Country: _____	Student Code: _____

23rd INTERNATIONAL BIOLOGY OLYMPIAD

8th – 15th July, 2012

SINGAPORE

THEORETICAL TEST – PAPER 1

Write all answers in the **ANSWER SHEET**

將答案寫在答案紙上

Dear Participants

- You have a total of 3 hours (180 minutes) for answering this theory paper.

  你有3個小時可回答本份理論題

- Use the **Answer Sheet**, which is provided separately, to answer all the questions.

  請在答案紙上回答所有問題

- The answers written in the Question Paper will **NOT** be evaluated.

  寫在試卷上的答案將不計分

- Write your answers legibly. **Note that there may be more than one correct/incorrect answer and every cell should be filled.**

  For example:

  請依下列方式作答, 注意: 答案中可能有多於一個正確 /錯誤的, 每個空格都要填寫!

  例如下方所示:

a	b	c	d	e
×	✓	×	×	✓

- NOTE: Some of the questions may be marked “Skipped” / “Deleted”. DO NOT attempt these questions. Also, read the question completely before attempting it as some questions may continue from one page to the next.

  注意: 有些題目已被標示為刪除, 請勿作答! 同時也要在看完整個題目後再作答, 因為有些小題會出現在下一頁中。

- The maximum number of points for this paper is 89. 3 .

  本試題共計89.3 分

- Stop answering and put down your pen IMMEDIATELY when the bell rings.

  當鈴聲響起, 應立即停止作答並放下原子筆

- Your Answer Sheets as well as the Theoretical Test question paper will be collected at the end of the test period.

  最後, 監試人員會來收走試題及答案紙。

Good Luck! ☺

CELL BIOLOGY 細胞生物學

1. The Table below shows the genetic codes of amino acids. 下表為胺基酸的遺傳密碼

	U	C	A	G	
U	Phe	Ser	Tyr	Cys	**U**
	Phe	Ser	Tyr	Cys	**C**
	Leu	Ser	STOP	STOP	**A**
	Leu	Ser	STOP	Trp	**G**
C	Leu	Pro	His	Arg	**U**
	Leu	Pro	His	Arg	**C**
	Leu	Pro	Gln	Arg	**A**
	Leu	Pro	Gln	Arg	**G**
A	Ile	Thr	Asn	Ser	**U**
	Ile	Thr	Asn	Ser	**C**
	Ile	Thr	Lys	Arg	**A**
	Met	Thr	Lys	Arg	**G**
G	Val	Ala	Asp	Gly	**U**
	Val	Ala	Asp	Gly	**C**
	Val	Ala	Glu	Gly	**A**
	Val	Ala	Glu	Gly	**G**

Some viruses (e.g. tobacco mosaic virus (TMV)) have RNA sequences that contain a "leaky" stop codon. In TMV 95% of the time the host ribosome will terminate the synthesis of the polypeptide at this codon but the rest of the time it continues past it.

The following sequences show part of a mRNA from TMV. Indicate the sequence(s) that may result in two polypeptides in the indicated frame with a tick (✓) and those that will not with a cross (✗). (1.8 points)

某些病毒（例如煙草鑲嵌病毒 TMV）的 RNA 遺傳密碼中，會有"煞車失靈"的轉譯終止密碼子。在煙草鑲嵌病毒 TMV，當宿主的核糖體有 95%的機會遇到這些終止密碼子，會終止胜肽的合成，但是其他時候則會繼續讀過去這些終止密碼子。

以下的序列秀出由煙草鑲嵌病毒來的一部份 mRNA。以下序列可能會造出兩條胜肽鏈的選項請打勾 (✓)，不會的選項請打叉 (✗)。（1.8 分）

a. 5′-AUG-UCU-UGU-CUU-UUC-ACC-CGG-GGG-UAG-UAU-UAC-CAU-GAU-GGU-UAA-3′

b. 5′-AUG-ACC-CGG-GGG-UUU-CUU-UUC-UAG-UAU-GAU-CAU-GAA-GGU-UGU-UAA-3′

c. 5′-AUG-CUU-UUC-UCU-UAU-UAG-CAU-GAU-GGU-UGU-ACC-CGG-GGG-CCC-UAA-3′

d. 5′-AUG-CAU-GUU-CUU-UUC-UCU-UAU-UGU-GGU-UGU-ACC-CGG-GGG-UUC-UAA-3′

e. 5′-AUG-CAU-GAU-GGU-UGU-ACC-CGG-GGG-UAG-CUU-UUC-UCU-UAU-UGC-UAA-3′

f. 5′-AUG-UCU-UAU-UGG-CAU-GAU-GGU-UGU-CUU-UUC-ACC-CGG-GGG-AAA-UAA-3′

2. Mitochondria are mainly concerned with the following functions: 粒線體主要被認為具有下列功能

a. thermogenesis 產熱作用

b. apoptosis 細胞凋亡

c. production of ATP 產生 ATP

d. fatty acid metabolism 脂肪酸代謝

Indicate the extensive presence of mitochondria with a tick (✓), intemediate presence (-) and absence of mitochondria with a cross (✗). Match the key function(s) of mitochondria (a to d) suited to the respective cells. (1.8 points)

細胞大量存在粒線體的請打勾(✓)，粒線體之含量中等的請以短破折號表示(-)，沒有粒線體的打叉(✗)。請對應粒線體之主要功能於匹配的對應細胞（1.8 分）

3. Arrange the order of the DNA molecules from lowest to highest in terms of their melting temperature (Tm). (0.9 points)

   將以下 DNA 分子，按照可將雙股分開之溫度（melting temperature, Tm），由低到高排列。（0.9 分）

   a. 5′-AAGTTCTCTGAA-3′
      3′-TTCAAGAGACTT-5′

   b. 5′-AGTCGTCAATGCGG-3′
      3′-TCAGCAGTTACGCC-5′

   c. 5′-GGACCTCTCAGG-3′
      3′-CCTGGAGAGTCC-5′

4. There are various mechanisms by which a cell can commit suicide – a phenomenon known as "apoptosis". One of the mechanisms is triggered by reactive oxygen species. The outer membrane of mitochondria normally expresses a protein Bcl-2 on its surface. Another protein Apaf-1 binds Bcl-2. Reactive oxygen species cause Bcl-2 to release Apaf-1 and a third protein Bax to penetrate the mitochondrial membrane, releasing cytochrome c. The released cytochrome c forms a complex with Apaf-1 and caspase 9. This complex sequentially activates many proteases that digest cellular proteins.

   有不同的機制會導致細胞自殺 — 此現象稱為細胞凋亡（apoptosis）。其中有一種情況是由活性氧物質（reactive oxygen species）所導致。粒線體的外膜表面有一個稱為 Bcl-2 的蛋白質。另一個蛋白質 Apaf-1 則可以結合 Bcl-2。活性氧物質導致 Bcl-2 釋放出 Apaf-1 和第三個稱為 Bax 的蛋白質來穿過粒線體的膜導致 cytochrome c 的釋放。被釋放的 cytochrome c 可與 Apaf-1 和 caspase 9 形成一個複合體。此複合體依序活化很多的蛋白質水解酶來水解細胞的蛋白質。

   What will be the fate of a cell exposed to reactive oxygen species in the following conditions?

   當細胞在以下的情況接觸到活性氧物質時， 細胞的命運將會如何？

I. The cell has expressed a mutant form of Apaf-1 that constitutively (always) bind Bcl-2.

細胞表現出一種突變形式的 Apaf-1，可持續（總是）結合 Bcl-2

II. The cell does not express Bcl-2 at all.

細胞無法表現出 Bcl-2

III. The cell overexpresses a form of Bcl-2 that is targeted to cell membrane only.

細胞過量表現出一種形式的 Bcl-2，其目的地僅可被指定於細胞膜

IV. A chemical which extends the half life of Bcl-2 is added to the cell.

一個可以延長 Bcl-2 之半衰期的化學物質被加入細胞中。

Match the following fates of the cell with the conditions (I to IV). (2 points)

細胞處於 I 到 IV 的狀況時，其命運為何：（2 分）

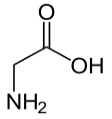
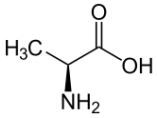
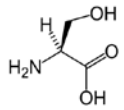
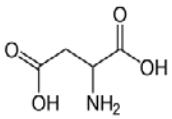
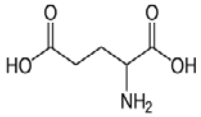
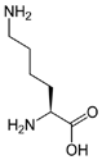
a. The cell resists apoptosis. 細胞會抵抗細胞凋亡

b. The cell is forced towards apoptosis. 細胞會執行細胞凋亡

c. The fate of the cell cannot be predicted. 細胞的命運無法被預測

5. The Table below shows the chemical structure, pK_1, pK_2 and pK_R of some amino acids.

下表秀出某些胺基酸的化學結構、pK_1、pK_2 和 pK_R。

Amino acid	Structural formula	pK_1 α-COOH	pK_2 α-NH_2	pK_R side chain
Glycine (Gly)		2.35	9.78	---
Alanine (Ala)		2.35	9.87	---
Serine (Ser)		2.19	9.21	---
Aspartic acid (Asp)		1.99	9.9	3.9
Glutamic acid (Glu)		2.1	9.47	4.07
Lysine (Lys)		2.16	9.06	10.54

5.1. Determine the predominant form (ionic or neutral) for heptapeptides, A to C, at pH 1, pH 7 and pH 12. Calculate their corresponding net charges (with an integer approximation). (3.6 points)

計算出一段由 7 個胺基酸所組成之胜肽鏈（A 到 C）的主要形式（離子態的或中性的），在 pH 1、pH 7 和 pH 12 的狀況下。計算出他們對應的淨電荷（net charges），請寫概估的整數（3.6 分）

5.2. What is the best pH for the electrophoretic separation of these three peptides from each other?

Indicate the best pH with a tick (✓) and the other pH values with a cross (×). (0.6 points)

哪一個 pH 值是用來分離這三段胜肽鏈的最佳電泳條件？最佳的那一個 pH 值請打勾(✓)，其餘的 pH 值請打叉(×)。（0.6 分）

6. Which of the following sequence(s) of cell-cycle phases is/are characteristic of eukaryotes? [G: gap; S: synthesis; M: mitosis]? Indicate correct sequence(s) with a tick (✓) and incorrect ones with a cross (×). (0.5 points)

以下哪一個細胞週期的順序是真核細胞的典型特徵？[G: gap; S: 合成期(synthesis); M: 細胞分裂期(mitosis)]? 正確的順序請打勾(✓)，不正確的打叉(×)（0.5 分）

a. G_1 - S - G_2 - G_0 - M

b. G_0 - G_1 - S - G_2 - M

c. G_1 - G_0 - G_2 - S - M

d. G_1 - G_0 - G_1 - G_2 - S - M

e. G_1 - G_0 - G_1 - S - G_2 - M

7. About the G_2 phase 關於 G_2 時期

7.1. Which of the statement(s) describe(s) a cell in the G_2 phase? Indicate correct statement(s) with a tick (✓) and incorrect ones with a cross (×). (0.4 points)

對於有關 G_2 時期的描述，對的請打勾(✓)，錯的請打叉(×)。

a. The homologous chromosomes are lined up on the equator.

細胞內同源染色體排列在赤道板上。

b. The homologous chromosomes have been pulled to their respective poles by the spindle apparatus.

細胞內同源染色體已被紡錘絲拉向紡錘體兩側。

c. The homologous chromosomes have not been replicated yet.

細胞內同源染色體還沒有被複製。

d. The homologous chromosomes are now in the haploid or n condition.

