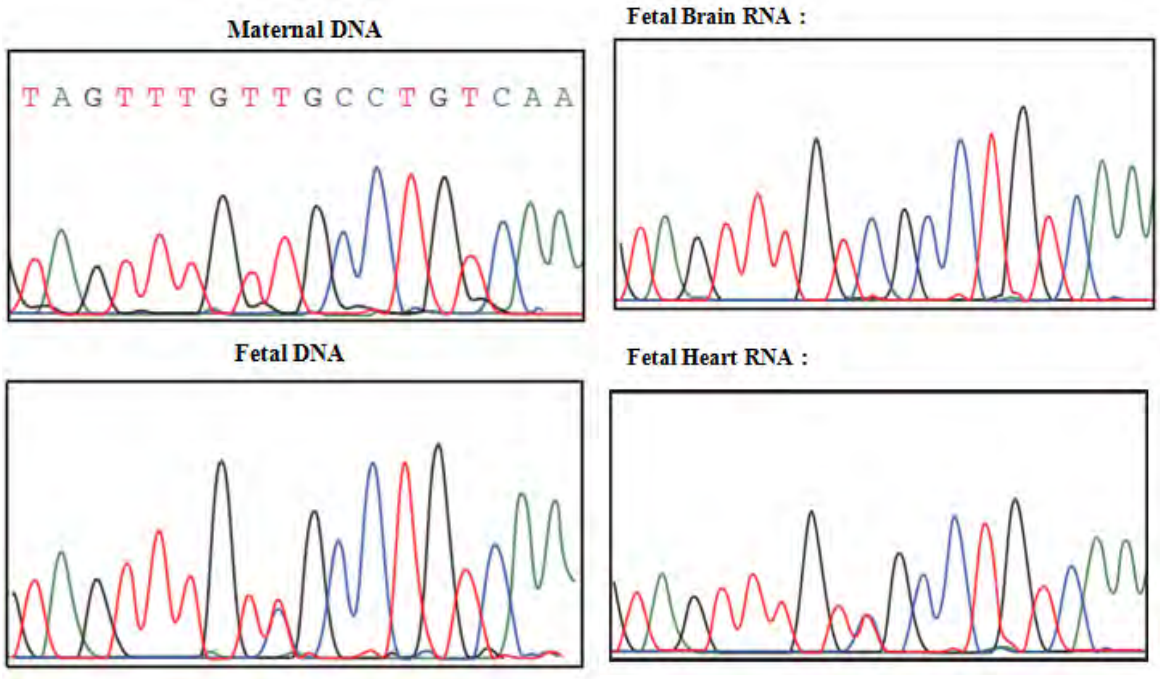
A. Isolate C belongs to the group of nitrifying bacteria (oxidize ammonium to nitrite then nitrate)
C 為硝化細菌（將氨氧化成亞硝酸鹽，再氧化成硝酸鹽）

B. Isolates B and D are denitrifying bacteria (reduce nitrate to molecular nitrogen).
B 與 D 為脫氮細菌（將硝酸鹽還原成氮分子）

C. Isolates C and E are chemoheterothropic bacteria.
C 與 E 為化學異營細菌

D. Isolates A and F are able to use nitrate as an oxydizer to produce energy
A 與 F 能將硝酸鹽當成氧化劑產生能量

9. The figure below shows part of the DNA sequence of the autosomal gene X from a mother and her child (fetal). The mRNA was obtained from fetal heart and brain and then sequenced. Before sequencing, mRNA was converted to cDNA and amplified by PCR (see figure below).
下圖為體染色體X基因的定序結果，樣本來源分別為母親與胎兒，同時也分析胎兒 X基因在心臟 (heart) 與腦 (brain) 的 mRNA。定序之前，mRNA 先轉成 cDNA 再經由 PCR 倍增。



Indicate if each of the following statements is true or false.
請分別回答下列有關敘述，是 正確 或 錯誤

A. The father must be heterozygous at this locus.
父親在該基因座為異基因型

B. In the fetal brain, the gene X was expressed from the maternal chromosome.
胎兒腦部的X基因表現來自母親的染色體

C. In the fetal heart, the gene X was expressed from both parental chromosomes.
胎兒心臟的X基因表現來自父母雙親的染色體

D. This result suggests tissue specific splicing of gene X.
結果顯示，組織中X基因會經過特殊的剪接

10. There are several mechanisms in eukaryotic cells to generate a diversity of proteins from a single gene. Alternative splicing of the Down Syndrome Cell Adhesion Molecule (DSCAM) gene, for instance, may result in 38,000 different protein products. , VDJ recombination in the formation of mouse immunoglobulin may result in 144,000 different heavy-chain proteins.
真核細胞中，存在著許多單一基因可產生多樣性蛋白的機制。例如，唐氏症細胞黏附蛋白 (DSCAM) 基因經選擇性剪接會產生 38,000 種的不同蛋白產物。小鼠形成免疫球蛋白過程中的 VDJ 重組，則會生成 144,000 不同的重鏈組合。

Indicate if each of the following statements is true or false.
請分別回答下列有關敘述，是 正確 或 錯誤

A. Protein diversity on the immunoglobulin heavy-chain is generated while on the DSCAM proteins is generated at the DNA level.
免疫球蛋白重鏈組合源自 RNA 重組；DSCAM 蛋白源自 DNA 重組

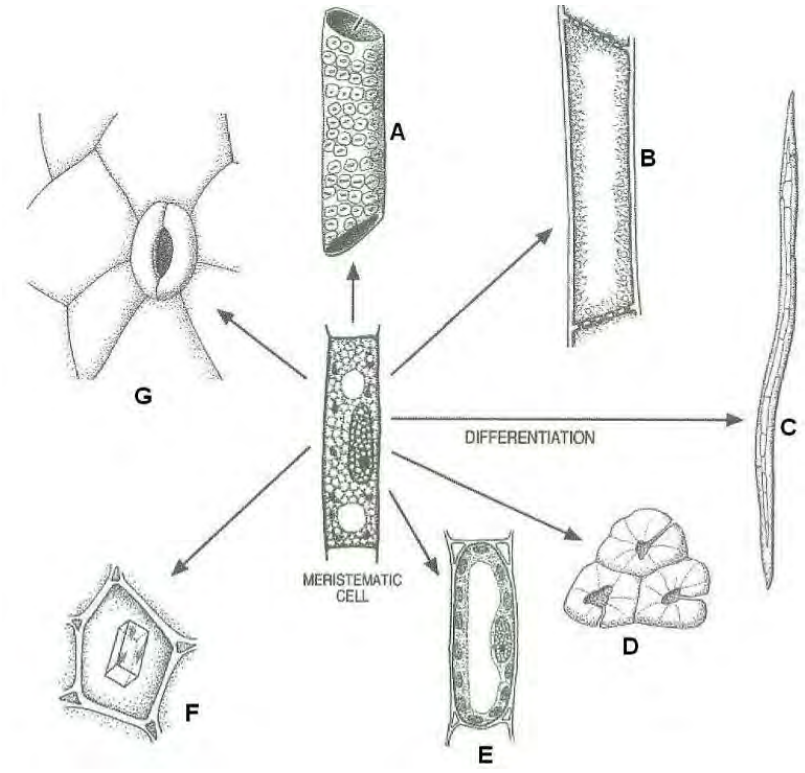
B. Only one type of heavy-chain protein is produced by a plasma cell, while there are often more than one protein types produced by a single cell in which the DSCAM gene is actively expressed.
單一的漿細胞只會生成一種重鏈；單一的細胞則會產生不止一種具活性的 DSCAM 基因蛋白

C. Disorder in the VDJ recombination maybe related to immunodefficiency diseases.
VDJ 排列重組錯誤屬於免疫缺損疾病

D. Although alternative splicing of DSCAM results in various mRNA sequences, these are all of the same length.
DSCAM 經選擇性剪接後會產生許多不同式樣的 mRNA 序列，他們的長度都是相同

PLANT ANATOMY AND PHYSIOLOGY 植物解剖及生理學

11. The following diagram shows representative end products of plant cell differentiation from a meristematic cell. 下圖顯示分生細胞可特化成的多種細胞類型。



Indicate if each the following statements is true or false. 判斷下列各敘述的真偽。

A. B, F, and G are living cells.
B, F, 及 G 為活細胞。

B. Differentiation of a meristematic cell into A, B, C and D requires lignin biosynthesis.
分生細胞要特化為 A, B, C 及 D 需要有木質素的合成。

C. Cell E can differentiate into Cell D.
細胞 E 可特化為細胞 D。

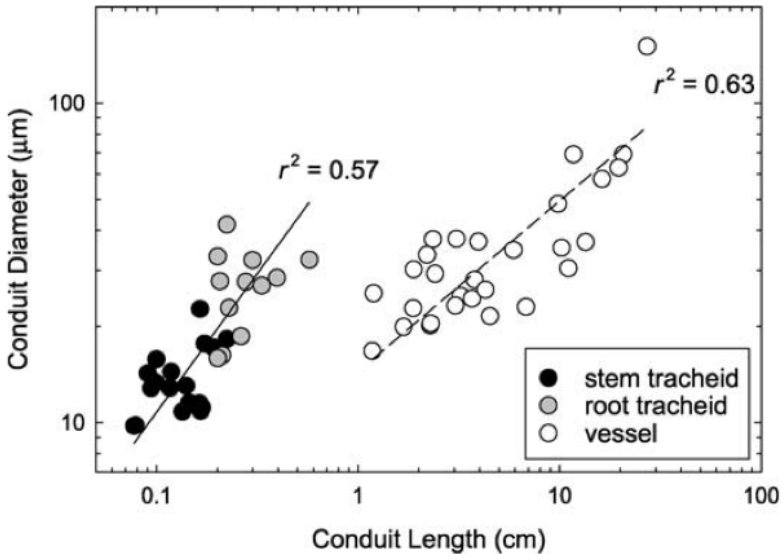
D. Cell B can dedifferentiate with particular hormone treatment.
藉由特定激素處理，細胞 B 可進行特化。

12. Plant xylem transport can be understood only by invoking biomechanics. Conduit diameter and length have major consequences for conducting efficiency, which agree with Hagen–Poiseuille formula as follows: 植物木質部運輸作用可用生物機械性原理來解釋，輸送管道的直徑及長度是影響運輸效率的主要因素，可用以下公示來表示。

$$volumetric\ flow\ rate(速率) = \frac{\pi r^4}{8 \times viscosity黏性} \times \frac{\Delta \Psi p}{L}$$

whereas:
r = radius 半徑
Ψp = pressure potential 壓力勢
L = length 長度

The figure shows the range of conduit diameter and length of tracheid in gymnosperms and vessels in angiosperms. 下圖顯示裸子植物的管胞以及被子植物的導管，其管道直徑及長度之比較。



Indicate if each the following statements is true or false. 判斷下列各敘述的真偽。

A. The largest difference between vessels and tracheids is in the length, rather than diameter.
導管及管胞最大的不同在於長度，而非直徑。

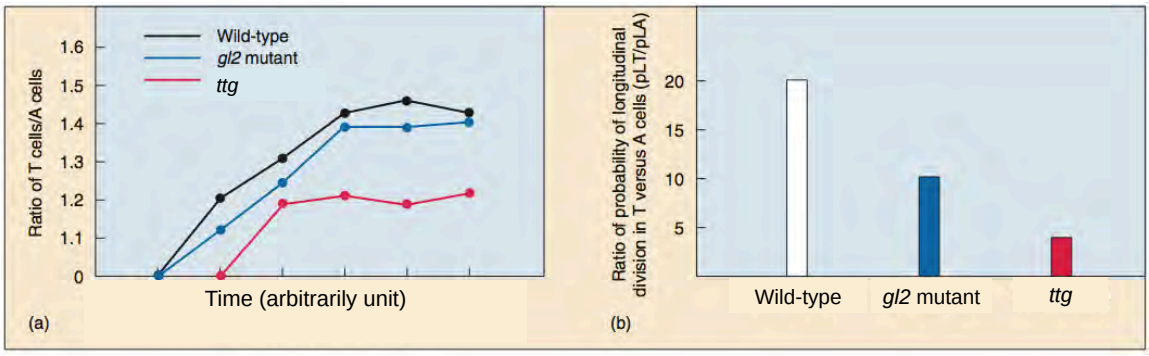
B. Movement rate in vessels is approximately equal to that in stem tracheids.
導管的水分運輸效率大約與莖部管胞相等。

C. Root tracheids can be wider than stem tracheids because they do not need as much reinforcement to hold up the foliage and to resist bending of the axis.
根部管胞的口徑可比莖部管胞大，因為他們不需如莖部管胞藉增加厚壁來支撐葉片及避免莖軸曲折。

D. The bigger the diameter of vessels, the smaller its frictional resistance.
導管的直徑愈大，其抵抗曲折的能力愈低。

13. Two developmental mutants of *Arabidopsis thaliana* were used to investigate whether the control of cell differentiation and the pattern of cell division were linked. A balance between cell production and cell differentiation can be achieved by controlling the rate of cell division in meristematic cells. The *TTG (transparent testa glabra)* gene alters early events in root epidermal cell differentiation, while *glabra2* (*gl2*) acts later. Developing root epidermal tissues contain two cell types, atrichoblast (A), which form mature hairless cells and trichoblast (T), which form root hairs. Longitudinal periclinal division of the epidermis is necessary for maintenance of root radial structure. The figures below show the comparison between differentiation and cell division of T cells versus A cells in root epidermis.