細胞內同源染色體數量是單倍 (n)。

7.2. How many chromatin threads are there in a human somatic cell in the G_2 phase? (0.5 points)

一個處於 G_2 時期的人類體細胞，其內含有多少條染色質絲？（0.5 分）

8. The morphology of three species of bacteria (A to C) are shown below:

三種細菌(A 到 C)的形態如下：

A (coccus) B (flagellated bacillus) C (capsulated filament)

A（球形菌） B（鞭毛桿菌） C（具莢膜的桿狀細菌）

8.1. Bacteria in nature prefer to attach to surfaces and exist in a form known as “biofilms”. During the attachment stage, before reaching the surface for attachment, bacteria will encounter a zone of repulsive force as they come very close to the surface. Which bacteria are likely to have an advantage to overcome this repulsive zone? Indicate the correct answer(s) with a tick (✓) and incorrect answer(s) with a cross (×). (0.6 points)

細菌在自然情況下，傾向貼附於表面並以一種稱為生物膜（biofilms）的形式存在。在貼附時期，當細菌到達表面以進行貼附的過程中，就在他們非常靠近表面時，細菌將遭遇到一個排斥力的區域。哪一個細菌較具優勢來克服此排斥區？正確的一個答案請打勾(✓)，其餘較不正確者請打叉(×)。（0.6 分）

a. Bacterium A （細菌 A）

b. Bacterium B （細菌 B）

c. Bacterium C （細菌 C）

8.2. After overcoming the repulsive zone and reaching the surface, the strength of attachment on the surface of the three bacteria is likely to be different. Arrange the correct order of attachment strength of the three bacteria in **the Answer Sheet**. (0.6 points)

當克服此排斥區而到達表面後，此三種細菌貼附於表面的能力似乎不同。將此三種細菌的表面貼附能力排序，寫於**答案卷**上。（0.6 分）

8.3. A stagnant pool of water was originally rich in organic content, but the nutrient concentration soon became diluted with rainwater. All three bacteria were affected and would attempt to survive the best way they could under this condition. Indicate true statement(s) with a tick (✓) and incorrect statement(s) with a cross (×). (0.6 points)
一個停滯不動的水池原本富含有機物質，但雨後不久養分濃度就被稀釋。此三種細菌都受影響，而嘗試在此狀況下存活。將正確的敘述打勾(✓)，不正確的敘述打叉(×)。（0.6 分）

a. Bacterium A allows the fastest relative diffusion of nutrients into the interior of its cell.
細菌 A 允許相對最快的養分擴散速度，讓養分進入細胞內部。

b. Bacterium B can extend its flagellum to reach nutrients above the water level.
細菌 B 可延長其鞭毛以獲取水面上的養分

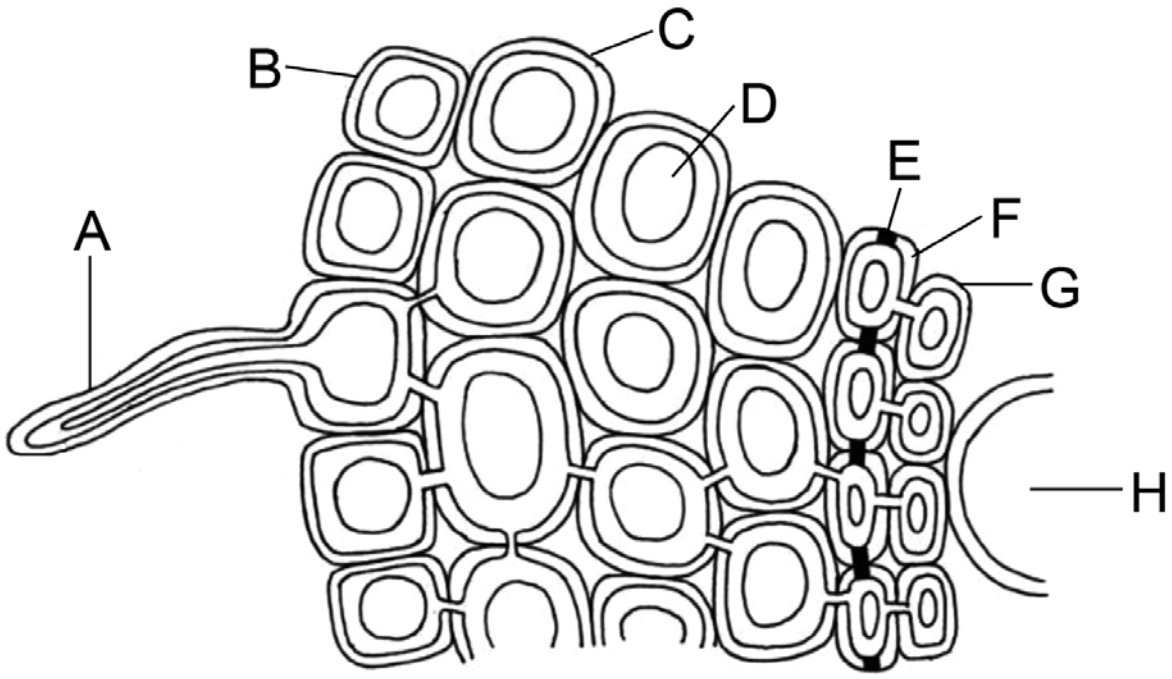
c. Bacterium C has a capsule which can actively absorb more nutrients.
細菌 C 有莢膜可活躍地吸附更多養分

9. A laboratory technician stained unknown bacterial cells with different dyes before observing them. The dyes (stains) used are known to target (i) lipopolysaccharide, (ii) nuclear envelope, (iii) DNA, (iv) cytoplasm and (v) ribosomes. Which dyes are likely to stain positive no matter what type of bacteria there may be in the sample? Indicate with a tick (✓) if they will be stained and with a cross (×) if they will not be stained. (1 point)
一位實驗室的助理在觀察未知細菌前，用不同染劑對其染色。所使用的染劑已知可以染出 (i) 脂多醣 (lipopolysaccharide)、(ii) 核膜 (nuclear envelope)、(iii) DNA、(iv) 細胞質 (cytoplasm) 和 (v) 核糖體 (ribosomes)。不論樣品中含有何種細菌，染劑都可以有染色效果的物質為何。可被染到的請打勾(✓)，不會被染到的打叉(×)。（1 分）

PLANT ANATOMY AND PHYSIOLOGY 植物解剖及生理學

10. Study the transverse section of a root in the figure below. (4.6 points)

根據以下所示根的橫切面圖來回答下列問題



10.1. Match the codes (1 – 18) given in the table below with the labeled parts (A to H) in the above figure. (1.6 points) 用下表的號碼(1 – 18)來分別對應上圖所標示之構造(A ~ H)

No.	**Part** 構造	**No.**	**Part** 構造
1	Hypodermis 下皮	10	Sclerenchyma cell 厚壁細胞
2	Epithelial cell 內層細胞	11	Casparian strip 卡氏帶
3	Xylem parenchyma 木質部薄壁細胞	12	Central vacuole 中央液胞
4	Epidermal cell 表皮細胞	13	Phloem parenchyma 韌皮部薄壁細胞
5	Xylem fiber 木質部纖維	14	Pericycle 周鞘
6	Root hair 根毛	15	Companion cell 伴細胞
7	Exodermal cells 外皮細胞	16	Phloem fiber 韌皮部纖維
8	Xylem vessel 木質部導管	17	Endodermal cell 內皮細胞
9	Cortical parenchyma cell 皮層薄壁細胞	18	Collenchyma cell 厚角細胞

10.2. The following are three pathways of ion and water absorption:

下列三種為離子及水吸收的路徑

I. a symplastic pathway 共質體路徑

II. an apoplastic pathway 質外體路徑

III. a transmembrane pathway 穿膜路徑

Draw continuous lines and label (with I, II and III) the three different pathways from outside to H in the figure provided **in the Answer Sheet**. (3 points)

在答案紙上的圖中, 從根外至H, 以連續不斷的曲線畫出三種不同路徑並分別標示(I, II 及 III)

11. Match plant structures (1 – 10) with the corresponding function (A – J). (3 points)

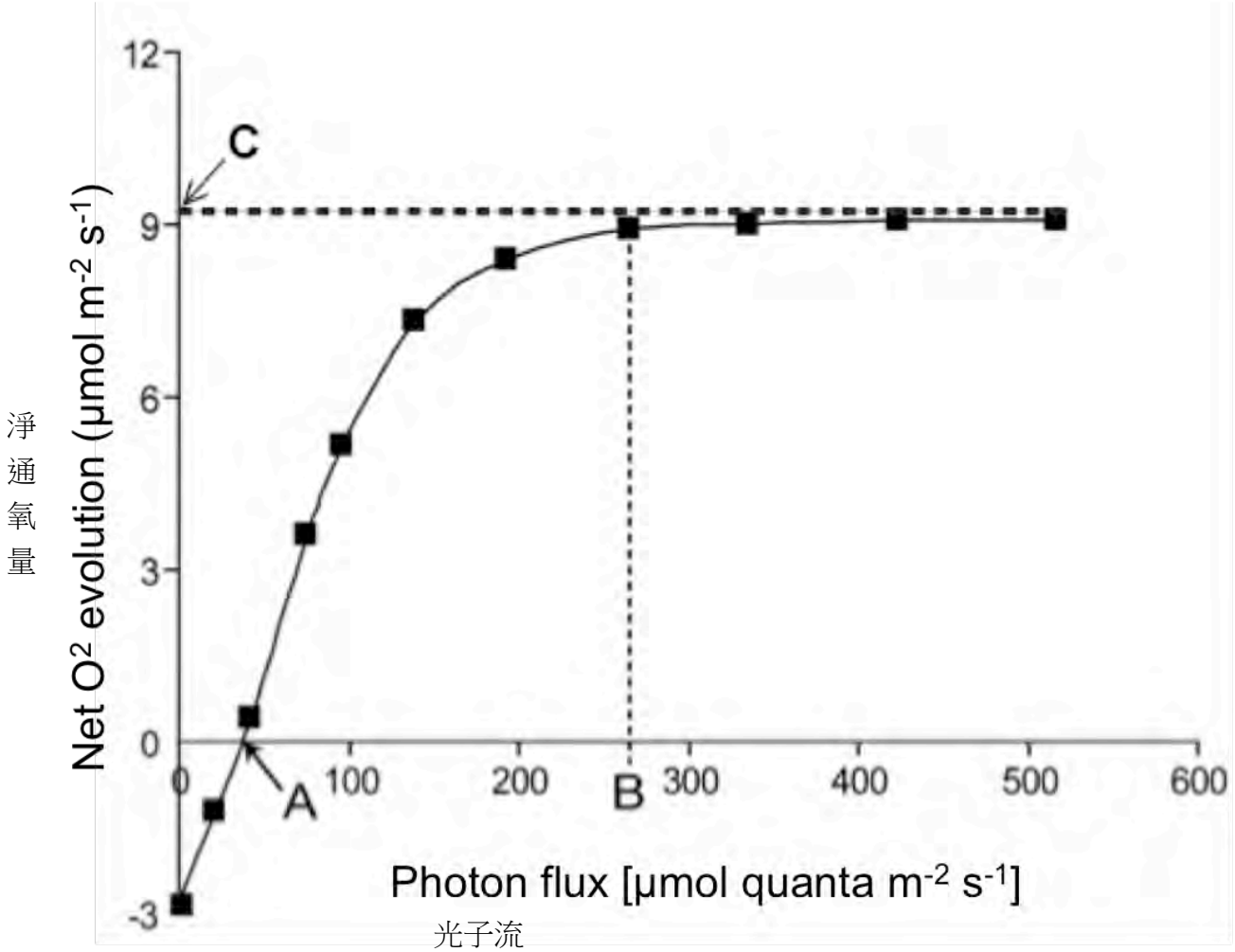
將植物構造(1 – 10) 對應其功能(A – J)

Plant cell / Tissue structure **植物細胞 / 組織構造**		**Function(s) / Feature(s)** **功能 / 特性**	
1	Thylakoid membranes 類綠囊的膜	A	An intercellular communication network 細胞間的聯繫網絡
2	Vascular cambium 維管束形成層	B	Storage of water, digestive enzymes and other inorganic and organic substances 儲存水分、消化酶及無機與有機物質
3	Central vacuole 中央液胞	C	Production of new plant tissues/organs 產生新的植物組織/器官
4	Plasmodesmata 原生質絲	D	Modified parenchyma cell without nucleus 特化的無細胞核之薄壁細胞
5	Apical meristem 頂端分生組織	E	Small opening in the surface of an ovule, through which the pollen tube penetrates. 胚珠表面的開孔, 花粉管由此處進入胚珠
6	Periderm 周皮	F	Mechanical support 機械性支持
7	Sieve tube 篩管	G	Presence of electron transport proteins 具有負責傳遞電子之蛋白質
8	Trichome 毛茸	H	Production of secondary vascular tissues 產生次生的維管束組織
9	Secondary cell wall 次生細胞壁	I	Secondary protective tissue 次生的保護組織
10	Micropyle 珠孔	J	Protection and absorption 保護與吸收

12. Study the graph below and determine which of the statements (a to h) are correct.

    Indicate correct answer(s) with a tick (✓) and incorrect ones with a cross (×). (1.4 points)

    根據下圖來判斷下列敘述(a - h)中哪些是正確的? 正確者標示(✓); 錯誤者標示(×)



a. It is a photosynthetic O_2 response curve.

   此圖是光合作用的O_2反應曲線

b. Point A is light saturation point.

   圖中的 A 點是光飽和點

c. Point B is light compensation point.

   圖中的 B 點是光補償點

d. C is the maximal photosynthetic rate.

   圖中的 C 點代表光合作用的最大速率

e. Plants stop growth when they grow under the irradiance greater than the value shown at point B.