利用阿拉伯芥的兩種發育突變株，來探討細胞特化的控制是否與細胞分裂方式有關。藉由控制分生細胞的分裂速率，可使細胞的生成與特化達到平衡。*TTG* (種皮光滑透明)基因可造成根部表皮細胞在特化初期產生變化；而 *glabra2* (*gl2*)基因則在特化較後期才發揮作用。根部表皮組織的發育包括兩種細胞類型: 無毛原胞(atrichoblast；**A**)發育成熟為不具根毛的細胞；有毛原胞(trichoblast；**T**)則長成具有根毛的細胞。表皮細胞的垂直平周分裂是維持根部徑向結構的必要條件。下圖顯示根部表皮中 **T** 及 **A** 兩類細胞的特化與細胞分裂之比較。



Axis 1：Ratio of T Cells/A Cells 軸 1: T 細胞/A 細胞的比值

Axis 2：Ratio of probability of longitudinal division in T versus A cells (pLT/pLA)

軸 2: T 細胞/A 細胞垂直分裂機率的比值

Indicate if each of the following statements is true or false. 判斷下列各敘述的真偽。

A. *TTG* controls epidermal cell fate specification.
TTG 控制表皮細胞之特化專一性。

B. *gl2* mutant retains the atrichoblast fate and the A cells remain as undifferentiated epidermal cells.
*gl2*突變株保留了無毛原胞的特化性質，且A細胞維持為未特化的表皮細胞。

C. The longitudinal division in root epidermis is more likely to occur in A cell than T cell.
根部表皮的垂直分裂較有可能發生在A細胞。

D. Ratio of longitudinal cell division in T versus A is much reduced in the *ttg* mutant, suggesting that it is under the control of TTG.
ttg 突變株中 T / A 細胞的垂直分裂比值明顯較低，表示這是受到 TTG 的控制。

14. The following table shows the adaptation of Plant A and Plant B in response to different conditions. 下表顯示植物 A 及 B 在其不同生長環境下的適應情形。

	Plant A	**Plant B**
Compensation point of CO_2 ($\mu L\ CO_2\ L^{-1}$) CO_2 的補償點	20 – 100	0 – 5
Quantum yield as function of temperature 與溫度相關的質子產生量	Declining 下降	Steady 穩定

Indicate if each of the following statements is true or false. 判斷下列各敘述的真偽。

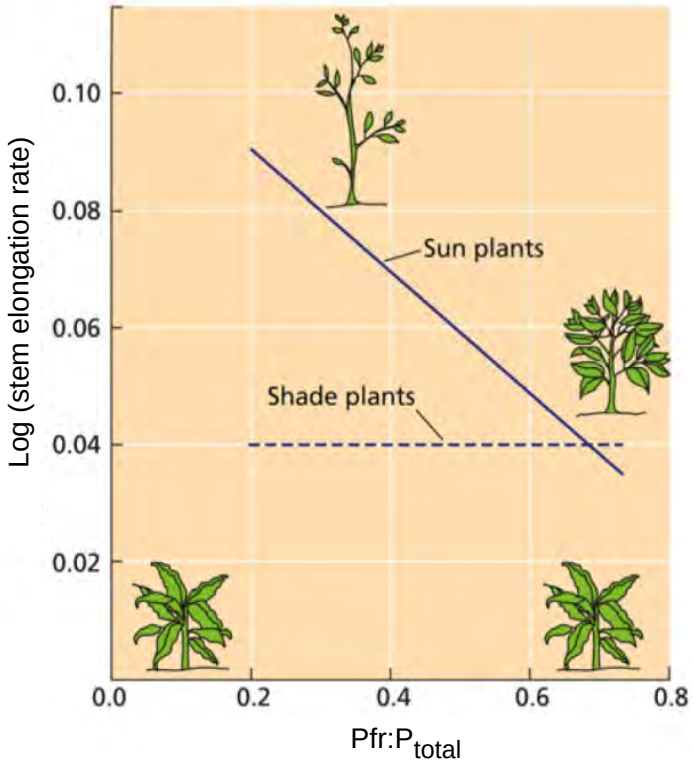
A. Plant B is C_3.
植物 B 屬於 C_3 植物。

B. Plant A is more competitive in limited water availability and high temperature environment.
在水分有限且高溫的環境中，植物 A 競爭力較強。

C. If atmospheric CO_2 concentration doubles, Plant A is likely to be more competitive.
若大氣中的 CO_2 濃度倍增，則植物 A 的競爭力可能較強。

D. If atmospheric CO_2 concentration doubles, photorespiration in Plant A is likely to be reduced.
若大氣中的 CO_2 濃度倍增，則植物 A 的光呼吸作用可能會下降。

15. This figure shows the role of phytochrome in a far red state (P_{fr}) in sun and shade plants. Based on phytochrome-mediated photomorphogenesis, **indicate if each of the following statements is true or false**.
下圖顯示光敏素遠紅光型(P_{fr})在陽性及陰性植物中的角色。根據光敏素調節光形態發育的作用，**判斷下列各敘述的真偽。**



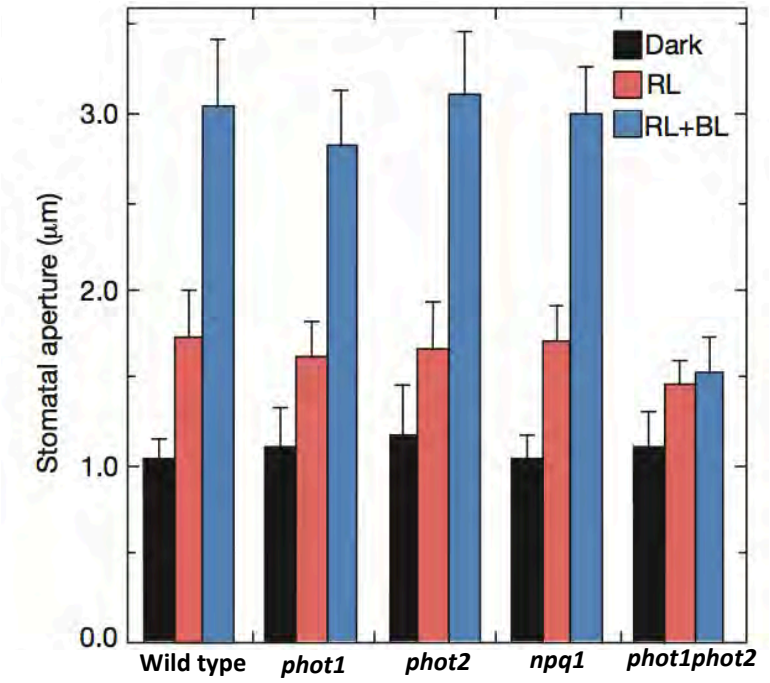
A. Treatment with red light does not affect stem elongation rate in shade plants.
以紅光處理並不會影響陰性植物的莖部伸長速率。

B. Treatment with far-red light decreases stem elongation rate in sun plants.
以遠紅光處理會降低陽性植物的莖部伸長速率。

C. If sun plants are treated in the conditions of sun and shade, elongation rate of plant placed in the sun is higher than one in the shade.
若對陽性植物分別給予光照或陰暗處理，光照下的植物其伸長速率較陰暗者高。

D. Natural forest clearings would give equal opportunity for sun and shade plants to recolonize.
森林中的自然破空(無遮蔽處)將可提供陽性及陰性植物相同的重新擴增機會。

16. An experiment was conducted to study the effect of darkness, red light (RL) and combination of red and blue light (RL+BL) on stomatal aperture. Mutant *phot1* and *phot2* do not express phototropin, while mutant *npq* does not accumulate zeaxanthin. Stomatal apertures less than 1.25 μm are considered closed, while apertures greater than 2.0 μm are considered opened more widely. 探討氣孔孔徑如何受到黑暗、紅光、以及紅與藍光共同處理的影響，其實驗結果如下。*phot1* 及 *phot2* 兩個突變株不能表現趨光素(phototropin)，而 *npq* 突變株不能累積玉米黃素(zeaxanthin)。若氣孔孔徑小於 1.25 μm 則視為關閉；大於 2.0 μm 則視為氣孔擴大。



Indicate if each of the following statements is true or false. 判斷下列各敘述的真偽。

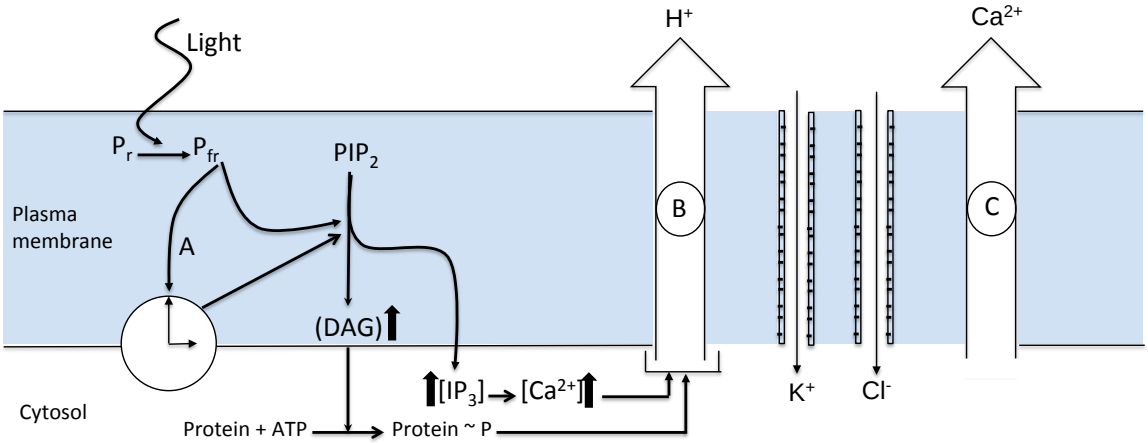
A. Stomatal apertures are closed if treated in darkness and slightly opened in red light illumination.
若以黑暗處理，則氣孔關閉；若照紅光，則氣孔些微打開。

B. Blue light significantly increases stomatal aperture size in all tested plants.
在所有實驗植物中，藍光可使氣孔孔徑顯著增加。

C. It is likely that the blue light receptor is active in mutant *npq*.
在 *npq* 突變株中，藍光受體可能呈現活化態。

D. The fact that single *phot* mutants respond to blue light and double mutants do not, suggests that *phot1* and *phot2* act redundantly as blue light receptors to mediate stomatal apertures.
單一 *phot* 突變株*(phot1)*對藍光有反應，而其雙突變株*(phot2)*則否。此結果表示 *phot1* 及 *phot2* 作為調控氣孔孔徑的藍光受體是多餘不必要的。

17. Nyctinasty is a sleep movement of leaves. The diagram shows a model of the interaction of phytochrome, biological clock, and IP_3 on nyctinasty. Arrow A stands for activation and Arrows B & C stand for active transport.
植物葉片可表現睡眠運動。下圖為睡眠運動機制中光敏素、生物時鐘及 IP_3 的交互作用模式。箭頭 A 代表活化作用，箭頭 B & C 則是代表主動運輸。



Indicate if each of the following statements is true or false. 判斷下列各敘述的真偽。

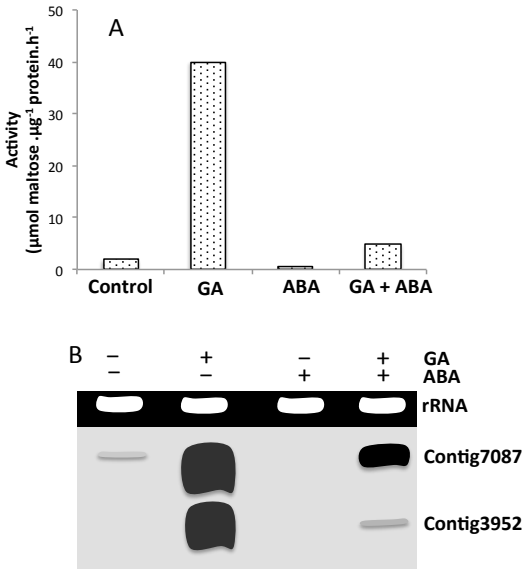
A. Light, mediated by phytochrome and modulated by endogenous clock, increases the level of IP_3 and DAG (diacylglycerol).
光照會增加 IP_3 and DAG (diacylglycerol 二脂醯甘油)的量；此光照接收受到光敏素調控，並受內在時鐘的控制。

B. IP_3 increases release of free calcium and thus stimulate proton extrusion.
IP_3 增加鈣離子的釋出，而刺激質子的排出。

C. The changes in electrochemical gradient energizes the uptake of K^+, subsequently reduces cell swelling, and thus causes nyctinastic movement.
電子的化學梯度改變促進 K^+的吸收，而使細胞膨大，導致睡眠運動。

D. An active transport (arrow C) extrudes Ca^{2+} as an aid to restoring Ca^{2+} homeostasis.
利用主動運輸排出 Ca^{2+}以維持體內的 Ca^{2+}平衡。

18. The effect of gibberellic acid (GA_3) and abscisic acid (ABA) on isolated barley aleurons was measured using α-amylase activity and transcriptional responses. Aleurons were treated with 1 µmol/L GA_3 and 50 µmol/L ABA for 15 hours. The activity of α-amylase was measured using maltose as a standard (Figure A). The accumulation of mRNA encoding high pI amylase (Contig3952) and low pI amylase (Contig7087) is shown in Figure B.
以下為利用量測α-澱粉酶的活性以及轉錄作用的結果來顯示吉貝素 (GA_3)與離層酸(ABA)對分離出來的大麥糊粉層的影響。在糊粉層以1 µmol/L GA_3 and 50 µmol/L ABA處理15小時之後，α-澱粉酶的活性是以量測其作用產物表示(以麥芽糖作為標準值)，結果如圖A所示。負責編碼**高** pI 澱粉酶的mRNA(Contig3952)以及負責編碼**低** pI 澱粉酶的mRNA(Contig7087)之表現結果如圖B所示。



Indicate if each of the following statements is true or false. 判斷下列各敘述的真偽。

A. The activity of α-amylase is reduced more than 80% on GA_3+ABA-treatment compare to GA_3 treatment only.
相較於僅用 GA_3 處理組，GA_3+ABA 處理組的 α-澱粉酶活性降低超過 80%。

B. GA_3 suppresses both high and low pI amylase gene expression.
GA_3 抑制高及低 pI 的兩種澱粉酶的基因表現。

C. ABA suppresses the effect of GA_3.
ABA 會抑制 GA_3 的作用

D. The GA_3 + ABA treatment synergistically induced expression of genes encoding a high pI amylase.
GA_3+ABA 處理組會共同誘導負責編碼**高** pI 澱粉酶的基因表現。

ANIMAL ANATOMY AND PHYSIOLOGY 動物解剖與生理

19. A blood alcohol test measures the concentration of alcohol (ethanol) in body fluids. Alcohol is quickly absorbed from the alimentary tract and distributes evenly within the extracellular and intracellular fluid of the human body. In a 70 kg person, 6.8 g ethanol is eliminated per hour, 90% is metabolized by the liver and the rest is excreted through lungs and kidneys. In most countries, the legal limit of blood alcohol level (BAL) for driving a motor vehicle is 0.08 gram alcohol in 100 mL of blood. Average water content in adult lean 70Kg man is about 65%.