若植物生長在大於 B 點所對應數值的光照強度下, 則植物將停止生長

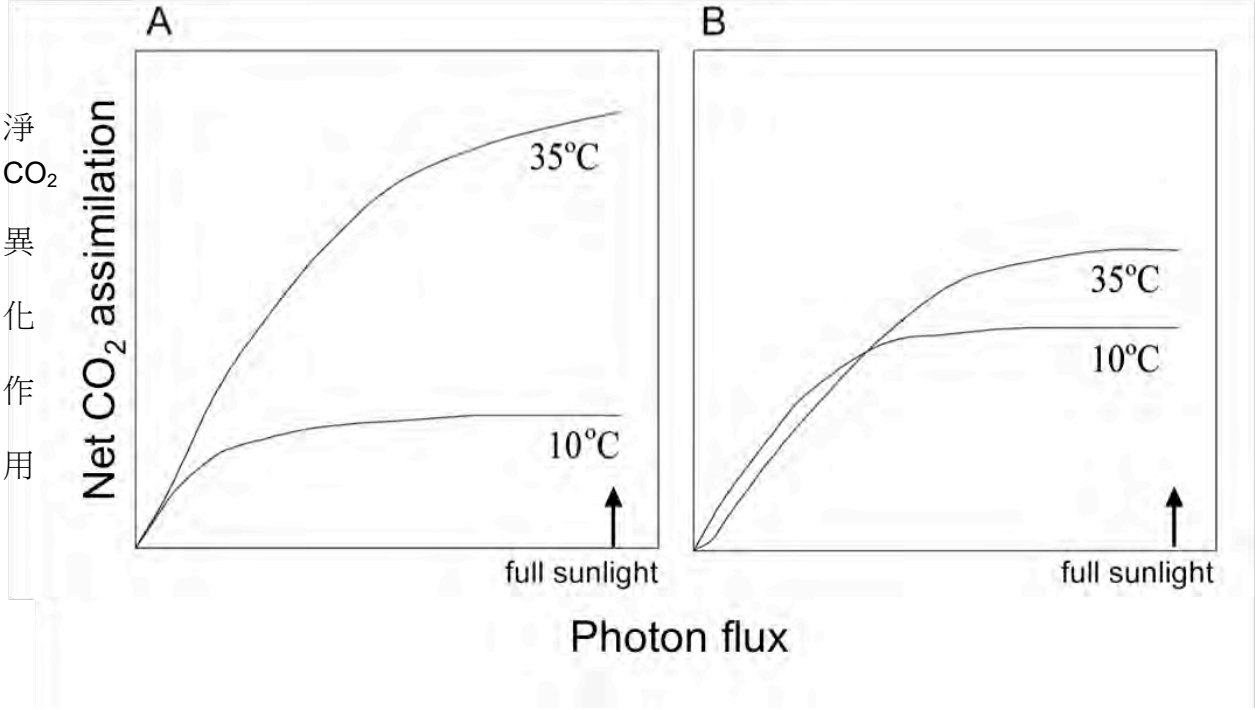
f. Respiration rate is greater than photosynthetic rate when plants are grown under the light below the value shown at point A.

若植物生長在小於 A 點的光照強度下, 則植物的呼吸作用速率會大於光合作用

g. Plants grow (accumulate biomass) when their growth light environments are higher than the photon flux shown at point A.

若植物生長在大於 A 點的光照強度下, 則植物會生長(累積生物量)

13. Study the light response curves for leaf photosynthesis of C_4 and C_3 plants shown below. Indicate correct statement(s) with a tick (✓) and incorrect statement(s) with a cross (×). (1.2 points) 下圖為C_4 與 C_3植物葉片光合作用之光反應曲線, 根據圖來判斷下列敘述, 正確者標示(✓); 錯誤者標示(×)



a. Figure A demonstrates the characteristics of C_4 plants.

A圖顯示出C_4植物的特性

b. C_3 plants have a competitive advantage over C_4 plants at high temperature and under full sunlight because of a reduction in photorespiration.

在高溫及強光下, C_3植物比C_4植物更具競爭優勢, 因為C_3植物的光呼吸降低

c. C_3 plants have a competitive advantage over C_4 plants at low temperature and under low light because of the higher quantum yield.

在低溫及弱光下, C_3植物比C_4植物更具競爭優勢, 因為C_3植物可吸收較多的光子

14. Some statements about photosynthesis are given below. Indicate true statement(s) with a tick (✓) and false statement(s) with a cross (×). (1.0 points)

判斷下列有關光合作用之敘述, 正確者標示(✓); 錯誤者標示(×)

a. Photophosphorylation involves ATP formation during the light reaction of photosynthesis.

在光反應過程中, 光磷酸化作用會有 ATP 產生

b. The essential initial role of light in initiating the light reaction of photosynthesis is to produce free oxygen.

在光反應的起始過程中, 光的重要角色是產生游離氧

c. In a plant cell, the ATP synthase complexes are only located in the thylakoid membrane.

在植物細胞中, ATP 合成酶只位在類綠囊的膜上

d. Photosystem II is required for cyclic photophosphorylation.

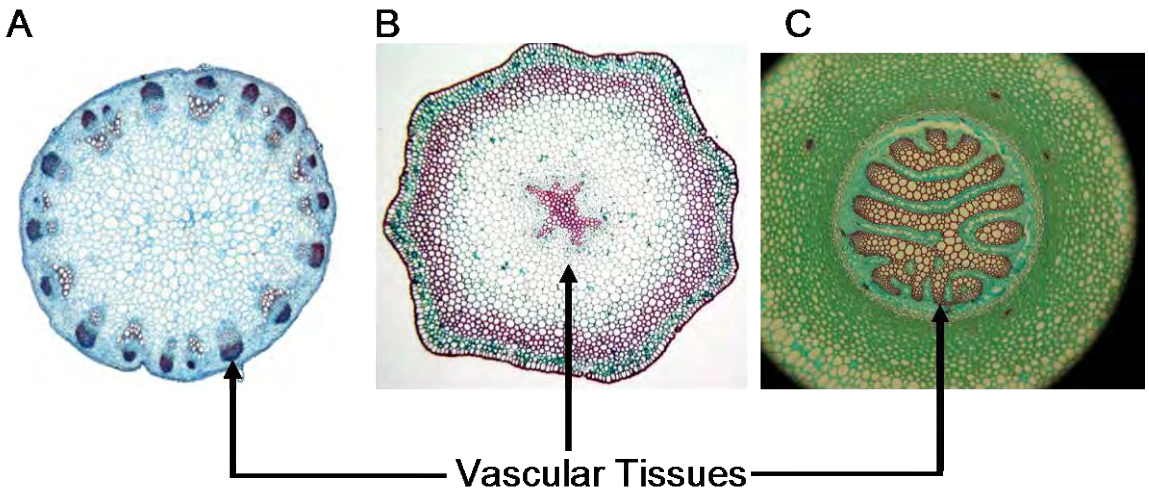
循環式光磷酸化反應需要有光系統 II

e. It is currently believed that the specific enzymes necessary for the fixation of CO_2 into sugar are located in the chloroplast stroma.

參與CO_2固定成為糖的特定酵素位在葉綠體的基質中

15. Arrange the following plants A to C in evolutionary order starting with the most primitive specimen to the most modern. (1.5 points)

將下列植物依其演化順序由原始至進化排列



16. Match the description or effect (A – J) with their corresponding terms (1 – 10). (1.8 points)

將敘述/作用 (A – J)對應專有名詞(1 – 10)

Term專有名詞		Description / effect 敘述/作用	
1	Ethylene 乙烯	A	Physiological reaction of organisms to the length of day or night 對一天中晝夜長短的生理反應
2	Photoperiodism 光週期性	B	Inhibition of the growth of lateral buds 抑制側芽生長
3	Apical dominance 頂芽優勢	C	Stem elongation in intact plants 在完整植株中, 促使莖伸長
4	Thigmotropism 向觸性	D	Prolonged exposure to cold temperatures promotes flowering 在低溫下可促進開花
5	Phyllotaxy 葉序	E	Leaf and fruit abscission 葉與果實的脫落
~~6~~	~~Auxin~~ ~~植物生長素~~ (刪除)	F	Bending of growing stems toward light sources 莖朝向光源彎曲生長
6	Cytokinin 細胞分裂素	G	The arrangement of leaves on a stem 葉在莖上的排列順序
7	Gibberellin 吉貝素	H	The response of plants to touch 植物對碰觸的反應
8	Statolith 平衡石	I	Delayed senescence 延緩老化
9	Vernalization 春化作用	J	Gravitropism 向地性

ANIMAL ANATOMY AND PHYSIOLOGY 動物解剖及生理學

17. ~~Referring to the events (I to VIII) below, fill in the correct sequence of events during cardiac excitation-contraction coupling. (1.5 points)~~ ~~此題已刪除~~

    I. ~~action potential triggers opening of Ca^{2+} channels in the endoplasmic reticulum~~

    II. ~~release of intracellular Ca^{2+} store~~

    III. ~~action potential triggers opening of L-type Ca^{2+} channels~~

    IV. ~~Ca^{2+} influx from the extracellular space~~

    V. ~~cytosolic Ca^{2+} binds to troponin~~

    VI. ~~cytosolic Ca^{2+} binds to tropomyosin~~

    VII. ~~crossbridge forms as myosin heads bind to actin~~

    VIII. ~~crossbridge forms as actin heads bind to tropomyosin~~

18. Given below are data on the breathing rate, heart rate and body temperature of four different mammals, A to D.

    以下數據為 A ～D 四種哺乳動物的呼吸率、心搏率及體溫

Animals 動物	Breathing rate (inhalations/min) 呼吸率(吸氣/分鐘)	Heart rate (beats/min) 心搏(次/分鐘)	Body temperature (°C) 體溫(°C)
A	160	500	36.5
B	15	40	37.2
C	28	190	38.2
D	8	28	35.9

    18.1. Rank Animals A to D in descending order for surface area per unit volume of the body. (0.8 points)

    依照身體之每單位體積所具表面積由大至小將動物 A 至 D 排序 (0.8 分)

    18.2. Rank Animals A to D in descending order for total volume of blood in the body. (0.8 points)

    依照動物體所具血液總量由大至小將動物 A 至 D 排序 (0.8 分)

19. Evaluate the following two statements regarding the respiratory processes of amphibians, reptiles, birds and mammals. Indicate true statement(s) with a tick (✓) and false statement(s) with a cross (×). (1.6 point)

下列兩個敘述分別與兩生類、爬蟲類、鳥類、哺乳類的呼吸過程相關，若正確請打鉤(✓)，錯誤請打叉 (×). (1.6 分)

I. Negative pressure used to force air into lungs

以負壓方式強迫使氣體進入肺部

II. Lungs are completely ventilated during each breathing cycle

肺部在每次呼吸循環均完全換氣

20. Gas exchange in animal taxa involves various respiratory organs (a – d), as well as the circulatory system (open and closed). For each animal, indicate open circulatory system(s) with a tick (✓) and closed circulatory system(s) with a cross (×). Match the appropriate organs (a – d) with the animals (adult). (2.6 points)

動物的氣體交換涉及不同的呼吸器官(a – d) 及循環系統(開放或閉鎖式)。表中動物(成體)使用開放式循環系統者打鉤(✓)、閉鎖式循環系統者打叉 (×)；並寫出其使用的器官代碼(a – d) (2.6 分)

a. Lungs 肺

b. gills 鰓

c. skin 皮膚

d. trachea 氣管

21. Urine production is the result of continuous filtration of plasma through the kidneys. Indicate true statement(s) about the mammalian kidney with a tick (✓) and false statement(s) with a cross (✗). (2 points)

尿液為血漿經流腎臟時經過連續過濾而產生，針對哺乳動物的腎臟，判別下列敘述的真偽，正確打鉤(✓)，錯誤打叉 (✗)

a. The kidneys have a direct effect on blood pressure.
腎臟能對血壓有直接影響

b. The kidneys help regulate total blood volume in circulation.
腎臟能幫助調控循環的總血量

c. The loops of Henle remove water, ions and nutrients from the blood.
亨耳氏套可除去血液中的水分、離子及養分

d. Those able to excrete the most hyperosmotic urine, such as the kangaroo rats living in the desert, have relatively short loops of Henle.
能排泄高張尿液的動物如沙漠中的跳鼠，其亨耳氏套較短

e. The kidneys partner the lungs in controlling the pH in plasma.
腎臟能配搭肺臟來控制血液中的 pH 值

f. The kidneys help maintain blood pH by excreting hydrogen ions and reabsorbing bicarbonate ions as needed.
腎臟能排泄氫離子和再吸收碳酸氫鈉，以幫助血液中 pH 值的維持

g. The kidneys dispose of volatile acids produced in metabolism.
腎臟能處理代謝作用所產生的揮發性酸

h. Ammonia (NH_3) is produced in proximal tubule cells during acidosis.
酸中毒時，氨(NH_3)是由近曲小管細胞所產生

i. The glomerular filtration rate is affected by blood pressure.
腎絲球的過濾速率會受血壓所影響

j. The kidneys produce ADH (antidiuretic hormone).
腎臟能產生 ADH(抗利尿激素)

22. The amount of saliva secreted by a mammal is related to how much chewing is required on feeding. Match the following animals (a – e) to the quantity of saliva secreted as given in the table **in the Answer Sheet**. (0.8 points)

哺乳動物的唾液分泌量與其進食的咀嚼次數相關，將下列動物 (a – e) 與答案卷上的唾液分泌量作配對(1 分)

a. wolf 狼

~~b. sheep 羊~~

b. horse 馬

c. cattle 牛

d. human 人

23. Allergy is a hypersensitive human immune system reaction which is a result of repeated antigen exposure. In comparison, although pseudoallergy is identical to allergy in clinical terms, there is no immunological stage in its development.