用血酒精測試可測知體液中的酒精(乙醇)濃度，酒精可由人體消化道迅速被吸收並被均勻分佈到身體細胞內外的體液中。一個 70 kg 的人每小時可排除 6.8 g 的酒精，90%酒精在肝臟代謝，其餘則由肺與腎排除。在大多數國家，機動車輛駕駛的血酒精濃度(BAL)合法上限為 0.08 gram/ 100 mL 血液。70 kg 成人平均水含量約為 65%。

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

指出下列敘述正確或錯誤

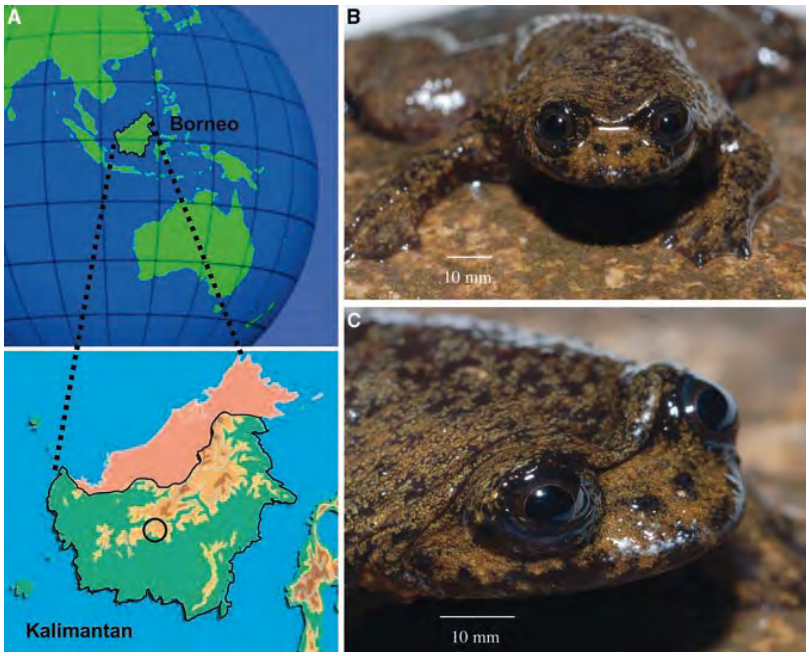
A. A 70kg lean man drinks 0.5 L beer with an alcohol content of 5% (weight/volume). One hour later his BAL is greater than 0.08 gram alcohol per 100 mL blood.
一個 70 kg 的瘦子，在飲用酒精含量為 5% (w/v)的 0.5 L 啤酒後 1 小時，BAL 會超過 0.08 gram/ 100 mL 血液

B. His identical twin drinks 0.2 L of vodka with an alcohol content of 40% instead of beer, and an hour later, his BAL exceeding 0.08 gram alcohol per 100 mL blood.
他的同卵雙生兄弟，在飲用酒精含量為 40% 的 0.2 L 烈酒後 1 小時，BAL 會超過 0.08 gram/ 100 mL 血液

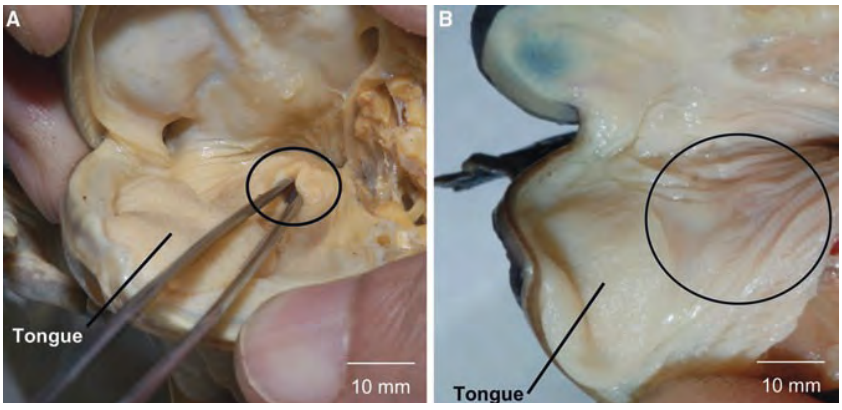
C. The time it takes for the 70Kg person to eliminate a BAL at 0.08 gram alcohol in 100 mL blood is more than 5 hours.
這 70 Kg 的人要排出 0.08 gram/ 100 mL 血液 的 BAL 須超過 5 小時

D. A 70 kg breast-feeding woman drinks 0.15 L of wine with an alcohol content of 12% (weight/volume). She then feeds her 5.0 kg baby 100 mL breast milk. 55% of the weight of a baby with normal body weight is water. The BAL of the baby will exceed 0.08 gram ethanol per 100 mL blood.
一個哺乳的 70 kg 婦女在飲用 0.15 L 酒精含量為 12 % (w/v)的酒後，餵食 5 公斤的嬰兒母乳，嬰兒體重的 55% 是的水分，嬰兒的 BAL 會超過 0.08 gram/ 100 mL 血液

20. *Barbuourula kalimantanensis*, an indigenous flat frog was found in Kalimantan, Indonesia in 2008 (A). The morphology of the frog (B,C) is shown below.
Barbuourula kalimantanensis 蛙是在 2008 年於印尼 Kalimantan 島(A 圖)上被發現的扁形蛙，下圖顯示此蛙的形態(B、C 圖)。



Comparison of (A) Typical frog mouth and pharynx (*Rana catesbeiana*), showing glottis (circled), tongue, and esophageal opening, and (B) *Barbuourula kalimantanensis* showing tongue, lack of glottis (circled), and an enlarged esophageal opening leading directly to the stomach.
Rana catesbeiana 蛙是典型蛙，其口咽部具有喉門(聲門)如圖(A)圓圈所示，*Barbourula kalimantanensis* 蛙的口咽部位不具喉門如(B)圖圓圈所示，因此其食道的開口可直通胃部。



Indicate if each of the following statements is true or false

指出下列敘述正確或錯誤

A. The frog is more likely to have stereoscopic vision as compared to ponds frog (*Rana* sp.).
與一般池塘青蛙(*Rana* sp.)相較，此蛙很可能具有立體視覺

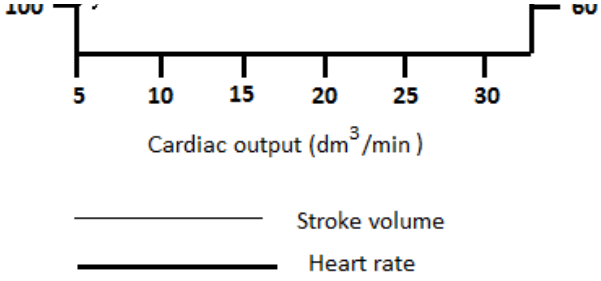
B. Skin of this exceptionally flat frog is the only respiratory organ in and gas exchange occurs in the blood vessels located on the skin surface.
極為扁平的皮膚是其唯一的呼吸器官，氣體交換發生在皮膚表面的血管中

C. *Barbourula kalimantanensis* is expected to have a low metabolic rate.
Barbourula kalimantanensis 蛙具有較低的代謝率

D. *Barbourula kalimantanensis* most probably lives in fast flowing cold water, often close to waterfalls.
Barbourula kalimantanensis 蛙最可能生活在快速流動的冷水中，常在瀑布附近

21. The diagram shows pulse rate, stroke volume and cardiac output in a healthy IBO student.
下圖顯示一個IBO學生的心跳速率、心搏量及心輸出量

本題作廢



Indicate if each of the following statements is true or false
指出下列敘述正確或錯誤

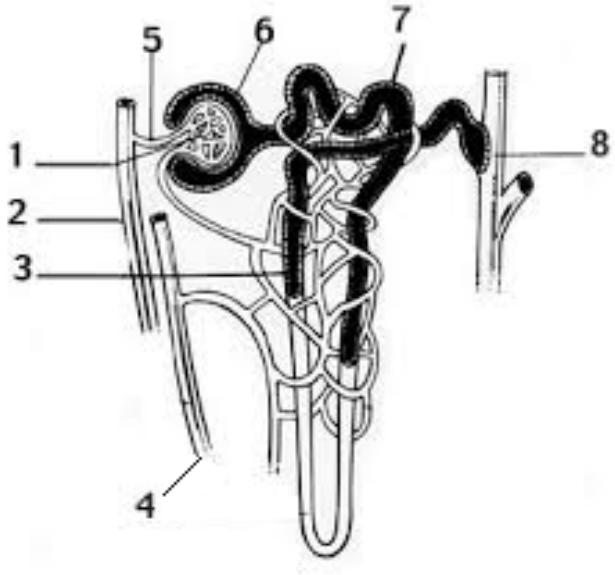
A. The stroke volume and the pulse rate are equal at a cardiac output of 25 dm^3/min.在心輸出量為 25 dm^3/min 時，心搏量與心跳速率相等

B. The most reliable estimate of the general fitness is obtained by measuring a work pulse within the interval of 120 – 150 min^{-1}.
體適能在休息 120 – 150 min 時間內測量最可靠

C. At high work intensity, an increase in cardiac stroke volume accounts for the increase in cardiac output.
高強度努力工作的人心搏量的增加是因為心輸出量的增加

D. At high work intensity, inadequate filling of the heart during diastole limits the cardiac output.
高強度努力工作的人在心臟舒張時，因流入的血液量不足導致心輸出量受限

22. The process of urine formation takes place in the nephron.
尿液的形成發生在腎元



Indicate if each of the following statements is true or false

指出下列敘述正確或錯誤

A. Transport from 5 to 6 in the figure, is dependent on blood pressure.
圖中從 5 至 6 的輸送是由血壓造成的

B. The most important process in the structure labelled 7 in the figure is ATP-dependent.
圖中 7 處的構造進行的最主要反應過程是需要消耗 ATP 的

C. The concentration of HCO_3^- is higher in structure 2 than in 4.
構造 2 處的 HCO_3^-濃度較構造 4 處的為高

D. The water reabsorption in the structure labeled 8 is driven by a concentration gradient.
構造 8 處水的再吸收作用是由濃度梯度所引起

23. Growth hormone (GH) is important for humans that raise the concentration of glucose and free fatty acid and promotes postnatal growth through direct and indirect effects on many tissues.
生長激素(GH)對人體重要，可升高葡萄糖及游離脂肪酸的濃度，能直接或間接作用在許多組織上以促進人體出生後的成長。

Indicate if each of the following statements is true or false

指出下列敘述正確或錯誤

A. Hyperglycaemia can stimulate the release of GH secretion.
高血糖會刺激 GH 的分泌

B. Exercising will increase GH production which in turn increases lipolysis.
運動可增加 GH 的生成，GH 再增加脂質分解

C. The effects of GH are attenuated by circulating androgen (eg testosterone) at puberty.
青春期時血液循環中的睪固□可降低 GH 的作用

D. Administration of GH will stimulate bone mass and muscle growth enhancement.
服用 GH 可刺激骨質及肌肉的成長

24. IBO2014 participants are from different continents around the world. Some students experience 'jet lag' due to crossing many time zones to reach Bali. These individuals feel fatigue as the body's 'clock' need to be adjusted to the new environment. Circadian rhythms are regulated by the pineal gland which produces melatonin during the dark.
IBO2014 參賽者來自世界各大洲，有些學生因跨越多個時區到達峇厘島而□生時差，他們會感到飢餓因生理時鐘需調整以適應新環境，日週期受黑暗時松果腺分泌的褪黑激素所調整

Indicate if each of the following statements is true or false

指出下列敘述正確或錯誤

A. Generally, for the same distance, flight from west to east (for example, from Europe to Bali) causes worse jet lag than flying in the opposite direction.
一般而言，相同的距離由西鄉東飛行，如由歐洲飛往峇厘島，所引起的時差會較往相反方向飛行的更嚴重

B. Light affects circadian rhythms and helps to re-establish synchronization with the light-dark cycle.
光會影響日週期以幫助身體重建與環境光-暗週期同步

C. Melatonin released in the morning can advance circadian rhythms, while melatonin released in the evening can delay circadian rhythms
早晨釋放的褪黑激素會使日週期提前，夜晚釋放的褪黑激素會使日週期延遲

D. Melatonin pills, as possible treatment to avoid jet lag and readjustment with the local light-dark cycle should be taken about half an hour before the sleep..
藥用褪黑激素可治療時差，為適應當地的光-暗週期，應在睡前 1 個半小時服用

25. Tetrodotoxin (TTX), a very powerful toxin, produced by the local puffer fish (*Ferodoxon multistriatus*), selectively blocks voltage gated Na+ channels in the neuron. As a result, TTX causes paralysis and a loss of vagal regulation of the heart. The victim eventually dies from respiratory paralysis.
Tetrodotoxin (TTX)是本地河豚(*Ferodoxon multistriatus*)所生成的一種強毒素，可選擇性阻斷神經元中的 Na+通道，會造成麻痺並失去迷走神經失去對心臟調節的結果。受害者最後會因呼吸麻痺而死亡。

Indicate if each of the following statements is true or false

指出下列敘述正確或錯誤

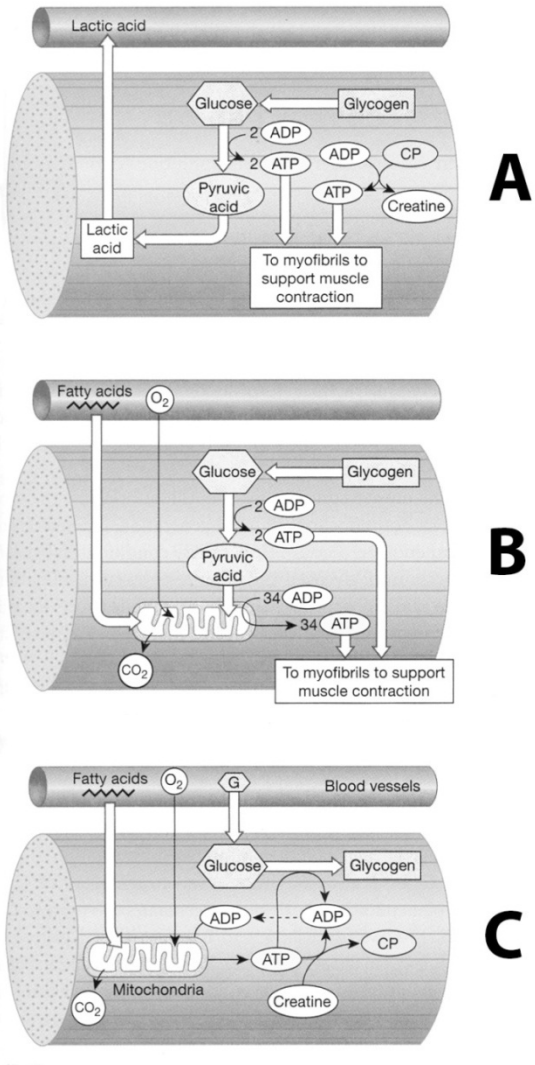
A. The puffer fish never gets poisoned by TTX. A possible explanation is that it has a mutated sodium ion channel to the resistant variant.
河豚不受 TTX 的毒害，可能解釋之一是其具有突變的 Na+通道

B. TTX also affects smooth muscle cells in the lungs and keep membrane potential of the smooth muscle cells in the resting state condition.
TTX 也會影響肺部平滑肌細胞，使細胞的膜電位維持在靜止狀態

C. TTX is absorbed in gastrointestinal tract and therefore travel first to the lungs via hepatic vein and interfere with its function.
TTX 會被腸胃道吸收，先經肝靜脈運輸至肺部，干擾其功能

D. If injected, TTX poison will result in very elevated heart rate
若注射 TTX 會造成心跳快速飆高

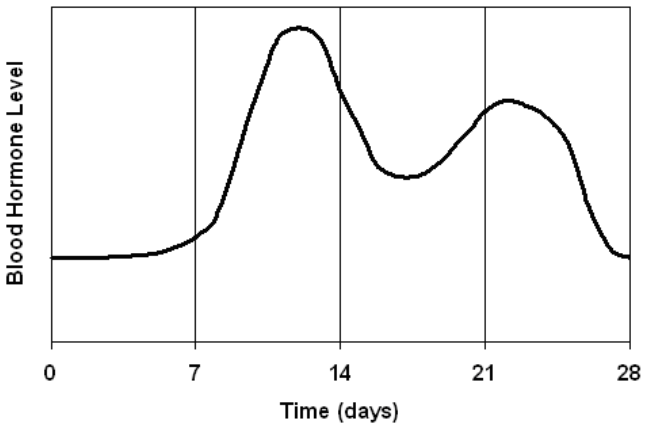
26. The figure shows the scheme of metabolism of a skeletal muscle in three physiological conditions. Identify which scheme of metabolisms corresponds to each of the functional states.
下圖顯示骨骼肌在三種不同生理狀況下的代謝情形



Indicate if each of the following statements is true or false
指出下列敘述正確或錯誤

A. Rest state of the skeletal muscle is shown in figure C
圖 C 顯示處於休息狀態的骨骼肌
B. Moderate activity of the skeletal muscleis shown in figure B
圖 B 顯示處於中度活化狀態的骨骼肌
C. Metabolism of leg muscle fibers during 100m sprint is shown in figure A
圖 A 顯示百米短跑時大腿肌纖維的代謝
D. Metabolism of leg muscle fibers of the trained marathon runner during the marathon competition is shown in figure B
圖 B 顯示馬拉松跑者在馬拉松賽時大腿肌纖維的代謝

27. Menstruation cycle involves several hormones. One of the hormones in the menstruation cycle has a fluctuation pattern as shown below:
月經週期包括數種激素，下圖顯示其中一種激素的波動情形



Indicate if each of the following statements is true or false?

指出下列敘述正確或錯誤

A. The first peak in the hormone level triggers ovulation.
該激素的第一個波峰時會引起排卵

B. The physiological effect of the hormone is instantly mediated by cell surface receptors.
該激素的生理效應受細胞表面的受體所快速調控

C. The peaks result from hormones produced by the oocytes.
卵細胞所產生的激素造成這些波動的變化

D. If implantation occurs, plasma concentration of the hormone is maintained at high level.
若發生著床，該激素在血液中的濃度會維持在高水平狀態

28. Estrogen receptor knockout (ERKO) mice have been generated in an effort to define the points of estrogen receptor function. The effects of ERKO on the uterus and bone are shown in figures A and B.

A single estradiol injection greatly stimulates cell division in the uterus 16-18 hours later measured as in vitro[^{3}H] thymidine uptake) in wild type mice but not in ERKO alpha mice. Vertebral bone density is reduce by about 10% in ERKO-α male mice compare to wildtype. Data is expressed as the percentage of total bone area that exists as compact bone (Figure B).

為了解動情素受體的功能，因此將老鼠產生動情素受體的基因剔除的基因剔除鼠(ERKO)。下圖(A)及(B)顯示ERKO對老鼠子宮及骨骼的效應。

在注射雌二醇(動情素) 16-18小時後，野生鼠的子宮受刺激會有大量細胞分裂，基因剔除鼠的不會(以[^{3}H]腺嘧啶去氧核苷的吸收測得)

圖(B)顯示與野生鼠比較時，基因剔除鼠的脊椎骨密度會降低10% (一塊骨骼中緻密骨所佔的區域百分比)。

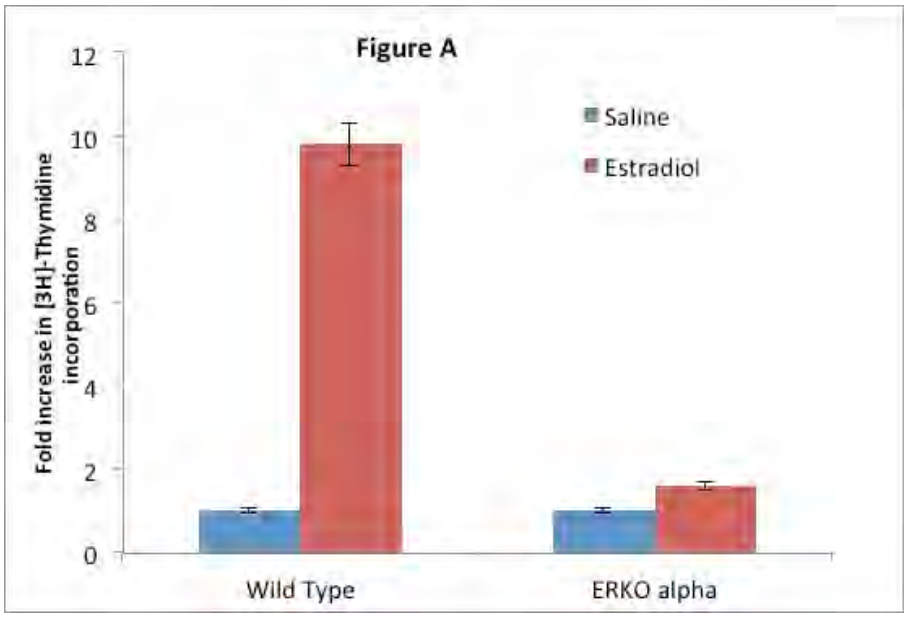


Figure A. Uterus of ovariectomized wild type and ERKO mice treated with estrogen

圖A. 動情素對卵巢切除之野生鼠及ERKO鼠子宮的效應

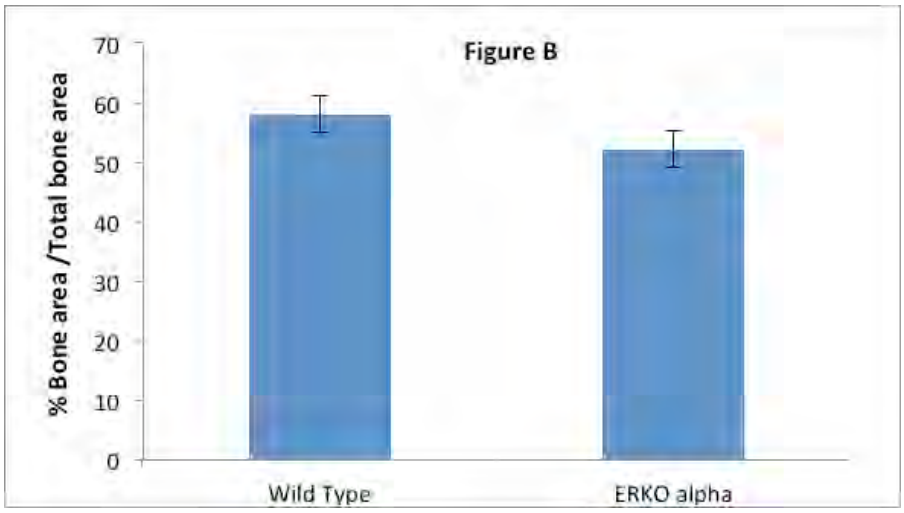


Figure B. Vertebral density of wild type and ERKO male mice
圖B. 雄性野生鼠及ERKO鼠的脊椎骨密度

Indicate if each of the following statements is true or false

指出下列敘述正確或錯誤

A. ERKO mice perform normal ovarian cycle as wild type mice
基因剔除鼠與野生鼠月經週期的表現相同

B. ERKO female and male mice bones become more vulnerable to be broken
基因剔除的雄鼠與雌鼠其骨骼皆容易破碎

C. Female ERKO mice are infertile
ERKO 基因剔除的雌鼠為不育

D. ERKO mice do not produce estrogen hormone
基因剔除鼠不會產生動情素

29. X-linked agammaglobulinemia (AGG) disease occurs mostly in boys. X-linked agammaglobulinemia patients have a non-functional bruton tyrosine kinase (BTK), a protein essential for the development and maturation of B cells. The concentrations of several immunoglobulins of a 5-year old boy with AGG were compared with standard normal conditions.
X 染色體連鎖的伽瑪球蛋白缺乏症(AGG)多發生於男孩，該患者的 bruton tyrosine kinase (BTK) 失去功能，BTK 是在 B 細胞發育與成熟過程中的重要蛋白酶，下表為一 5 歲男性 AGG 患者體內幾種免疫球蛋白數值與正常值得比較

	Patient values 患者數值 (mg mL^{-1})	Standard values 正常值 (mg mL^{-1})
IgG	0.80	6-15
IgA	0	0.50-1.25
IgM	0.10	0.75-1.50
IgE	0	0.005

Indicate if each of the following statements is true or false

指出下列敘述正確或錯誤

AGG boys: AGG男性患者

A. have larger tonsils and spleens than normal children.
與正常小孩相比，具有較大的扁桃腺與脾臟

B. are more vulnerable to infection by pathogens through the gastrointestinal tract.
腸胃道更容易受病原體感染

C. do not show evidence of this condition in the first six months of life.
出生後六個月內還不會顯現出上述病症

D. will not experience allergy to pollen.
不會對花粉過敏

30. Consider four animals A1, A2, A3 and A4. Data regarding the ratio of body masses and the ratio of oxygen consumption per kg body weight is tabulated below.

本題作廢

動物 A1 的心肺功能較 A3 and A4.的低

B. Animals A1 and A2 are most likely to be warm blooded animals (homeotherms) while A3 and A4 are cold blooded (ectotherms).
動物 A1 及 A2 為內溫動物，動物 A3 及 A4 為外溫動物

C. Surface to volume ration of A3 is lower than that of A2.
動物 A3 的體表面積/體積較 A2 的低

D. Total oxygen consumption (V O_2lt/h) of A1 will be greater than A4.
動物 A1 的氧總消耗(V O_2lt/h) 較 A4 的大

GENETICS AND EVOLUTION 遺傳與演化

31. Wild type *Drosophila melanogaster* individuals were crossed with individuals homozygous for three recessive mutations: *b* (black body), *sc* (scarlet eyes) and *vg* (vestigial wings). The resulting F1 individuals were then crossed to individuals homozygous for the same mutations, resulting in the progeny shown in the table below.