過敏乃因人類免疫系統再次接觸某些抗原所引起。相對的，假性過敏 雖在臨床上類似過敏，但缺乏免疫上的發展步驟。

The underlying pathological processes are listed below as observations:

下列項目是此二病理過程的觀察：

a. General level of IgE class antibodies in the serum is raised.

血清中 IgE 類的抗體量上升

b. Specific IgE class antibodies in the serum is detected.

血清中可偵測到專一性的 IgE

c. Histamine – the main mediator of inflammation is released.

發炎主要介質– 組織胺 的釋出

d. A minimal amount of the antigen is needed to demonstrate the reaction

抗原必須達到一最小劑量才能引起反應

Indicate for allergy, as well as pseudoallergy, the observation(s) that apply with a tick (✓) and the observation(s) that do not with a cross (×) **in the Answer Sheet**. (0.8 points)

分別針對 過敏及假性過敏，各 觀察項目若是符合 在 **答案卷**上打鉤(✓)，不符合打叉 (×). (0.8 分)

24. The age of animal fossils can be determined by measuring the content of carbon isotope ^{14}C in the bones. How is ^{14}C accumulated in the bones? Indicate correct statement(s) with a tick (✓) and incorrect statement(s) with a cross (×). (0.6 points)

動物化石的年齡可用其骨中碳的同位素^{14}C來測定，^{14}C如何累積在骨中？下列敘述對的打鉤(✓)，錯的打叉 (×) (0.6 分)

a. through consumption and assimilation of organic compounds in the bones

藉由攝取及同化動物骨中有機質

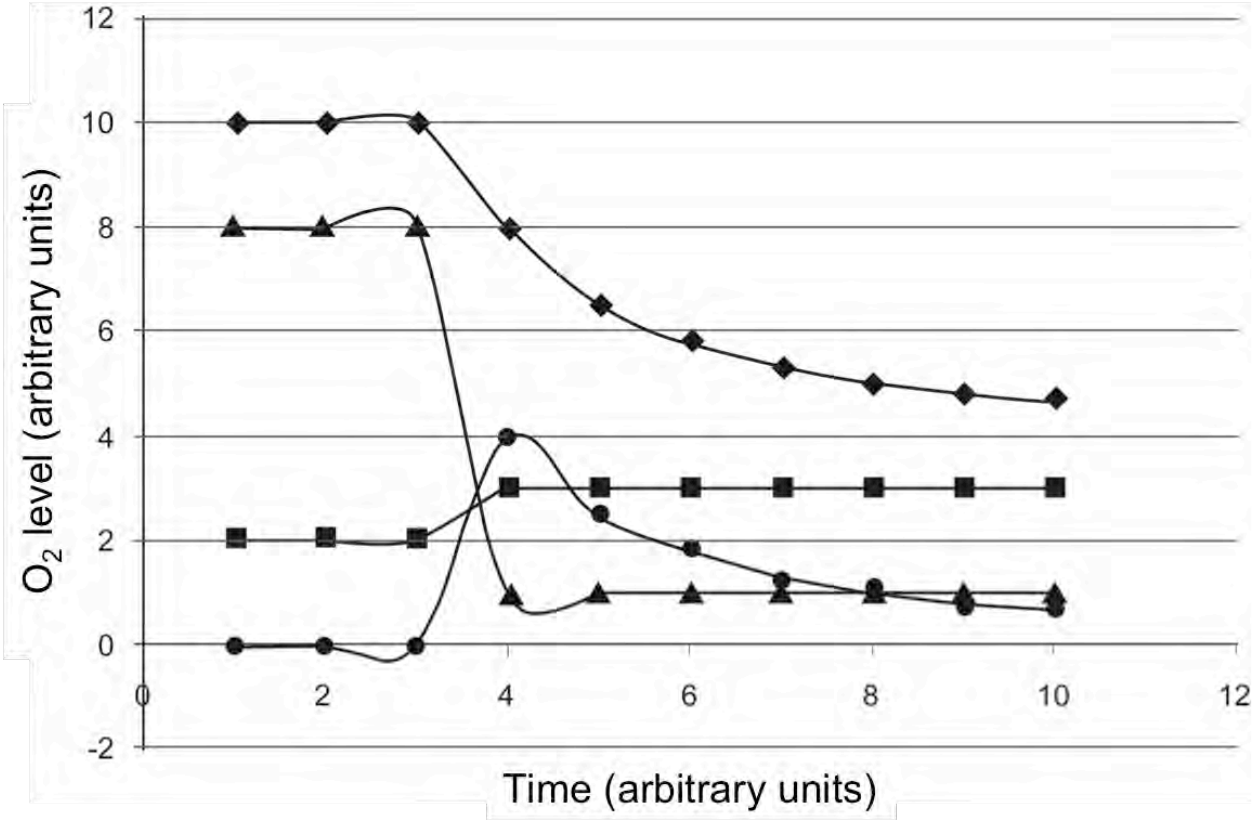
b. through converting CO_2 into organic compounds in the bones

藉由轉化CO_2成為骨中的有機質

c. through accumulation of residual CO_2 during respiration deposited in the bones

藉由將呼吸時所殘留的CO_2累積到骨中

25. European (freshwater) eel usually obtains oxygen by gills but can spend long periods of time out of water using dermal respiration. The graph below shows the level of blood saturation by oxygen and oxygen supply through different organs when the eel was removed from the water (in arbitrary units):
歐洲(淡水)鰻通常藉由鰓來得到氧，但也能用皮膚呼吸而長時間離開水。下圖顯示當鰻被移出水後，其血中氧的飽和度及氧經不同器官的供應，



◆A, ▲B, ■ C, ●D

Match the following statements (I to IV) to the corresponding lines (A – D) shown above. (1.2 points)
將下列敘述(I ～ IV)與上圖之曲線(A – D) 配對(1.2 分)

I. Total blood saturation by oxygen
血中氧的飽和度

II. Oxygen supply through gills
經鰓供應的氧

III. Oxygen supply through skin
經皮膚供應的氧

IV. Oxygen supply from air bladder
經魚鰾供應的氧

26. Anatomical characteristics of animals are adapted for their different modes of feeding (a – d).

動物的解剖特徵與其食性(a ～ d) 的適應相關

a. carnivores 肉食動物

b. omnivores 雜食動物

c. non-ruminant herbivores 非反芻類植食動物

d. ruminant herbivores 反芻類植食動物

26.1. Match the different modes of feeding (a – d) with the corresponding dental features (I – IV). (1.2 points)

將不同食性 (a – d) 與動物的齒式(I – IV)作配對(1.2 分)

I. no upper incisors, have dental pad, molars allow only lateral movements

無上方門齒、具牙床、臼齒只能橫向移動

II. canine teeth highly developed and used for tearing

犬齒高度發達用以撕裂

III. grinding teeth patterns on posterior teeth (molars)

後方具有適於研磨的齒式(臼齒)

IV. incisors for nipping, molars slightly angled, jaws move circularly (vertical and lateral)

門齒用以穿刺、臼齒略帶角度、下顎能作環狀(垂直及橫向)移動

26.2. The gastrointestinal (GI) tract surface area to the body surface area ratio differs between herbivores, omnivores and carnivores. Match the different modes of feeding (a – d) with the corresponding GI tract surface/body surface area ratio as listed in the table **in the Answer Sheet**. (1.2 points)

植食動物、雜食動物及肉食動物腸胃道表面積對體表面積的比例不同，將不同食性 (a – d) 與答案卷上動物腸胃道表面積對體表面積的比例作正確配對(1.2 分)

27. Match the adaptations of the digestive systems (a – c) with the corresponding anatomical descriptions. (0.9 points).

將不同消化系統適應 (a – c) 與下列解剖敘述作配對(0.9 分)

Anatomical descriptions: 解剖敘述：

I. simple stomach, limited utilization of foliage-based diets

簡單的胃、能有限的以葉為食

II. simple stomach incapable of utilization of foliage-based diets

簡單的胃、不能以葉為食

III. highly developed sacculated stomach capable of extensive and effective utilization of foliage-based diets

高度發達呈囊狀的胃、可廣泛而有效地以葉為食

Digestive adaptations: 消化適應：

a. extensive fermentation after primary sites of digestion and absorption

在通過主要的消化及吸收位置後，進行大量的發酵

b. extensive fermentation before primary sites of digestion and absorption

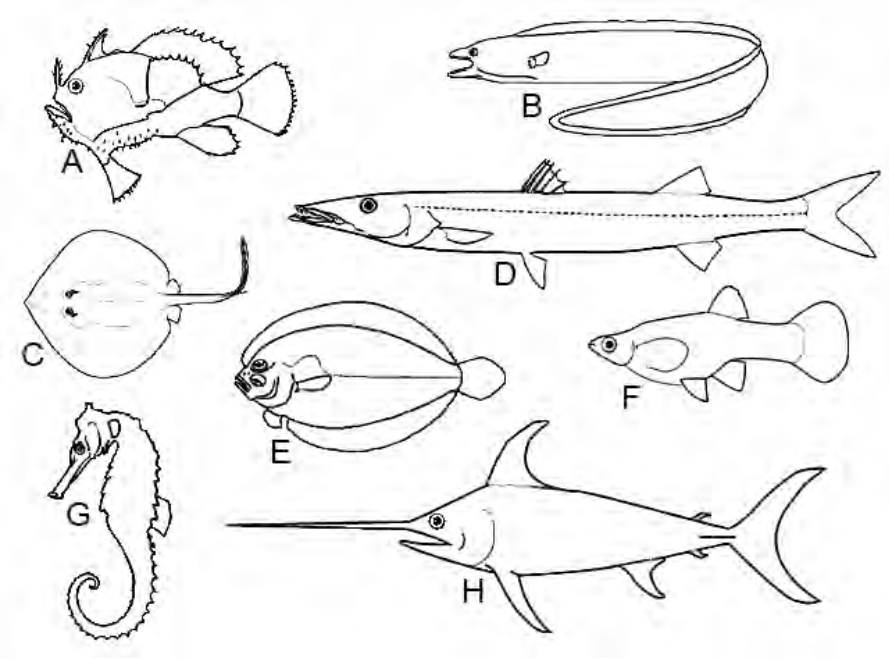
在主要消化及吸收位置前，先進行大量的發酵

c. unable to digest some of the substances in grains, fruits and vegetables

不能消化穀物、水果及蔬菜中的某些物質

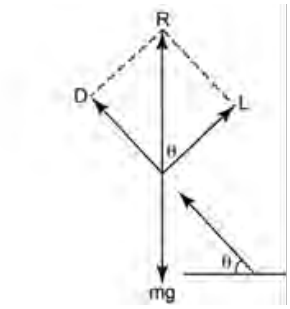
28. Fishes are specially adapted for aquatic life in different parts (e.g., surface, middle, bottom) of the water column and various special habitats (e.g., sea grass beds, rock crevices). Their swimming speeds are also partly dependent on their body morphology. Match the fishes (A – H, not drawn to scale) with their respective habitats and indicate the two fastest swimmers and the two slowest swimmers. (2.4 points)

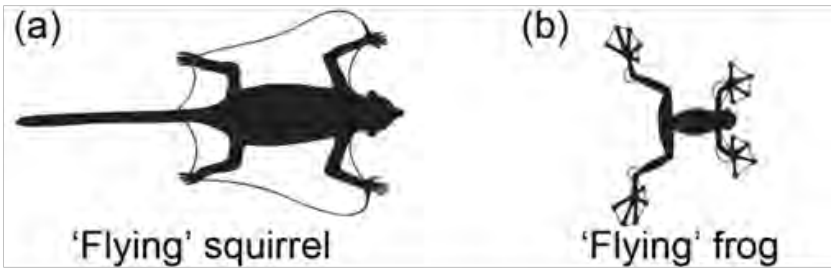
魚類會適應不同的垂直水域 (如表層、中層、底層) 或不同的特殊棲所(如海草床、石隙)。牠們的游速部分決定於其體型，將不同的魚(A – H, 圖示未按比例 繪製) 與其居所環境及游速作配對, 並指出最快與最慢者各兩種(2.4 分)



29. In all classes of vertebrates, there are at least a few species that may occasionally take to the air (e.g., 'flying' fish, frog, lizard, and squirrel). They are not capable of true flight but make use of non-flapping locomotion such as gliding and parachuting to slow their descent.
在脊椎動物的各綱中, 至少都有一些物種偶爾會適應以飛翔的方式在空中移動 (如飛魚、飛蛙、飛蜥蜴及飛鼠)。牠們不具真正的飛行能力, 但可藉由非擺動的方式移動, 如滑翔及跳傘的方式來阻緩其下降。

29.1. Animals that glide minimize drag (D) and use lift (L) to produce a more favourable lift-to-drag ratio (L/D ratio). In contrast, animals that parachute maximize D as they often have no significant surface area to produce enough L. When an animal has a steady glide, several forces act upon it (see figure below). Resistance (R) of the outstretched body against the airstream produces L. Drag (D) in the direction opposite to travel is also present, and weight (mg) acts as well. The descending path makes an angle (θ) with the ground.
會滑行的動物儘量減少拉力(D)並用昇力(L)來營造出更有利的昇與拉的比例(L/D ratio), 而動物採取跳傘方式移動者則儘量增加 D, 此係因此類動物通常沒有足夠的表面積來產生足夠的 L。當一隻動物進行穩定的滑翔時, 好幾種力量作用於其上(參閱下圖)。當身體伸張時所產生的阻力(R)與氣流接觸時會產生昇力(L)。與行動方向相反的拉力(D)亦會呈現, 而重量(mg)也會有類似的作用。下降的路線與地面呈一夾角為(θ)。