野生型果蠅與具隱性表徵黑身(b)、紅眼(sc)、退化翅(vg)的同型合子果蠅交配，所得 F1 子代再與同樣具以上三隱性表徵的同型合子果蠅交配，生出的 F2 子代之表現型如下表

Phenotype 表現型	**Percentage 百分比**
Normal (wild type) 野生型	20.5
Scarlet eyes 紅眼(sc)	20.5
Vestigial wings 退化翅(vg)	4.5
Black body 黑身(b)	4.5
Scarlet eyes, black body 紅眼(sc) 、黑身(b)	4.5
Vestigial wings, black body 退化翅(vg) 、黑身(b)	20.5
Scarlet eyes, vestigial wings 紅眼(sc)、退化翅(vg)	4.5
Black body, scarlet eyes, vestigial wings 黑身(b)、紅眼(sc)、退化翅(vg)	20.5

Indicate if each of the following statements is true or false

推定下列各敘述是正確 true 或錯誤 false

A. Crossing two F2 individuals with black bodies and with wild type phenotypes for the other genes results in flies of different wing types.
2 隻黑身但其他性狀皆正常的 F2 果蠅交配，會生出不同翅型的子代

B. The loci *b* and *vg* are located less than 20 cM from each other.
b 基因和 vg 基因間的重組遺傳距離小於 20 cM

C. Individuals heterozygous for *b* and *sc* but homozygous for *vg* produce gametes of four different genotypes in equal proportions.
基因型為 ”b、sc 異型合子 vg 同型合子” 的個體產生的配子有 4 種，且他們的比例相同

D. When individuals heterozygous for *vg* and *sc* are crossed, 18.75% of the progeny will have vestigial wings.
“vg、sc 異型合子” 的個體交配，其子代中 18.75%為退化翅

32. In a mouse population, there are three different coat colors: Yellow (Y), Agouti (A) and Black (B). To understand their inheritance, the following crosses were conducted:
小鼠族群中有三種毛色個體：黃 yellow(Y)、灰 agouti(A)、和黑 black(B)，為了解毛色遺傳模式，做了以下雜交，其結果如下

No	**Crosses (Parental Phenotypes)** 交配組合(親本表現型)	**Ratio of Phenotypes** 子代表現型
1	Y x Y	2Y : 1A
2	Y x Y	2Y : 1B
3	A x A	All A
4	A x A	3A : 1B
5	B x B	All B
6	A x B	All A
7	A x B	1A : 1B
8	Y (F1 from cross 1) x A (F1 from cross 3)	1Y : 1A
9	Y (F1 from cross 1) x B (F1 from cross 5)	1Y : 1A
10	Y (F1 from cross 2) x A (F1 from cross 3)	1Y : 1A

Indicate if each of the following statements is true or false.
推定下列各敘述是正確 true 或錯誤 false

A. Coat color in mouse is coded by one gene with multiple alleles. The dominance of the alleles is agouti > yellow > black.
小鼠毛色是由單一基因控制，此基因具多個等位基因，而其顯隱性順序為
灰 agouti > 黃 yellow > 黑 black.

B. A ratio of 1Y:1B is expected among the progeny of a cross between a Y offspring of cross 2 and a B offspring of cross 5.
將交配組合 2 得到的 Y 和交配組合 5 得到的 B 交配，其子代表現型為 1Y:1B

C. A ratio of 3Y:1A is expected among the progeny of a cross between Y offspring of crosses 1 and 2.
將交配組合 1 得到的 Y 和交配組合 2 得到的 Y 交配，其子代表現型為 3Y:1A

D. A ratio of 1A:2Y:1B is expected among the progeny of a cross between a Y offspring of cross 2 and an A offspring of cross 7.
將交配組合 2 得到的 Y 和交配組合 7 得到的 A 交配，其子代表現型為 1A:2Y:1B

33. Consider a polygenic and additive inheritance of height in which a tall (uppercase letter) and a short (lowercase letter) allele segregate at each implicated gene and all tall alleles increase height by the same amount. In a species with two implicated genes, for instance, individuals with genotypes AaBb and AAbb are equally tall, but smaller than those with genotype AaBB.

In a particular plant species, height was found to vary between 6 and 36 cm. Crossing two plants of 6 cm and 36 cm, respectively, resulted in offspring, all 21 cm tall. In the F2 population, all known heights were observed, but most plants were 21 cm, and only 1/64 of the plants were 6 cm.

身高性狀為多基因累加性遺傳，每一影響身高的基因都有一個 ”高” 等位基因(大寫)和一個 ”矮” 等位基因(小寫)，各基因的每一個高等位基因都可使身高增加同樣長度。例如，某一物種有二個影響身高的基因 A 和 B，而 AaBb 個體 和 AAbb 個體一樣高，也都比 AaBB 個體矮。
有一種植物，其高度為 6 ~ 36 cm。6 cm 和 36 cm 植株雜交的 F1 子代皆為 21 cm，而 F2 子代中，所有已知的高度都出現了，但最多的個體是 21 cm，而 6 cm 的個體只佔 1/64。

Indicate if each of the following statements is true or false

推定下列各敘述是正確 true 或錯誤 false

A. Three genes are involved in determining the height of the plants.

這種植物的高度由 3 個基因控制

B. Six different phenotypes was observed in F2.

在 F2 中共有 6 種不同表現型

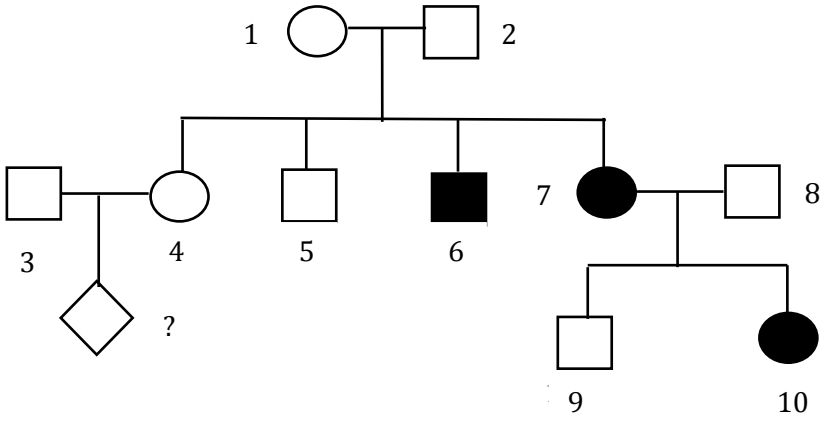
C. There are seven possible genotypes for plants with a height of 21 cm.

高度為 21 cm 的個體的可能基因型共有 7 種

D. In F2, the number of 11 cm plants was similar to the number of 26 cm plants

在 F2 中，11 cm 的個體數和 26 cm 的個體數目相近

34. The pedigree of a family is shown below in which some members (shown in black) are affected by a genetic disease with a prevalence of 9% in the population. The phenotype of the individual marked with ? is unknown.
以下族譜中記載了某種遺傳性疾病的罹病個體(黑色圖示)，此遺傳疾病在族群中的發生率為 9%，”？”個體的表現型不詳。



Indicate if each of the following statements is true or false
推定下列各敘述是正確 true 或錯誤 false

A. The disease is most likely caused by autosomal recessive allele.
此疾病最有可能是由一個體染色體的隱性等位基因引起

B. Individual 5 is heterozygous with a probability of 50%.
個體 5 是此致病等位基因異型合子的機率為 50%

C. Under the assumption that the disease-causing allele is in Hardy-Weinberg equilibrium, individual 3 is heterozygous with a probability of 46%.
假設此致病等位基因頻率處於哈-溫平衡，個體 3 是致病基因異型合子的機率為 46%

D. If affected individuals had a reduced fertility, the disease-causing allele would be eliminated from a population.
若罹病個體的生殖力下降，則此致病等位基因將會從族群中消失

35. Two *Neurospora crassa* strains can be crossed (fused into diploid cells) by growing the first strain for four days on a suitable medium, and then adding cells of the second strain. When mating, the first strain consisting of larger cells will contribute both nucleus and cytoplasm to the zygote. In contrast, the second strain will only contribute its nucleus. After cell fusion, the diploid cells undergo meiosis and produce four haploid spores.

In an experiment, wild type *Neurospora* were crossed with two mutant strains *poky* and *cyt* showing slow growth due to mitochondria malfunction. The growth phenotype of 400 offspring per cross is shown in the table below.

二個麵包黴菌菌種可以交配(融合成為二倍體)，做法如下：先在培養基上培養第一個親本菌種 4 天，再加入第二個親本菌種進行交配。進行交配產生二倍體合子時，第一個菌種的細胞較大，提供細胞質和細胞核，第二個菌種只提供其細胞核。完成交配後的二倍體細胞進行減數分裂產生 4 個單倍體孢子。

將野生型麵包黴菌分別和二種突變菌種 *poky* 和 *cyt* 交配，這二個突變種都因為粒線體功能異常而生長緩慢。分析各種交配組合產生的 400 個孢子，其生長表現型區分如下表：

First Parent 第一親本	**Second Parent** 第二親本	**Frequency of growth phentotype** 生長表現型	
		wild type 野生型	***slow*** 生長緩慢
cyt	*wt*	197	203
wt	*cyt*	209	191
poky	*wt*	0	400
wt	*poky*	400	0

Indicate if each of the following statements is true or false
推定下列各敘述是正確 true 或錯誤 false

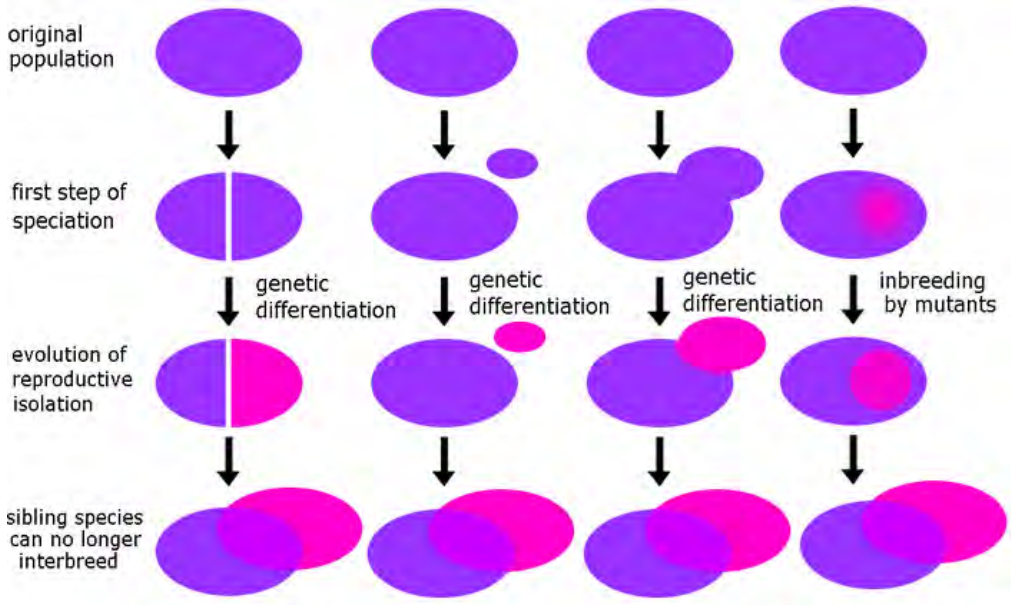
A. *poky* mutation is a mutation located on the gene in nuclear DNA.
poky 突變基因位於細胞核 DNA

B. *cyt* mutation is a mutation located on the gene in mitochondrial DNA.
cyt 突變基因位於粒線體 DNA

C. 50% of the offspring of a cross between *cyt* (first parent) and *poky* (second parent) are expected to show slow growth.
以 *cyt* 突變菌為第一親本，*poky* 為第二親本的交配組合，可預期 50%的子代生長緩慢

D. All offspring of a cross between *poky* (first parent) and *cyt* (second parent) are expected to show slow growth.
以 *poky* 突變菌為第一親本，*cyt* 為第二親本的交配組合，可預期全部子代生長緩慢

36. The following figure shows four possible speciation mechanisms, each involving several stages
下圖呈現四種可能的種化機制，各種機制皆包括數個步驟



Mechanism 1 **Mechanism 2** **Mechanism 3** **Mechanism 4**

圖中註解
original population 源始族群 first step of speciation 種化第一步
evolution of reproductive isolation 生殖隔離演化
sibling species can do no longer interbreed 兄弟種間無法繁殖
genetic differentiation 遺傳區隔 inbreeding by mutants 突變後只可自交

Indicate if each of the following statements is true or false
推定下列各敘述是正確 true 或錯誤 false

A. Only one mechanism of speciation from the above involves a geographic barrier.
以上機制中只有 1 種含有地理隔離

B. A small sub-population emigrates into an uninhabited island, and over time evolves. Later, the new island and original populations come into secondary contact but are not able to interbreed. This is an example of “Mechanism 3”.
源始族群中的一小群個體遷移至一個沒有同種棲居的小島，長時演化後，此小島族群和源始族群再次接觸，但已無法彼此間進行繁殖，這是屬於 Mechanism 3 的例子

C. In a plant species, some individuals evolve a shift in the color of their flowers. This may lead to speciation according to “Mechanism 4”.
一植物族群的部分個體演化出不同的花色，這可能會依照 Mechanism 4 發生種化

D. A change in ploidy can provoke immediate speciation.
多倍體的產生能引發立即的種化

37. The following is a list of mutational changes. For each of the specific mutations described below, indicate if the stated possible cause of the mutation is true or false.
以下是各種不同的突變，對各突變發生的可能機制推定是正確 true 或是錯誤 false

A. The change of AT base pair in the wildtype gene to a GC pair might be caused by deamination.
從野生型基因中的 AT 變成 GC 可以因鹼基脫氨作用(deamination)造成

B. The change of the sequence AACGTCACACACACATCG to AACGTCACATCG might be caused by DNA polymerase slippage.
由 AACGTCACACACACATCG 變為 AACGTCACATCG 可以因為 DNA 聚合酶的滑動導致

C. The change in the order of genes from *bog-rad-fox^{1}-fox^{2}-try-duf* to *bog-rad-fox^{1}-mel-qui-txu-sqm* might be caused by gene conversion.
染色體上的基因順序由 *bog-rad-fox^{1}-fox^{2}-try-duf* 變為 *bog-rad-fox^{1}-mel-qui-txu-sqm* 可能是因為基因轉換 gene conversion 而得

D. The change of the sequence AAGCTTATCG to AAGCTTTATCG might be caused by ultraviolet light.
由 AAGCTTATCG 變為 AAGCTTTATCG 可以因為照射紫外光而誘發

38. In ethnic Tibetans, living mostly above 4000 m, a gene (*EPAS*1) coding for the Endothelial PAS domain-containing protein 1 (*EPAS*1) was found to be a promising candidate gene for adaptation to high altitude. EPAS1 is a transcription factor involved in the response to hypoxia. A single-nucleotide polymorphism (SNP) in *EPAS1* is associated with erythrocyte abundance. The frequency of Allele A of this SNP is 78% higher in Tibetan than Chinese samples,
在生活於海拔 4000 公尺以上的西藏族人中，發現了一個在內皮細胞表現的 EPAS1 基因可能與適應高海拔有關。這個基因所表現的蛋白質是一轉錄因子，參與缺氧時的反應。EPAS1 基因中一個特定單核甘酸的改變，也就是單核甘酸多型性(SNP)， 與紅血球量的充裕有關。在 EPAS1 基因此一核甘酸位置的 SNP 中，等位基因 A 在西藏族的頻率比在漢族中高 78%