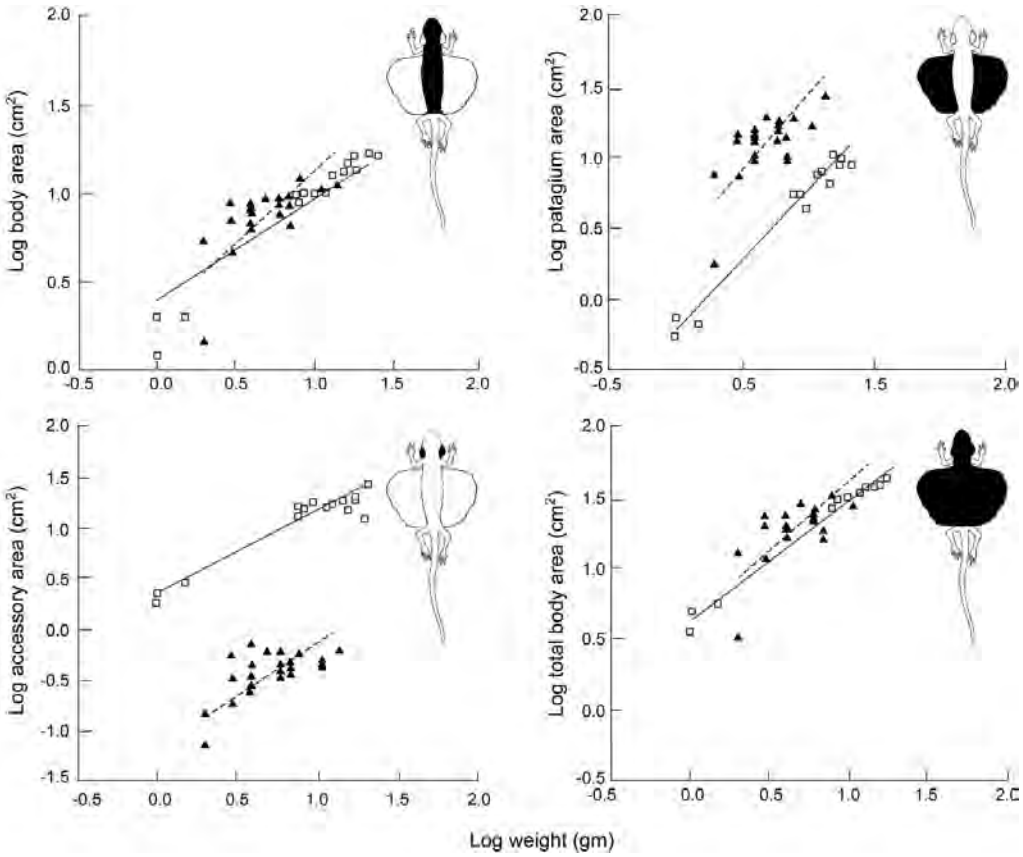




Match the correct animal, (a or b), with the expected values of L/D and θ in the table **in the Answer Sheet**. (1 point)
由答案卷中所提供的L/D 及 θ 資訊表, 選擇適當的動物(a 或 b)填入

29.2. In 'flying' lizards, the patagium is a fold of skin connecting the forelimbs and hind limbs. Russell and Dijkstra (2001) compared the patagia and accessory aerodynamic surfaces between two species of lizards, *Draco volans* ('flying' dragon) and *Ptychozoon kuhli* ('flying' gecko).

在飛蜥蜴中, 飛膜是連接前、後肢間的皮褶, Russell and Dijkstra (2001)比較二種蜥蜴 *Draco volans* (飛龍) 和 *Ptychozoon kuhli* (飛行守宮)的飛膜及具有流體力學的其它輔助面積。



▲------ *Draco volans*; □—— *Ptychozoon kuhli*

Indicate correct conclusion(s) that can be drawn from the study about the morphological adaptations of the lizards for aerial locomotion with a tick (✓), and incorrect conclusion(s) with a cross (✗). (2 points)

下列敘述有關蜥蜴在空中移動時所產生的形態適應, 可從此研究得出正確結論者打鈎(✓); 錯誤打叉(✗)

a. Although the mean weight of *D. volans* is smaller than that of *P. kuhli*, their body area per unit mass is very similar.

雖然 *D. volans* 的平均重量小於 *P. kuhli*, 但牠們每單位重量之表面積則非常接近

b. Comparison of the patagial area to mass indicates that the patagia of *P. kuhli* are larger than those of *D. volans* of equivalent mass.

由飛膜面積及重量的比較顯示: 在兩個物種體重相當時, *P. kuhli* 有較大的飛膜

c. The accessory structures contribute more significantly to total available aerodynamic area in *D. volans* than they do in *P. kuhli*.

D. volans 之輔助構造對於整體可用之流體力學面積較 *P. kuhli* 能提供更多且更顯著的作用

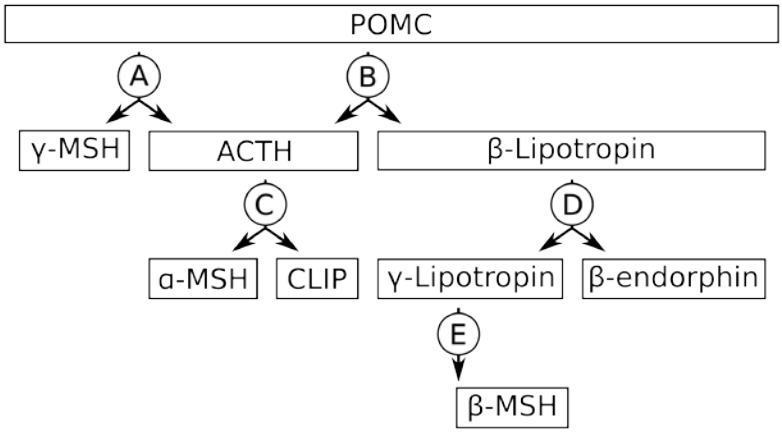
d. The total body area of the two taxa is very similar.

此二物種之總體表面積是非常相似的

e. The proportional area that is contributed by the patagium is much larger in *D. volans* than in *P. kuhli*, which compensates by the addition of extensive accessory flaps and folds.

在 *D. volans* 的飛膜對整體面積的貢獻遠大於 *P. kuhli*, 而 *P. kuhli* 則靠更多的附屬膜翅及褶皺來補償

30. In the hypophysis, several regulatory peptides are built from the propeptide, Pro-opiomelanocortin (POMC). POMC is cleaved proteolytically (A – E) into various products. Every polypeptide below is represented with N-terminal on the left and C-terminal on the right.
腦垂體中的幾種調節性多肽可由 POMC 原多肽分子形成，POMC 可經 (A – E) 蛋白分解為不同產物。下面的各個多肽分子均以 N-端在左、C-端在右來代表。



30.1. Write down the minimum number of enzymes needed by a cell to produce β-MSH from POMC. (1 point)

一個細胞由 POMC 造出 β-MSH 最少需幾種酵素 (1 分)

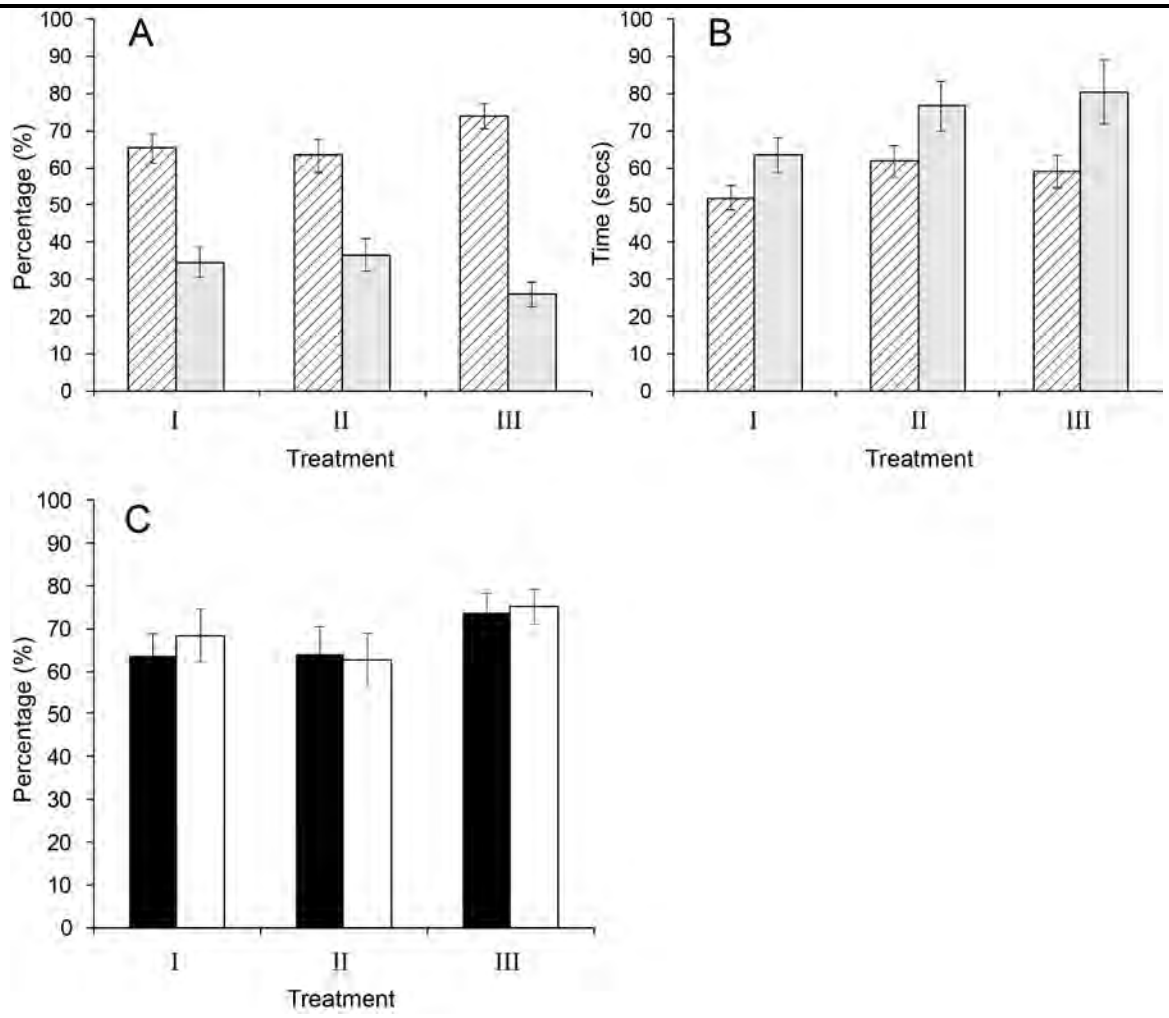
30.2. Write down the minimum number of enzymes needed by a cell to produce α -MSH from POMC. (1 point)

一個細胞由 POMC 造出 α -MSH 最少需幾種酵素 (1 分)

ETHOLOGY

31. Male fiddler crabs use their enlarged claws chelipeds (major chelipeds) for signalling (e.g., fighting for burrows, waving at females, etc.). A student studied male-female interactions by using mirrors to reflect two different-sized images of the same waving male crab to females. Mirror combinations used in the experiment were: 10x : 3x (Treatment I), 3x : 1x (Treatment II) and 10x : 1x (Treatment III). Ten waving males were presented to 20 females in three trials for each treatment. She recorded the percentage of females (Graph A) and time taken by each female to approach each reflection (Graph B) for each treatment as well as whether the male was right or left-handed (Graph C).

雄性招潮蟹用其大螯來傳遞信息，如：爭奪洞穴時打鬥、向雌性示意時舞動等。一位學生用鏡子所呈現個體兩種不同大小的影像，來研究雌雄間的互動行為，觀察雌性對同一雄性個體對雌性示意時在鏡中呈現不同影像時的反應。 三組鏡像組合分別為 10x : 3x (10 倍：3 倍 第 I 組)、 3x : 1x (第 II 組) 及 10x : 1x (第 III 組) 。以 10 隻雄性個體分別對 20 隻雌性個體進行實驗，針對上述 3 組實驗，每組重複 3 次。她記錄各組實驗數據，雌蟹對影像反應的比例(圖 A)及雌蟹受刺激後前往影像前所花的的時間(圖 B) ，另亦紀錄該雄性的大螯是在右側或左側(圖 C)。


A
Percentage (%)
Treatment
I
II
III
B
Time (secs)
Treatment
C
Percentage (%)
Treatment
Larger image; Smaller image; Right-handed male; Left-handed male
大型影像 小型影像 右螯雄性 左螯雄性

Indicate correct conclusion(s) that can be drawn about the interactions between male and female crabs with a tick (✓),incorrect conclusion(s) with a cross (×) and statement(s) that cannot be concluded with a dash (-). (1.5 points)

下列有關雌雄間互動實驗所下的結論，正確者請打勾(✓)， 錯誤者請打叉(×)，不確定者以減號 (-) 表示。(1.5 分)

a. Female fiddler crabs generally prefer larger males.

一般而言，雌蟹喜好體型較大的雄性

b. In mate-choice selection, male handedness is an important criterion.

在伴侶的性擇中，雄性的大螯在左側或在右側扮演關鍵的角色

c. Males that wave faster generally attracted more females.

雄性的大螯揮動得較快者，一般會吸引較多的雌性

d. The mean time taken for females to make a choice differed between Treatments II and III.

在實驗組別 II 及 III 間，其雌性決定是否對雄性產生反應，所花費的平均時間有所差異

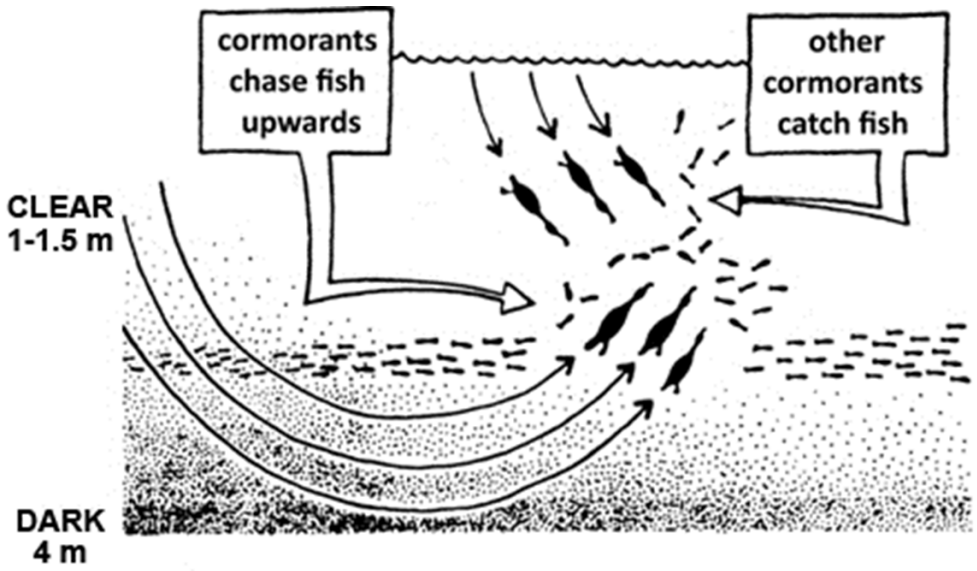
e. An obvious difference in cheliped size of males may be necessary before females become more decisive.

雄性大螯的差異，可能是影響雌性最後做出決定的關鍵

32. Cormorants (*Phalacrocorax carbo)* feed on fish. They dive in the water and chase fish by sight, so water clarity is important. Normally cormorants fish individually, but if the water is murky they may develop a cooperative hunting method in a group. (1.2 points).

鸕鷀(*Phalacrocorax carbo)*以魚為食，他們潛入水中藉視覺捕魚，所以水的混濁度對牠們的影響很大。鸕鷀平時多單獨捕魚，但當水混濁時，牠們會展現合作捕食(1.2 分)

鸕鷀將魚趕往上方　　其他鸕鷀捕捉魚



Indicate the process(es) that play(s) a role in developing the collaborative hunting strategy of the cormorants with a tick (✓) and use a cross (✗) for inappropriate process(es).

指出下列係何種方式或哪些方法造成了鸕鷀發展出合作捕食的答案，正確者請打勾(✓)， 錯誤者請打叉(✗)。

a. competition 競爭

b. conditioning 制約反應

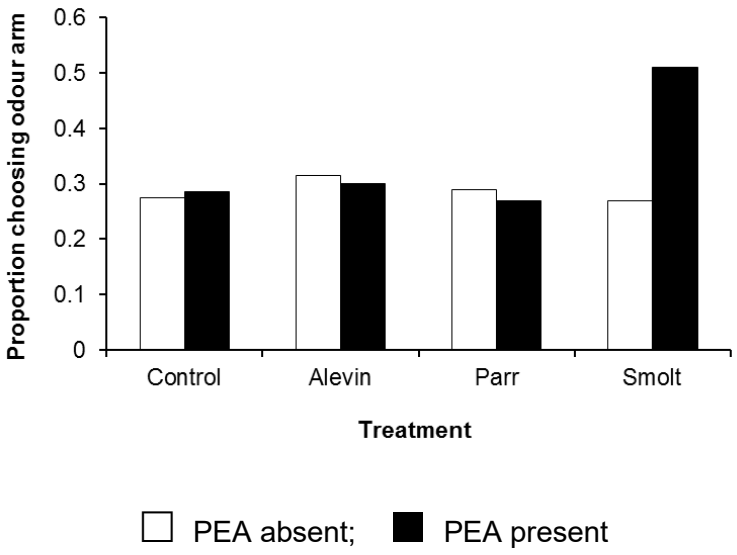
c. habituation 習慣化

d. social learning 社會學習

e. imprinting 印痕

f. trial and error 試誤學習

33. The figure below from Dittman et al. (1999) shows the behavioural response of mature hatchery-reared Coho salmon, *Oncorhynchus kisutch* to an artificial odorant, β-phenylethyl alcohol (PEA) placed in one arm of a two-arm arena. These salmon were exposed to PEA at different specific developmental stages: alevin (Stage I), parr (Stage II) and smolt (Stage III) in the hatchery before maturity and experimentation. Control fish had never been exposed to PEA.
下圖來自 Dittman et al. (1999)，探討由飼養場養大的成熟 Coho 鮭魚(*Oncorhynchus kisutch*)，其鮭魚個體在 Y 型池中對一種人工合成的香料β-phenylethyl 醇 (PEA)所產生的行為反應 (香料放於二岔中的一岔)。這些魚在其發育的過程中曾經有接觸過此種香料(PEA)的經驗，分別屬三個不同的發育階段，有些在稚魚期(alevin，階段 I)、有些在中魚期 (parr ，階段 II) 以及有些在亞成魚期(smolt，階段 III)，控制組的魚則在成長過程中從未接觸過此香料。



說明： Proportion choosing odour arm 個體選擇 Y 型池中有香料的一岔所佔的比例

Indicate correct conclusion(s) with a tick (✓); incorrect conclusion(s) with a cross (×) and inconclusive statement(s) that cannot be concluded with a dash (-).

下列敘述，如正確者請打勾(✓)， 錯誤者請打叉(×)，不確定者以減號 (-)表示。(1.2 分)

a. Salmon that had previous exposure to PEA had equal preference for both arms of the arena.

鮭魚在成長過程如曾有接觸過 PEA 者，對 Y 型實驗池中香料的有無，沒有偏好

b. Age of salmon is the most important criterion for navigation to natal stream.

鮭魚的年齡是影響其尋找出生地水域最重要的因子

c. Chemical cues play a secondary role in salmon homing behaviour.

化學線索對鮭魚的返家行為扮演次要的角色

d. There is a critical period for olfactory imprinting in the Coho salmon.

嗅覺印痕的關鍵期在 Coho 鮭魚是存在的

GENETICS AND EVOLUTION 遺傳學和演化

34. Bateson and Punnett (1908) studied the flower colour and pollen grain shape in the sweet pea (*Lathyrus odoratus*, which is related to the garden pea, *Pisum sativum*, which Mendel studied). They crossed a true-breeding purple-flowered plant that had long pollen grains with a true-breeding red-flowered plant that had round pollen grains, and tabulated the following results for the F_2 progeny:

Bateson and Punnett (1908)研究甜豆 (*Lathyrus odoratus*)花色和花粉粒形狀的遺傳，甜豆和孟德爾實驗用的豌豆是相關但不同的物種。他們將紫花、長花粉粒的純系和紅花、圓花粉粒的純系雜交，其F_2的表現型如下表：

Phenotype 表現型	Observed 觀察到的個體數
Purple flowers, long pollen grains 紫花、長花粉粒	296
Purple flowers, round pollen grains 紫花、圓花粉粒	19
Red flowers, long pollen grains 紅花、長花粉粒	27
Red flowers, round pollen grains 紅花、圓花粉粒	85
Total number of progenies 子代總個體數	427

34.1. If the genetic traits are assorted independently, what phenotype ratio would you expect to see? Fill in the expected values for the respective phenotype and test for independent assortment by calculating the χ^2 value. (4 points)

如果這二種遺傳性狀是獨立分配的(assorted independently)，則這四種表現型的比例為何？依此比例，將各種表現型的期望個體數填入表中，並計算χ^2值以檢測是否為獨立分配。(4 分)

df	χ^2
1	3.841
2	5.991
3	7.815
4	9.488
5	11.070

Table: χ^2 values for α (p value)= 0.05

34.2. Indicate the likely explanation with a tick (✓) and inappropriate explanations with a cross (×) for the above observation. (0.8 points)

根據以上實驗觀察的結果，判定答案卷上的各項解釋，對的請打勾(✓)，錯的請打叉(×) (0.8 分)

35. The DNA sequence of the Atlantic salmon (Salmo salar) genome, which contains 28 pairs of autosomal chromosomes and a pair of sex chromosomes (XY), has been recently completed. DNA microinjection technique was used to successfully transfer a growth hormone transgene construct into the zygotic stage of salmon fish embryos. Subsequently, 4 transgenic individuals (F0 founders), 2 males and 2 females, were obtained. The growth hormone transgene is under the regulation of a liver-specific enhancer and all 4 transgenic founders have high plasma growth hormone levels leading to accelerated growth. It was confirmed that the transgene is inserted as a single copy within their genomes. Stable lines of transgenic salmon with accelerated growth will be established through crossing. For the establishment of the F1 generation, both the male and female transgenic founders (F0) are outcrossed to the respective gender of wild-type (non-transgenic) salmon

大西洋鮭魚(*Salmo salar*)具有 28 對體染色體和 1 對性染色體(XY)，其DNA基因組(genome)已被定序完成。使用DNA微注射技術(DNA microinjection)將生長激素基因轉入鮭魚授精卵，得到 4 個轉殖個體(F_0 founders)，2 條雄魚，2 條雌魚。轉入的生長激素基因受肝細胞專一強化子(enhancer)調控，4 條轉殖魚都有高生長激素的表現及加快的生長，並且被確認只有一個copy的生長激素基因插入到基因組內。為建立穩定表現轉殖基因加快生長的品系，F_0 founders的雄魚和雌魚都分別和野生型(非轉殖)魚交配，而得到F_1世代。

35.1. For the establishment of the F_2 generation you have been asked to carry out a sibling-pair cross in order to recover homozygous transgenic individuals carrying the growth hormone transgene. What would be the expected genotype ratio expressed as a %? (1.5 points)
為得到帶有轉殖基因的同結合型(homozygous) F_2世代，將F_1的兄弟姊妹魚互相交配，你預期在F_2世代中，各種結合型的百分比分別為何？(1.5 分)

35.2. When you check the ratio of males versus females of the F_2 generation you found that there are always more females (70%) than males (30%) regardless of whether the growth hormone transgene is present as null, heterozygous or homozygous within the individuals of the F_2 generation. Indicate the appropriate reason(s) with a tick (✓) and the inappropriate one(s) with a cross (×) from the list below. (0.8 points)
當你檢查F_2世代的個體時，發現無論是否帶有轉殖基因，無論是同結合型或是異結合型，總是雌魚佔 70%，雄魚佔 30%。下列可能原因中，對的請打勾(✓)，錯的請打叉(×)。(0.8 分)

a. Epigenetic silencing in some male individuals has shut down the growth hormone transgene.
在一些雄魚中，生長激素轉殖基因被關閉。

b. Integration of the growth hormone transgene is no longer stable.
生長激素轉殖基因不再穩定的留在基因組內。

c. Besides the XY sex chromosomes, environmental factors might have a secondary role in sex determination.
除了 XY 性染色體外，環境因素也可能隱響性別的決定。

d. The growth hormone transgene has translocated onto the sex chromosomes leading to sex reversal of some males.
生長激素轉殖基因已經轉移到性染色體上，導致某些雄魚變成雌魚。

36. Chicken with short wings and legs are called “creepers”. When creepers are mated with normal birds they produce creepers and normal chickens with equal frequency. When creepers are mated with creepers they produce two creepers to one normal. Crossing between normal birds produce only normal progeny.