Indicate if each of the following statements is true or false

推定下列各敘述是正確 true 或錯誤 false

A. This SNP affects their capability to take up oxygen at low partial pressure of oxygen.
這個 SNP 影響在低氧分壓時獲得氧氣的能力

B. These results suggest that this phenotypic response likely includes multiple genes.
這些結果顯示對高海拔的表現型適應有許多基因參與

C. The amino acid sequence of EPAS1 may vary among carriers of Allele A.
等位基因 A 的攜帶者其 EPAS1 蛋白的胺基酸序列可能不同

D. The SNP is likely to be under balancing selection in Tibetans.
此 SNP 在西藏族群中可能處於天擇平衡

39. Several population of a particular species of fish inhabit nearby but isolated fresh water ponds. In the predator-rich ponds, fish tend to swim in short, fast bursts. In ponds with few predators, fish tend to swim continuously for a long time. When placed together in the same body of water, the two kinds of female fish exhibit exclusive breeding preferences.
同一種魚棲息於數個分離但鄰近的池塘，在掠食者較多的池塘中，魚多做短暫而快速突然的游動；在掠食者較少的池塘中，魚多做長時連續的游動。將來自不同池塘的雌魚放在一起時，它們表現出不同的生殖偏好

Indicate if each of the following statements is true or false

推定下列各敘述是正確 true 或錯誤 false

A. When fish from both populations were put together in the same pond hybridization did not occur due to the result of natural selection.
將不同族群的魚放在一起時，也無法彼此交配，是因為自然淘汰

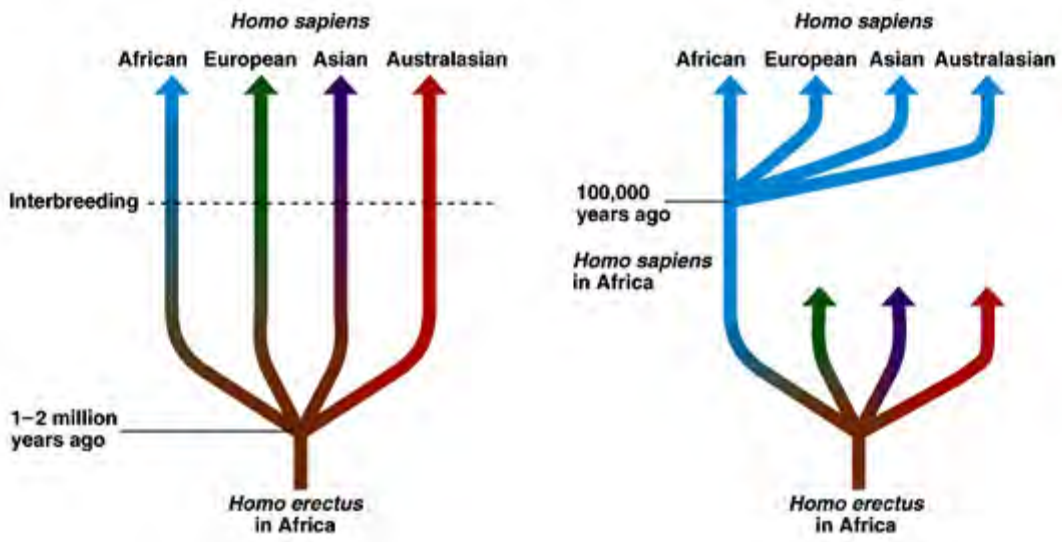
B. Sexual selection increases the divergence between fish populations
選擇性交配可增加不同族群間的歧異度

C. By building canals between the ponds through which the fish, but not their predators may migrate, genetic diversity would be maintained.
在池塘間建造只允許這種魚通過，而其掠食者無法通過的渠道，遺傳歧異度會被維持

D. Reciprocal transfer of females from one population to another will restore swimming style variation in predator rich ponds.
互換不同池塘間的雌魚，會重建掠食者較多的池塘中游動模式的變異性

40. There are two competing theories about how Homo sapiens arise. The 'multiregional' theory. declared that *H. sapiens* independently evolved in each region of the world from *H. erectus* that migrated out of Africa and was an early version of *H. sapiens*, not a different species. The second, 'out of Africa' theory, declared that all *H. sapiens* evolved in Africa, and migrated from Africa about 100,000 years ago.

有關智人 *Homo sapiens* 的起源，有二種不同的理論(如圖)："多起源區"理論認為由非洲遷出到世界各區的 *H. erectus* 各自獨立演化為 *H. sapiens*；而"遠離非洲"理論則認為所有的 *H. sapiens* 是在非洲演化出後，在 100,000 年前遷離非洲。



Genetic analysis has been done using mitochondrial DNA to resolve this puzzle. The data from mtDNA can be summarized into two main points below:

I. African people has greater mitochondrial genetic diversity compared with people from other continent
II. mtDNA genetic variations in modern human populations are low.

粒線體 DNA(mtDNA)的遺傳分析嘗試去解決此一謎題，整理此分析結果如以下二結論：

I. 非洲人族群內的粒線體遺傳歧異度大於其他大陸族群內歧異度

II. 粒線體 DNA 的遺傳變異在現代人族群中很低

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

推定下列各敘述是正確 true 或錯誤 false

A. Using mtDNA genetic markers was an advantage over nuclear genetic markers due to the lower mutation rate and absence of recombination of mtDNA.
使用粒線體 DNA 作為遺傳指標的好處是因為其低突變率和不會發生重組

B. Under the 'Out of Africa' theory, mtDNA extracted from a 200,000 years old skeleton found in a Himalayan cave, is expected to be more similar to the mtDNA of modern day Asians than modern day Europeans.
依照"遠離非洲"理論，在喜瑪拉雅洞穴發現的 200,000 年前遺留的骨骸中，取出的粒線體 DNA 會比較接近現代亞洲人，而不是現代歐洲人。

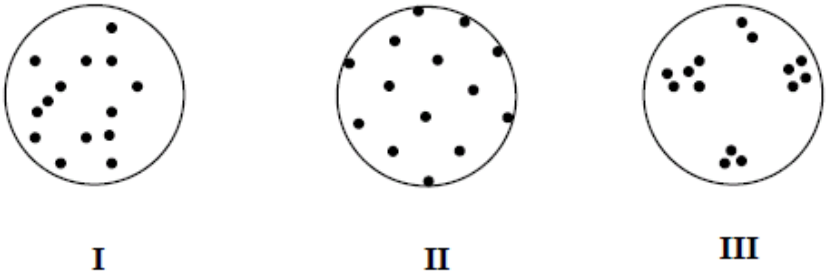
C. According to the 'Multiregional' theory, gene flow between populations explains the mtDNA genetic variation in modern human populations.
依據"多起源區"理論，族群間基因流通可解釋了現代人族群中粒線體 DNA 的遺傳變異

D. The greater mtDNA genetic diversity among African people support the 'out of Africa' theories.
非洲人族群內的粒線體遺傳歧異度較大的現象支持"遠離非洲"理論

ECOLOGY 生態學

41. The spatial dispersion of individuals in a population reflects interactions among individuals and between individuals and the environment. Below are three population dispersion patterns.

族群中個體的空間散佈可反映出個體-個體間以及個體與環境間的交互作用。
下列是三種空間散佈的型態



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

指出下列敘述何者正確或錯誤

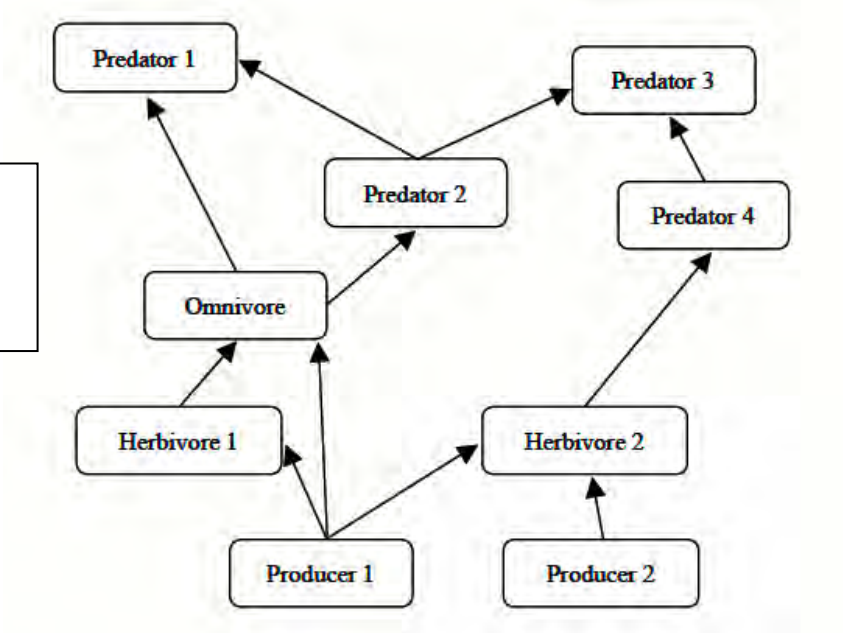
A. Pattern I suggests strong interactions among individuals.
型態 I 指出個體間有強烈的交互作用。

B. Pattern II suggests antagonistic interaction among individuals.
型態 II 指出個體間有對抗的交互作用。

C. Pattern III suggests symbiotic interaction among individuals.
型態 III 指出個體間有共生的交互作用。

D. Pattern I suggests the attraction of individuals to a common resource.
型態 I 指出個體被一個共同的資源所吸引。

42. In the food web below, the population of Predator 4 has been declining sharply due to hunting by humans. This is expected to affect the populations of other species.
在下列的食物網中，掠食者 4(Predator 4)的族群由於受到人類的獵捕而呈急速下降，此現象將會影響其他物種的族群。



Predator 掠食者
Ommivore 雜食者
Herbivore 草食者
Producer 生產者

Indicate if each of the following statements is true or false:
指出下列敘述何者正確或錯誤

A. A population decrease in Predator 4 will result in an increase of Herbivore 2.
掠食者 4 族群的減少會造成草食者 2 族群的增加。

B. A population decrease in Predator 4 will result in an increase of Predator 3.
掠食者 4 族群的減少會造成掠食者 3 族群的增加。

C. A population decrease in Predator 4 will result in a decrease in the Omnivore.
掠食者 4 族群的減少會造成雜食者族群的減少。

D. There are four tertiary consumers in the food web above.
在此食物網中有 4 個 3 級消費者。

43. The Sumatran elephant (*Elephas maximus sumatranus*) seen in the Bali Safari Park is a protected herbivore in Indonesia. Despite this, elephant populations are threatened by poaching and habitat loss, including the conversion of forests into oil palm plantations and cultivated lands. This has led to the fragmentation of forest areas. Consequently, elephants often enter human inhabited areas, damaging plantations and increasing human-elephant conflict. Elephants tend to strongly avoid areas intensively used by humans.
在峇里島的野生動物園所看到的蘇門答臘象，在印尼是被保護的草食性動物。雖然如此，大象仍受到盜獵及棲地喪失的威脅，包括將森林轉變為油棕栽種區及農耕地，如此造成森林地區棲地破碎化。棲地破碎化的結果造成大象經常進入人類居住區域、破壞栽種區以及增加人類與大象的衝突。大象明顯傾向避免進入人類活動頻繁的地區。

Indicate if each of the following statements is true or false.
指出下列敘述何者正確或錯誤

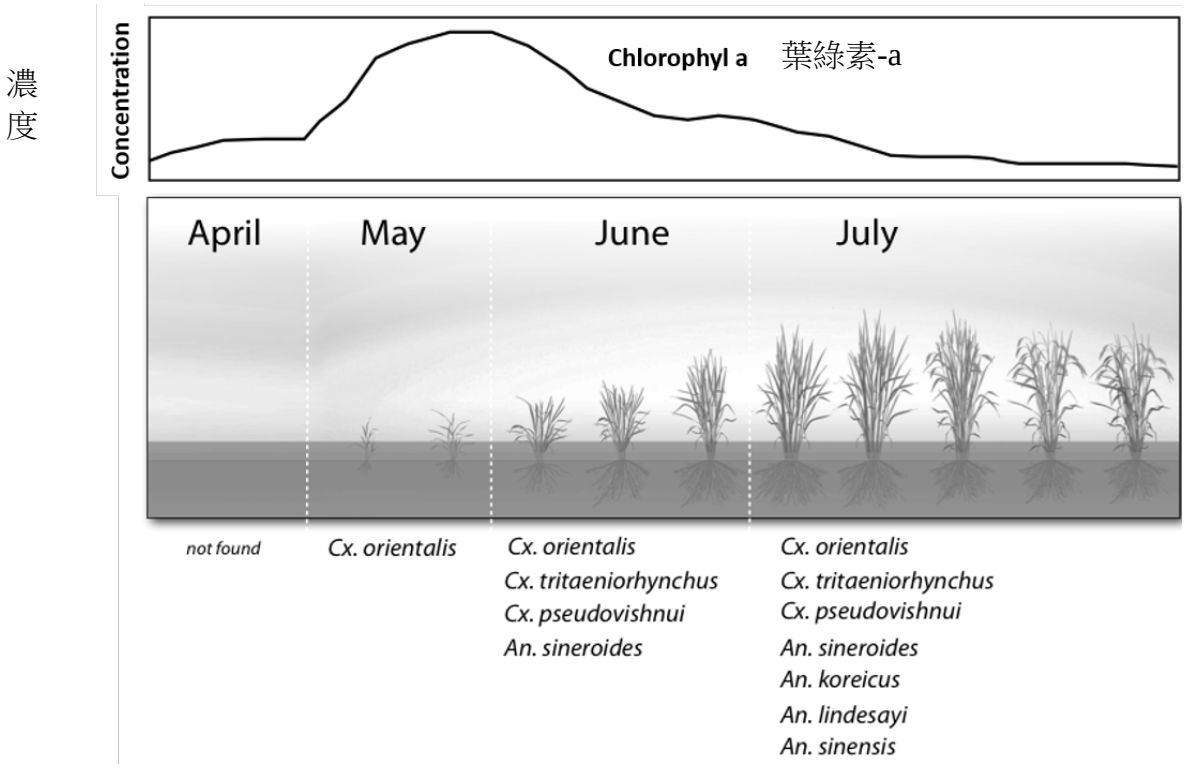
A. Elephants often cannot fulfil their dietary needs in the forest and are attracted to cultivated plants.
在森林中，大象經常無法滿足其覓食需求而被耕地的農作所吸引。

B. Elephants will enter human settlements because they are part of the elephant's natural home range.
大象會進入人類居住區，因為這些地方是大象自然家園的一部份

C. Elephants occupy the top position in the food chain.
大象位於食物鏈的頂端

D. Habitat fragmentation may not lead to the formation of elephant metapopulations becauses elephants are very adaptable
棲地破碎化或許不會造成大象形成複合式族群，因為大象的適應力非常好

44. Paddy (rice) fields in Indonesia are habitats for many aquatic organisms, including mosquito larvae and the phytoplankton they feed on. Phytoplankton depend on water and sunlight availability for their growth. The figure below shows the relationship between the four-month variation in the amount of phytoplankton (chlorophyll-a) and the community composition of *Anopheles* (*An.*) and *Culex* (*Cx.*) mosquitoes.
印尼的稻田是許多水生生物的棲地，包括蚊子幼蟲及其所覓取的浮游植物。浮游植物依賴水及陽光的多寡來生長。下圖顯示浮游植物(葉綠素-a)與兩類蚊子 *Anopheles* (*An.*) 和 *Culex* (*Cx.*) 群聚的關係在 4 個月內的變化情形。



Indicate if each of the following statements is true or false

指出下列敘述何者正確或錯誤

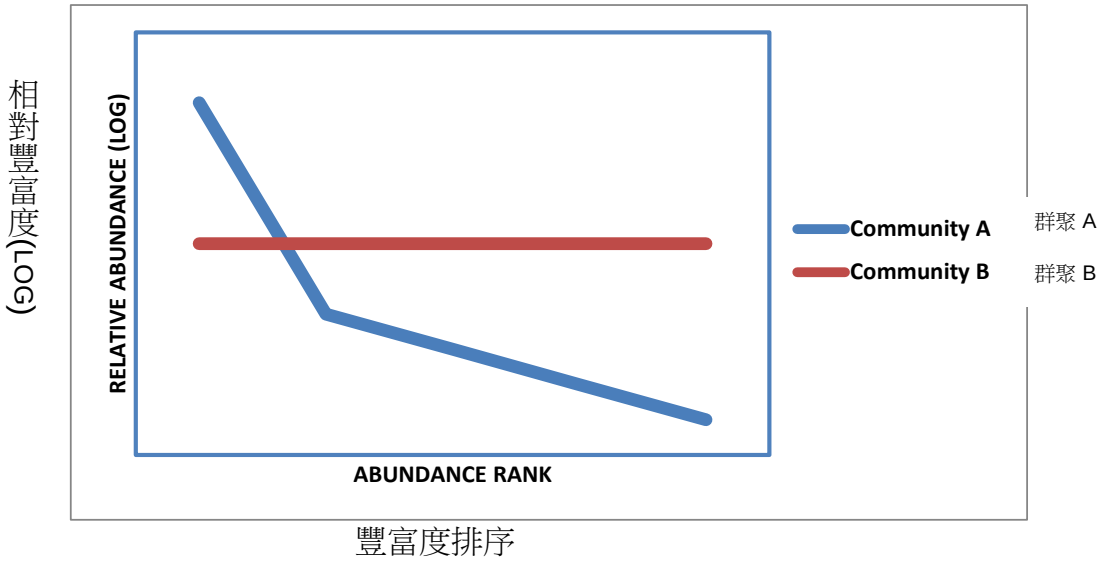
A. *An. sineroides* and *An. koreicus* have similar light intensity requirements.
An. sineroides a及 *An. koreicus* 蚊子對於光強度的需求相似。

B. *Cx. orientalis* can avoid interspecific competition due to its relatively high tolerance to heat.
Cx. orientalis 蚊子因對熱的容忍度高，所以可避免種間競爭。

C. The lower chlorophyll-a concentration in July is due only to heavy predation of phytoplankton.
葉綠素-a 在7月呈現較低的濃度，完全是由於浮游植物被強烈取食所致。

D. Paddy biomass is positively correlated with richness of mosquito species.
水稻的生物量與蚊子的物種豐富度呈正相關。

45. A rank-abundance curve portrays the relative abundance and diversity of species within a plant community. The rank of each species is plotted along the horizontal axis according to decreasing abundance. The vertical axis plots the abundance of each species on a log scale. The following graph compares rank abundances in plant Communities A and B.
豐富度排序曲線(rank-abundance)顯現一個植物群聚內物種的多樣性及相對豐富度。橫軸為物種豐富度(多寡)由高至低的排序，縱軸是豐富度的對數值。下圖為植物群聚 A 及 B 豐富度序列曲線的比較。



豐富度排序

Indicate if each of the following statements is true or false:

指出下列敘述何者正確或錯誤

A. Plant Community A has a lower species richness than Plant Community B.
植物群聚 A 的物種數較植物群聚 B 低。

B. Plant Community A has a lower species evenness than Plant Community B.
植物群聚 A 的物種平均指數較植物群聚 B 低。

C. Plant Community A has a lower diversity index than Plant Community B.
植物群聚 A 的物種多樣性指數較植物群聚 B 低。

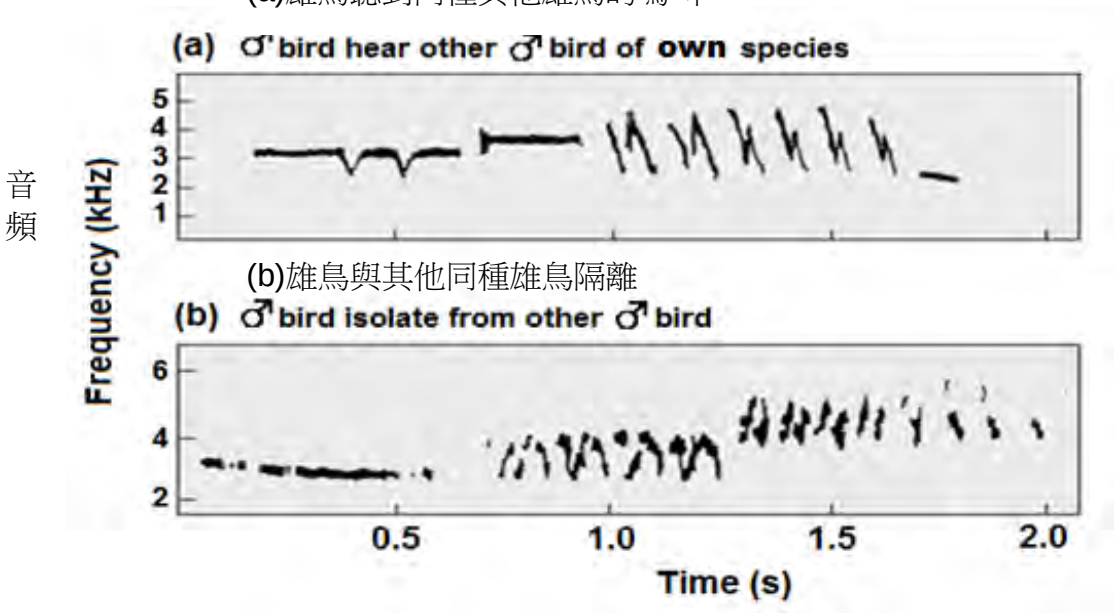
D. Plant Community A is likely to be exposed to more generalist herbivores than Plant Community B.
植物群聚 A 較植物群聚 B 更能供給廣食性草食動物利用。

ETHOLOGY 行為學

46. Peter Marler's studies on song learning in white-crowned sparrows showed how innate programs and experience each contribute to the development of singing and behavior. Mature male white-crowned sparrows sing a species-specific courtship song during the mating season. Marler asked if the song was the result of an innate program, learning, or both. The spectograms of two analysed songs are shown below:

Peter Marler's研究白冠雀對歌曲的學習，顯示本能的機制及外在的經驗如何影響鳴唱行為的改變。白冠雀成熟的雄性個體在繁殖季時會唱屬於該種特有的求偶歌曲。Marler想了解此種歌曲是否受本能機制、學習影響或兩者皆有。下圖為兩首求偶歌曲的聲譜圖：

(a)雄鳥聽到同種其他雄鳥的鳴叫



(b)雄鳥與其他同種雄鳥隔離

Indicate if each of the following statements is true or false

指出下列敘述何者正確或錯誤

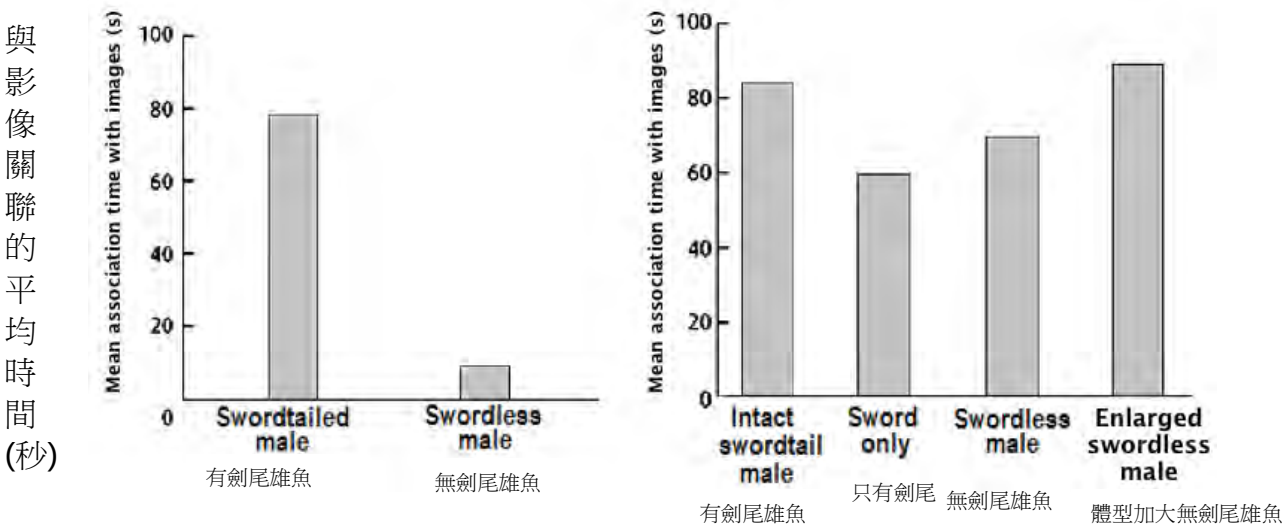
A. When young birds hear their own species' song, they selectively learn songs sharpened their genetic template to an exact one which they attempt to match with their song output.
當幼鳥聽到同種鳥鳴唱的歌曲時，牠們會選擇性地學習可精化其物種遺傳特性的歌曲，而成為能更精準地鳴唱出專屬牠們的歌曲。

B. Isolated birds' song do not contain elements of adult songs.
遭受隔離的鳥，其歌曲不具有成鳥鳴唱時所呈現出的要素。

C. The male that do not learn song from conspecifics may lost their reproductive advantage.
雄鳥沒有從同種鳥學到歌曲，有可能會使牠在繁殖時失去優勢

D. Auditory feedback from conspecifics affects predominantly the syllable types that appear in a song.
藉由聽取同種間的歌曲及自我回饋練習(Auditory feedback)，主要會影響歌曲內音節的型態。

47. Selection experiments based on sexual signals have demonstrated that a male trait and female preference can coevolve. An experiment, shown below, was conducted to examine the responses of female swordtail fish *Xiphophorus helleri* to animated video images of: A. Intact swordtail male, B. swordless male, C. sword only, and D. enlarged swordless male. The Y axis shows the association of females with the respective images.
根據求偶訊號所設計的天擇實驗，顯示雄性特質與雌性的偏好可共同演化。下列實驗係針對劍尾魚(*Xiphophorus helleri)* 雌性個體對動畫影像的反應所設計：A. 完整的雄魚、B. 去劍尾的雄魚、C.只有劍尾、D.體型加大但無劍尾的雄魚。Y 軸為雌魚與上述各動畫影像的關聯。



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

指出下列敘述何者正確或錯誤

A. Females favor the more exaggerated male traits and find them attractive
雌魚喜好比較誇大的雄性特徵，且覺得牠們更具吸引力。

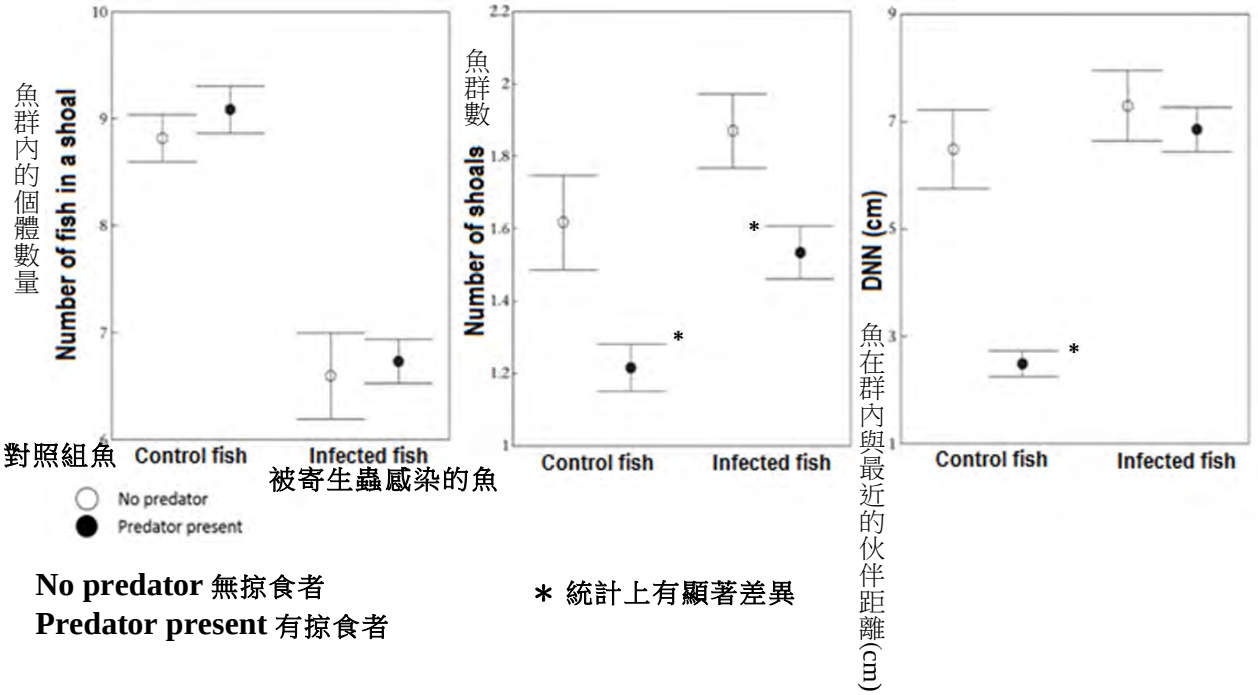
B. Body size is a stronger cue than swordtail for female preference
體型大小比具有劍尾的特性對雌魚更有吸引力。