具短翅短腳的雞被稱為 creepers。當 creepers 和正常的雞交配後，子代中 creepers 和正常雞各佔一半；當 creepers 和 creepers 交配後，子代中 creepers 和正常雞的比例為 2 : 1 ；正常雞和正常的雞交配只生出正常雞。

36.1. What is the simplest genetic basis for creepers and normal chicken? Indicate the correct answer(s) with a tick (✓) and incorrect answer(s) with a cross (✗). (0.6 points)

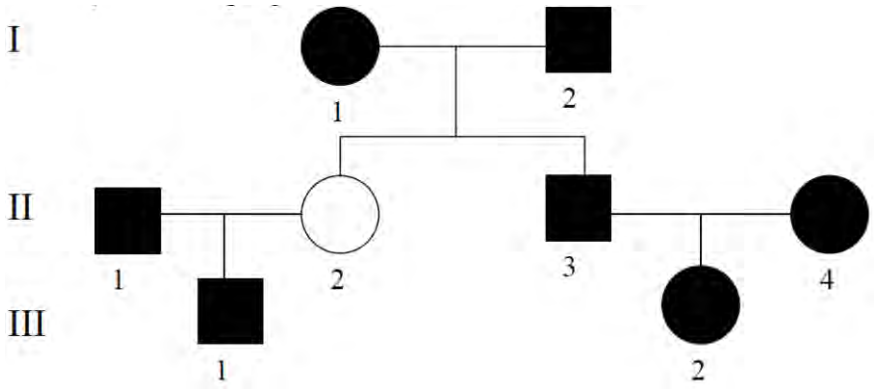
有關 creepers 和正常性狀的遺傳基礎，最簡單的解釋為何？對的請打勾(✓)，錯的請打叉(✗)。(0.6 分)

36.2. Indicate the correct phenotype of chickens carrying two creeper alleles with a tick (✓) and incorrect phenotypes with a cross (✗). (0.5 points)

若一隻雞帶有 2 個 creeper 等位基因，則關於其表現型，對的請打勾(✓)，錯的請打叉(✗)。(0.5 分)

37. The black hair of guinea pigs is produced by a dominant gene B and white by its recessive allele b. Assume that II1 and II4 do not carry the recessive allele.

天竺鼠的黑色毛由顯性 B 等位基因產生，白色毛則是由隱性 b 等位基因決定。假設下圖中的 II1 and II4 不帶有隱性 b 等位基因。



37.1. What is the probability of II3 being heterozygous? (1 point)

II3 是異結合型的機率是多少？(1 分)

37.2. What is the probability that one particular offspring of III1 x III2 will have white hair? (1 point)

III1 x III2 的子代是白色毛的機率是多少？(1 分)

38. Some allele combinations can result in a particular mental disorder in humans. The Table shows the enzyme activities of different genotypes (reported as percentage of the normal activity).

一種人類精神異常疾病與一個特定基因有關，此基因可表現出一個特定的酵素，不同缺失等位基因的組合會影響酵素活性(如下表所示是各種等位基因組合時，缺失酵素活性與正常酵素相比的百分比)，而某些缺失等位基因組合會導致此精神疾病。

Allele 2 等位基因 2	Allele 1 等位基因 1							
	R231X	P292L	R407W	IVS-12	E290K	R158Q	R271Q	Y424C
R231X	<1							
P292L	<1	<1						
R407W	<1	<1	<1					
IVS-12	<1	<1	<1	<1				
E290K				~2	<3			
R158Q					~6.5	10		
R271Q					**X**	~20	30	
Y424C						**Y**	40	50

All individuals homozygous or heterozygous for any combination of the first 5 alleles listed above exhibit the classical symptoms of the disease. Individuals heterozygous between Y424C and any of the first four alleles however have mild symptoms. R158Q/R158Q homozygous show classical symptoms of the disease, while R271Q/R271Q homozygous and R271Q/Y424C heterozygous have mild symptoms.

含前 5 種等位基因的人，無論是同結合型或是此 5 種等位基因間任一組合的異結合型，都表現出典型症狀；具 Y424C 等位基因與前 4 種等位基因任一者的異結合型，則表現出輕微症狀；R158Q/R158Q 同結合型表現典型症狀；R271Q/R271Q 同結合型和 R271Q/Y424C 異結合型則表現輕微症狀。

38.1. What is the enzyme activity in individuals for genotype combinations marked by X (R271Q/E290K) and Y (Y424C/ R158Q)? (2 points)

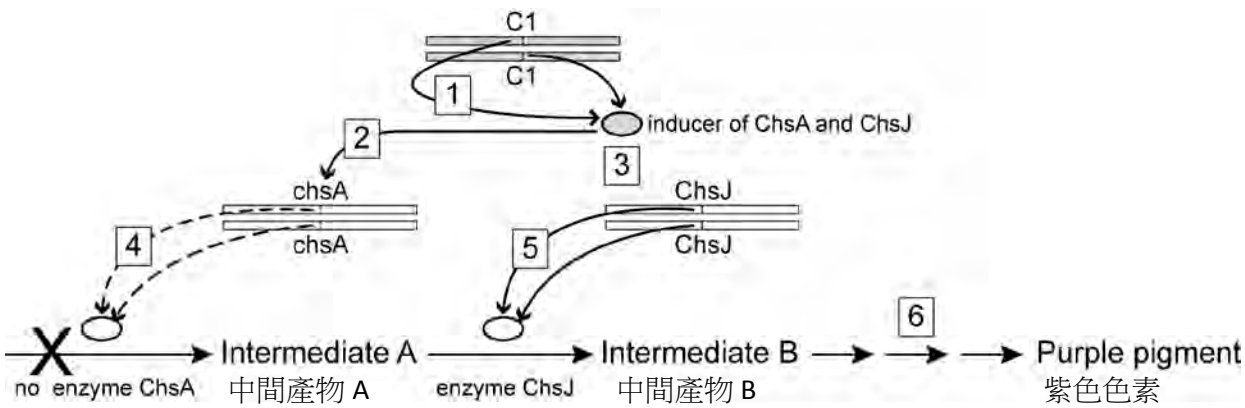
基因型 X (R271Q/E290K)和基因型 Y(Y424C/ R158Q)的酵素活性分別為何？(2 分)

38.2. What is the critical range defining those with classical symptoms from those with mild symptoms? (1 point)

區隔典型症狀和輕微症狀的酵素活性界限可能位在哪個範圍內？(1 分)

39. In a particular crop plant, several genes govern the production of anthocyanin. In the absence of anthocyanin, the seedling leaves show only green chlorophyll pigmentation. In the presence of anthocyanin, the seedlings have a purple cast on top of the green coloration. A gene locus called *Colourless 1* (C1) appears to function as a transacting inducer locus for at least two other loci (*ChsA* and *ChsJ*) that encode two enzymes in the pathway for anthocyanin synthesis (see figure below). The pathway for anthocyanin is blocked in homozygous recessive genotypes as shown for *chsA* in the figure. Assume the following conditions exist: (i) independent assortment applies to all three loci; and (ii) homozygosity for the recessive alleles at any of the three loci causes green seedlings.
在玉米植物中，數個基因控制花青素的產生。沒有花青素時，幼苗葉片只含綠色葉綠素；有花青素時，則在綠色中帶有紫色。有一名為 *Colourless 1* (*C1*)的基因，可表現出一個活化因子，此活化因子可活化 *ChsA* 和 *ChsJ* 基因的表現，*ChsA* 和 *ChsJ* 基因的產物是參與花青素合成過程的酵素(詳如下圖)。圖中舉例隱性突變 *chsA* 同結合型會中斷花青素的合成。假設下列 2 條件成立：(i) 上述三基因的遺傳為獨立分配自由組合，(ii) 任一基因若為隱性同結合型時，只產生綠色幼苗。

Indicate the expected phenotypic progeny ratios for the two crosses listed in the table **in the Answer Sheet** with a tick (✓) and inappropriate ones with a cross (×). (2.0 points)
對答案卷上的二種雜交組合，請分別指出其子代中表現型的比例，對的請打勾(✓)，錯的請打叉(×)。(2 分)



40. The marsupial moles (order Notoryctemorphia) inhabit the sandy desert regions of South Australia, Western Australia and the Northern territory. They tunnel through the sand, filling in the tunnel behind them and giving the appearance of "swimming" through the sand. The eyes of the marsupial mole are completely covered by skin, measure about 1 mm in diameter and lack a lens or pupil. The optic nerve is greatly reduced. Indicate the correct statement(s) (a – c) with a tick (✓) and incorrect statement(s) with a cross (✗). (0.6 points)

袋鼴(*Notoryctemorphia* 目)居住在南澳、西澳及北領地等處之沙質沙漠。牠們在沙裡鑽洞時，後方之沙隨即淹沒，使牠們看似在沙中游泳。此類動物的眼睛係完全包埋於皮膚下，直徑 1 毫米，無水晶體和瞳孔，視覺神經極度退化。下列有關其眼睛演化的敘述，對的請打勾(✓)，錯的請打叉(✗)。(1 分)

a. The lack of a lens is homologous to the lack of ommatidia in cave flies

袋鼴的眼睛缺少水晶體與洞穴蠅缺少小眼係屬同源演化。

b. The greatly reduced optic nerve is a vestigial (rudimentary) structure

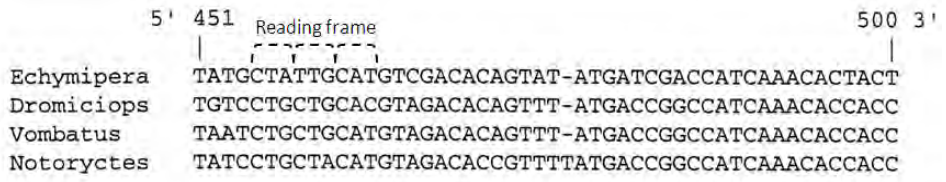
極度退化的視覺神經是一個殘留構造。

c. The eyes of the marsupial moles are analogous to the eyes of kangaroos

袋鼴的眼睛與袋鼠的眼睛係屬同功演化。

41. Interphotoreceptor retinoid binding protein (IRBP) is a single-copy gene, the product of which plays a role in the regeneration of rhodopsin in the visual cycle in mammals. This gene was sequenced in several marsupials and the resulting sequences were aligned for comparison. A portion of the sequence of the coding strand of IRBP is shown below. Note that this is not the beginning of the gene and that the correct reading frame has been indicated.

內生光受體 retinoid bindin protein (IRBP)由單一基因表現，它參與哺乳動物視覺循環中視紫質的再生成。不同種袋鼬的 IRBP 基因已被定序比較，其中部分的密碼股(coding strand)序列比較如下圖所示，注意：此非基因的起始點，而轉譯框架(reading frame)如圖中標示。



41.1. Starting with the codon involving the frameshift mutation, write down three consecutive amino acids coded for by this gene for *Vombatus* and *Notoryctes.* Use the genetic code table provided in **Question 1**. (1.8 points)

依據第 1 題的遺傳密碼表，自轉譯框架位移突變處(frameshift mutation) 開始，分別寫出在 *Vombatus* 和 *Notoryctes* 中的連續三個胺基酸序列。(1.8 分)

41.2. Indicate true statement(s) with a tick (✓), false statement(s) with a cross (×) and inconclusive statement(s) that cannot be concluded with a dash (-). (0.9 point)
下列各敘述，對的請打勾(✓)，錯的請打叉(×)，無法下定論的請畫短線(-)。(0.9 分)

Compared with that of Vombatus, the protein product of the IRBP gene in Notoryctes will:
與 Vombatus 的 IRBP 相比，Notoryctes 的 IRBP