C. An extravagant trait is metabolically expensive to produce and is expected to increase a male's chances of survival
一種華而不實的特徵是消耗代謝的產品，但可增加雄魚存活的機會。

D. Swords offer males a more metabolically inexpensive signal to attract females than an enlarged body
相較於增大體型，劍尾是一種可吸引雌魚但代謝消耗較少的特徵。

48. Shoaling, a group of conspecific, is a common antipredatory adaptation in several fish species. The advantages of shoaling include increased vigilance, lower individual risk of capture and confusion of predators. However, parasitic infections may alter shoaling behaviour by impairing sensory and motor systems and reducing the net benefit of shoaling. The effect of parasitic infection on shoaling behavior was investigated by measuring the number of fish in a shoal, number of shoals, and DNN or Distance to Nearest Neighbour within a shoal.

成群(Shoaling)是同種個體的聚集，在某些魚種中是一種常見的防禦天敵行為。成群的好處包括增加警戒、減少個體被捕的風險以及可混淆天敵。但是魚被寄生蟲感染時，會因感覺及運動系統的破壞，而改變成群的行為，減少成群所帶來的淨利 (net benefit)。寄生蟲感染對魚成群行為所造成的影響，可藉由測量魚群內的個體數量、魚群數及DNN(魚在群內與最近的伙伴距離)來表示。



No predator 無掠食者
Predator present 有掠食者

＊ 統計上有顯著差異

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

指出下列敘述何者正確或錯誤

A. Infected fish tend to form smaller shoals.
受感染的魚易形成較小的魚群。

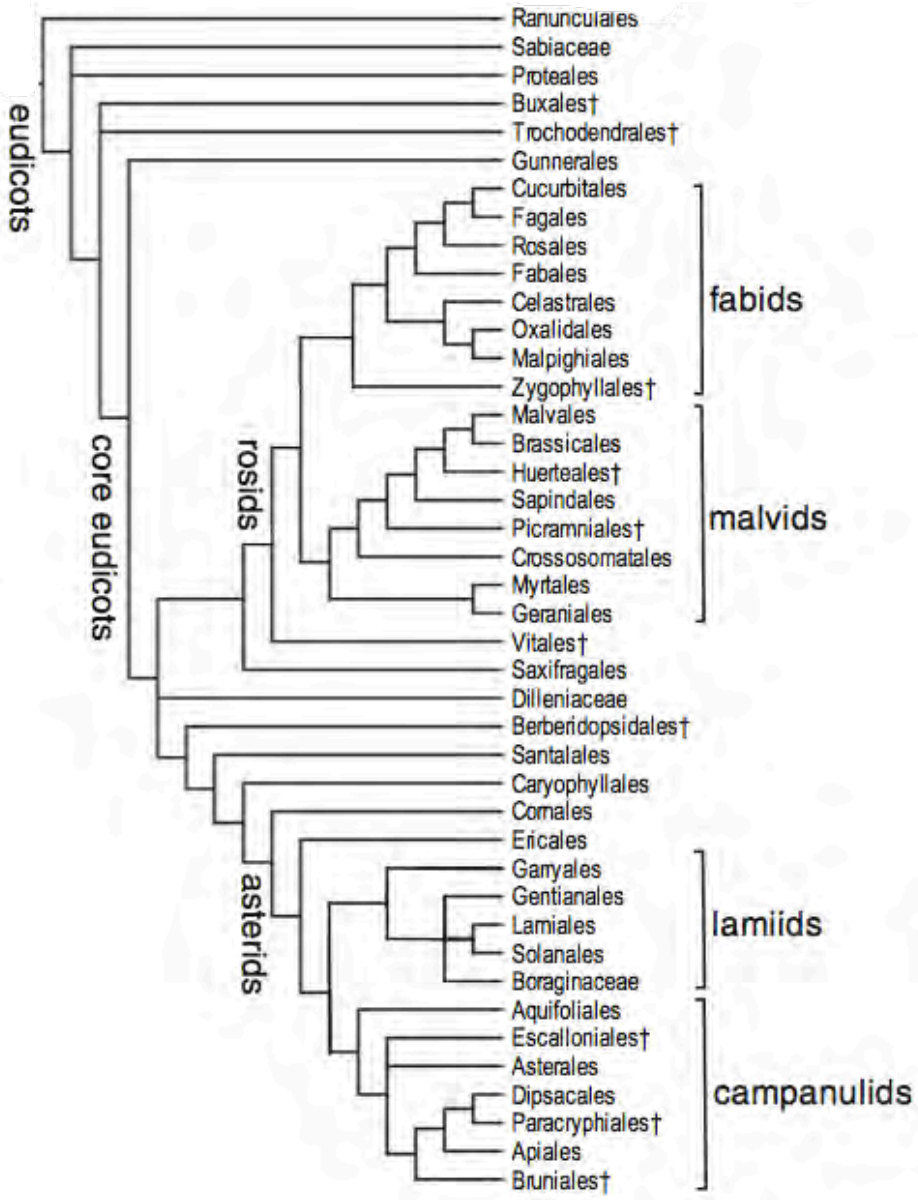
B. The tendency of fish to aggregate and form fewer shoals, when they encounter predators, is independent of infection.
當魚遇到掠食者時，牠們易聚集且魚群數較少，此與寄生蟲的感染無關。

C. Infected fish are more likely to be detected by a predator because they form larger number of shoals.
受感染的魚更有可能被掠食者偵測到，因為他們會形成的魚群數較多。

D. The confusion effect of shoaling is less effective with infected fish.
受感染的魚群對掠食者所造成的混淆效果較差

BIOSYSTEMATICS 系統分類

49. Assuming that the branches of a phylogenetic tree reflect taxon age, phylogenetic diversity is a measure of biodiversity, which includes information about the phylogeny of taxa. It can be estimated as the sum of branch lengths, including that of the group of interest, where the length of the smallest branch is one. A phylogenetic tree of eudicots is shown below.
假設親緣關係樹的分支可反映分類群的年齡，親緣多樣性可代表生物多樣性，此包括分類群親緣的相關資訊。它可用來估算分支的總長，包括所感興趣的類群，其最小的分支長度是 1。下圖為核心雙子葉植物(eudicots)的親緣關係樹。



Based on the phylogeny tree, indicate if each of the following statements is true or false.
根據親緣關係樹，指出下列敘述何者正確或錯誤

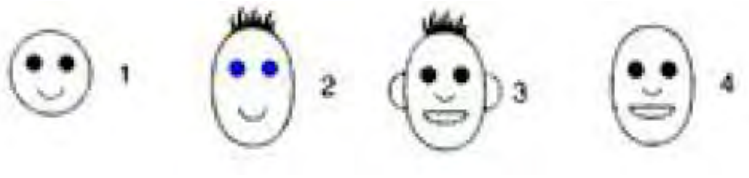
A. The phylogenetic diversity of malvids is higher than that of fabids.
Malvids 的親緣多樣性較fabids高

B. Dilleniaceae and Saxifragales are closer phylogenetically than are Malpighiales and Cucurbitales.
Dilleniaceae 與Saxifragales 的親緣關係較Malpighiales 與 Cucurbitales的親緣關係為近

C. The group consisting of Lamiids and Aquifoliales represents an adaptive rediation.
包含Lamiids 及 Aquifoliales的類群呈現輻射適應

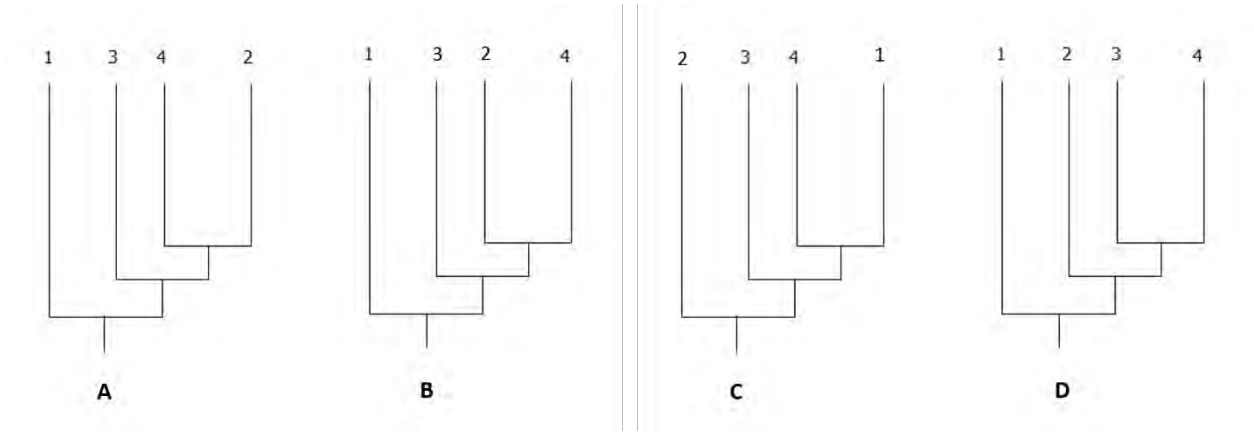
D. *Malpighiales* species may serve as outgroup to resolve the complete phylogeny of all Fabid species.
Malpighiales 物種可當作外群，以解決所有 Fabid 物種的整個親緣關係

50. Some imaginary taxa as shown below. They differ from each other in head shape, eye colour, mouth shape and the presence of ears, nose and hair.
某想像的分類群如下圖所示，他們彼此間的差異包括頭型、眼睛顏色、嘴巴形狀及耳朵、鼻與頭髮的有無。



The ancestor of these taxa has a round head, black eyes, no mouth, and no nose.
(add figure of ancestor)
這些分類群的祖先具有圓頭、黑眼、無嘴及無鼻。
(自行加上此祖先的圖)

Four possible cladograms for these taxa as shown below.
這些分類群的四個可能支序圖(cladograms)如下所示。



Using the information above, indicate whether the following cladograms truly explain the phylogenetic relationship between the taxa.

用以上的資訊，指出下列的 cladograms 是否能完全解釋在不同分類群的親緣關係。

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

指出下列敘述何者正確或錯誤

A. Trees A and C require the same minimal number of character changes.
演化樹A和C 需要相同最小數目的特徵改變

B. Of the trees shown, tree B is the least parsimonious.
由在上述的圖中，演化樹B是最少的簡約法則

C. Of the trees shown, tree D is the least parsimonious.
由在上述的圖中，演化樹D是最少的簡約法則

D. In general, there are more than seven different rooted topologies for four taxa.
一般而言，此四個分類群有超過七個不同根源的樹狀圖

END OF TEST

ANSWER SHEET

No.	Answer			No.	Answer		
	Statement	**T**	**F**		**Statement**	**T**	**F**
1.	A			14.	A		
	B				B		
	C				C		
	D				D		
2.	A			15.	A		
	B				B		
	C				C		
	D				D		
3.	A			16.	A		
	B				B		
	C				C		
	D				D		
4.	A			17.	A		
	B				B		
	C				C		
	D				D		
5.	A			18.	A		
	B				B		
	C				C		
	D				D		
6.	A			19.	A		
	B				B		
	C				C		
	D				D		
7.	A			20.	A		
	B				B		
	C				C		
	D				D		
8.	A			21.			
	B						
	C						
	D						
9.	A			22.	A		
	B				B		
	C				C		
	D				D		
10.	A			23.	A		
	B				B		
	C				C		
	D				D		
11.	A			24.	A		
	B				B		
	C				C		
	D				D		
12.	A			25.	A		
	B				B		
	C				C		
	D				D		
13.	A			26.	A		
	B				B		
	C				C		
	D				D		

No.	Answer			No.	Answer		
	Statement	**T**	**F**		**Statement**	**T**	**F**
27.	A			40.	A		
	B				B		
	C				C		
	D				D		
28.	A			41.	A		
	B				B		
	C				C		
	D				D		
29.	A			42.	A		
	B				B		
	C				C		
	D				D		
30.				43.	A		
					B		
					C		
					D		
31.	A			44.	A		
	B				B		
	C				C		
	D				D		
32.	A			45.	A		
	B				B		
	C				C		
	D				D		
33.	A			46.	A		
	B				B		
	C				C		
	D				D		
34.	A			47.	A		
	B				B		
	C				C		
	D				D		
35.	A			48.	A		
	B				B		
	C				C		
	D				D		
36.	A			49.	A		
	B				B		
	C				C		
	D				D		
37.	A			50.	A		
	B				B		
	C				C		
	D				D		
38.	A						
	B						
	C						
	D						
39.	A						
	B						
	C						
	D						

T = True
F = False

Signature

(……..)