a. contain multiple amino acid substitutions.
具有多個胺基酸被替換成其他胺基酸。

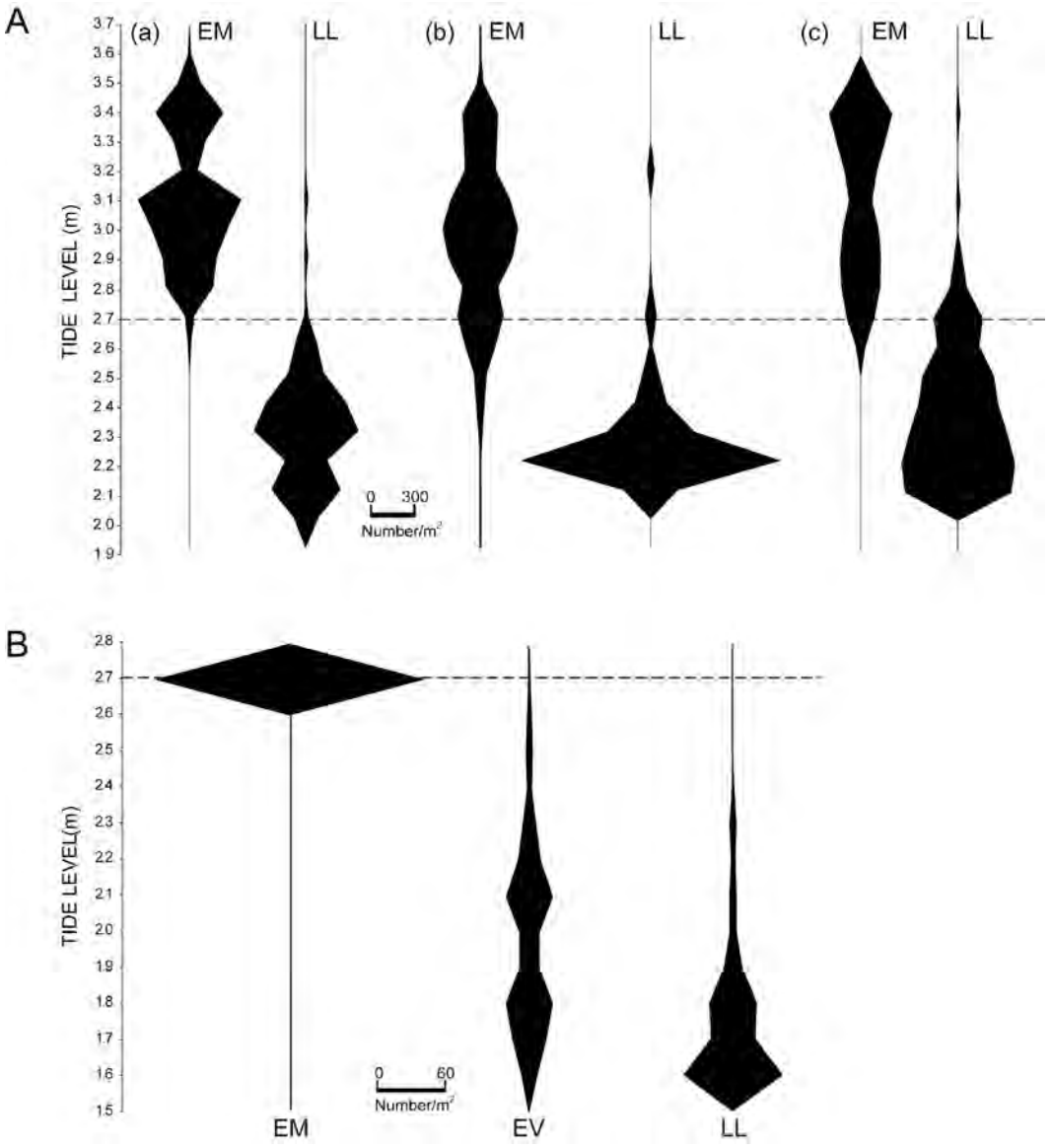
b. not begin to be translated as it lacks a START codon.
因為缺少一個起始 START 密碼，所以不會被轉譯。

c. be truncated as it contains a STOP codon at an earlier point.
因為帶有一個停止 STOP 密碼，所以會提早結束轉譯。

ECOLOGY

42. The zonation patterns of littorinid snails on the rocky shores in Singapore were studied at a vertical cliff and a sloping rock. Two taxa of littorinids were found on the vertical cliff (see A) and an additional species was found on the sloping rock(see B). The snail distribution was recorded in July, September and December 2002 (see A) when the mean temperatures of the rock surfaces were 42 °C, 34 °C and 27 °C respectively.

研究新加坡岩岸潮間帶螺在垂直岩壁及有坡度岩石的分布型態，結果顯示有兩種潮間帶螺出現在垂直岩壁(參考圖A)，而在有坡度岩石處又多記錄一種(參考圖B)。螺的分布是在 2002 年 7、9、12 月分所記錄(參考圖A)，當時岩石表面的平均溫度分別是 42 °C, 34 °C 及 27 °C 。



Kite diagram showing the distributions of littorinid species on (A) a vertical cliff: (a) July, (b) September, (c) December 2002; (B) a sloping rock.

上圖顯示不同種的潮間帶螺在垂直岩壁(A)以及有坡度的岩石(B)的分布。(a)7 月 (b)9 月 (c)12 月

"－－－·" Mean High Water Spring (MHWS) tide level. 春季平均高潮線

EM: *Echinolittorina malaccana*; EV: *E. vidua*; LL: *Littoraria* sp.;

Tide level(m)：潮水位(公尺)

42.1. Indicate correct conclusion(s) about the distribution patterns of the littorinids with a tick (✓), incorrect conclusion(s) with a cross (✗) and inconclusive statement(s) that cannot be concluded with a dash (-). (2 points)

下列有關潮間帶螺分布型態的敘述，正確者以打勾(✓)表示， 錯誤者以打叉(✗)表示，不確定者以減號 (-)表示。(2 分)

a. Sampling period has no influence on distribution pattern of the two littorinid taxa at the vertical cliff.

在垂直岩壁上，取樣時間對二種潮間帶螺的分布並無影響

b. *Echinolittorina vidua* and *Littoraria* sp. have similar zones of distribution.

EV 和 LL 具有相同的分布區域

c. The upper limits of the *Echinolittorina malaccana* zone at the vertical cliff were constant regardless of sampling period.

EM 在垂直岩壁上高度分布的上限是固定的，不受取樣時間的影響

d. The preferred zone of occupation of *Echinolittorina malaccana* is smaller than that of *Littoraria* sp. at the sloping rock.

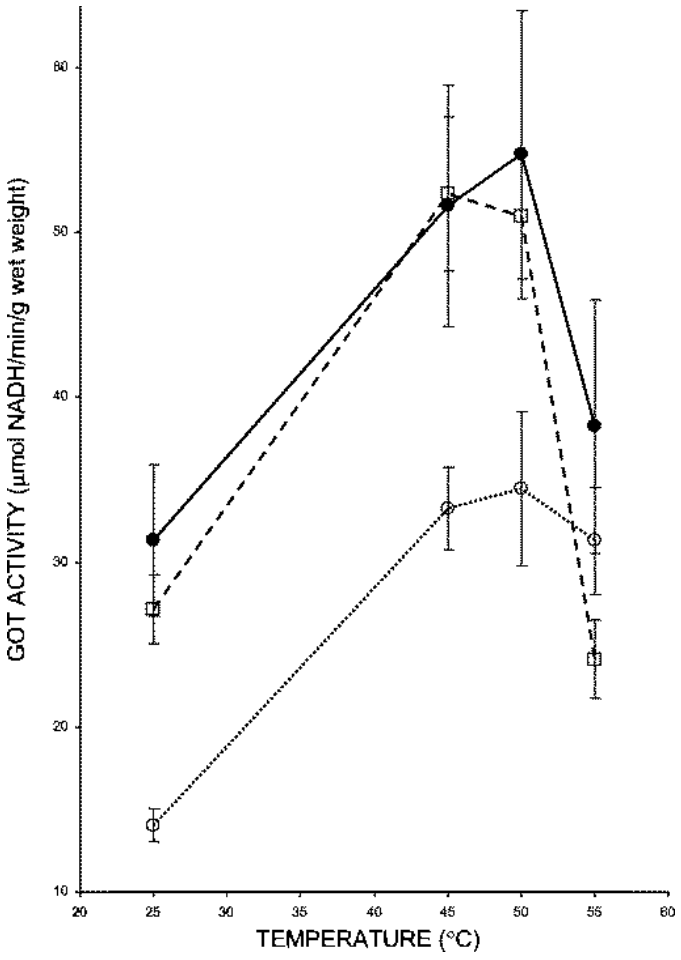
在有坡度的岩石上，EM 所喜好的分布區域小於 LL

e. *Echinolittorina vidua* is less heat-tolerant than its sympatric species, *E. malaccana*.

EV 與共域的 EM.相較，牠對熱的容忍度較低

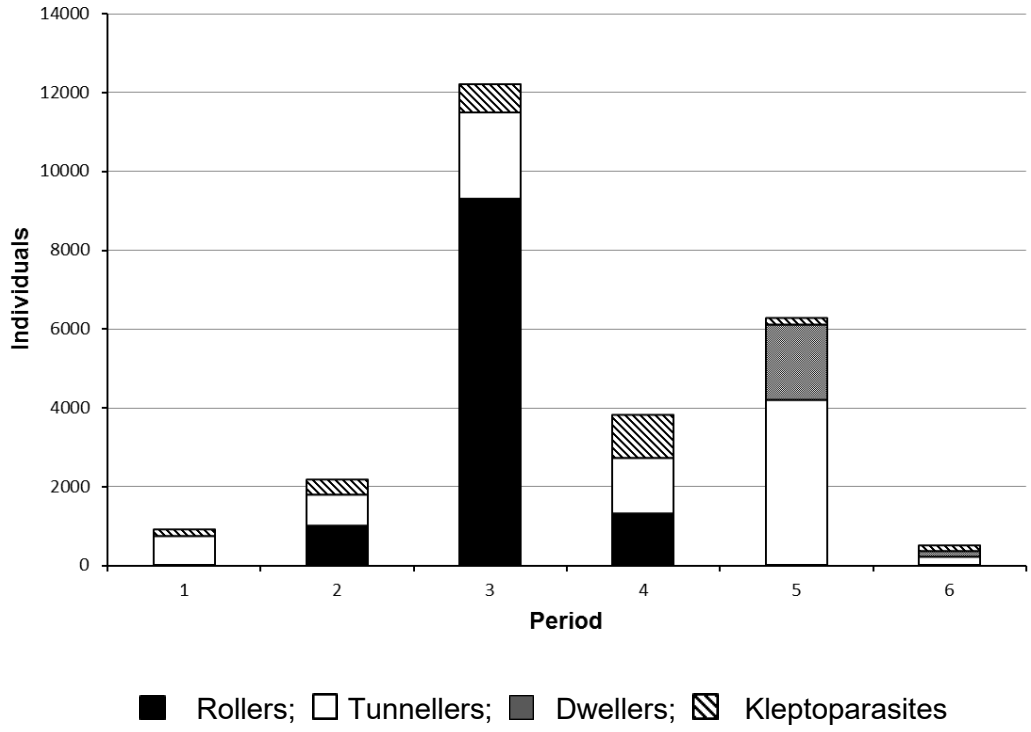
42.2. Snails were collected from the field and extracts of six tissue samples of each of the three littorinid taxa were incubated separately at different temperatures. Glutamate oxaloacetate transaminase (GOT) activity was determined and the results of the enzyme assays are presented in the graph below. Indicate the correct taxon (EM, EV or LL) that corresponds to the graph shown in the table **in the Answer Sheet**. (1 point)

從海邊收集此三種螺的標本，每種取出 6 個組織標本於不同的溫度下培養。測定 Glutamate oxaloacetate 轉胺酶 (GOT)的活性，其測定結果顯示於下圖。在答案卷上，針對其可能對應的酵素，填入不同的物種(EM, EV or LL)。



43. The ecology of a group of dung beetles was studied in West Africa by Krell-Westerwalbesloh et al. (2004). The beetle community was divided into four categories: (i) rollers, (ii) tunnellers, (iii) dwellers, and (iv) obligatory kleptoparasites. The rollers rapidly form balls from the faeces (in < 1 hour), roll them away from the food source, and deposit them in or on the soil to ensure exclusive use of the dung. The tunnellers make nests directly under the food source and transport dung into the nest where they form dung balls (≈ a few hours). Dwellers feed and reproduce directly in the dung pat. Kleptoparasites use faeces portions monopolised by other groups, e.g., by penetrating dung balls made by the rollers or the dung mass in the subterranean nests of the tunnellers. The abundance (see Table) and flight activity (see Figure) of these beetles (pooled data of 15 samples) at six different periods of the day were recorded.
Krell-Westerwalbesloh et al. (2004)在西非研究一群糞金龜的生態，此甲蟲群落分成四類(i)翻滾類(rollers)、(ii)鑽洞類(tunnellers)、(iii)原地居住類(dwellers)以及(iv)打劫維生類(obligatory kleptoparasites)。翻滾類快速地從糞便處將糞做成糞球 (在 1 小時內)，而後將其推滾離開食物資源，將糞球存於土壤表面或土中，以利完全使用糞球。鑽洞類直接在食物資源的下方築巢，將糞運送至巢內，在此形成糞球 (大約幾小時)。原地居住類在糞塊處直接取食及繁殖。打劫維生類搶奪其他類群具有的糞便資源，如鑽入翻滾類所形成的糞球或進入鑽洞類的地道利用其糞塊。經由一天 6 個時段的觀察，及綜合 15 個樣本的資料，得知各種甲蟲的豐度(參閱表) 及移動活動(參閱圖)的情形。

Period	1		2		3		4		5		6	
	0200-0600 h		0600-1000 h		1000-1400 h		1400-1800 h		1800-2200 h		2200-0200 h	
	N	%	N	%	N	%	N	%	N	%	N	%
Dwellers	51	6.46	31	1.45	4	0.03	78	2.09	1795	27.91	172	48.45
Obligatory kleptoparasites	51	6.46	536	25.01	1351	10.87	1230	33.00	253	3.93	24	6.76
Rollers	34	4.30	997	46.52	8559	68.87	1243	33.35	22	0.34	45	12.68
Tunnellers	654	82.78	579	27.02	2514	20.23	1176	31.55	4362	67.82	114	32.11



Indicate correct conclusion(s) that can be drawn from the study with a tick (✓), incorrect conclusion(s) with a cross (×) and inconclusive statement(s) that cannot concluded with a dash (-). (1.8 points)

下列敘述，正確者以打勾(✓)表示， 錯誤者以打叉(×)表示，不確定者以減號 (-)表示。(1.8 分)

a. There is intense competition in the dung beetle community.
在糞金龜的群落中，存在激烈的競爭

b. Rollers dominate the community of dung beetles.
翻滾類是糞金龜群落中的優勢者

c. The four groups of dung beetles cannot co-exist as they all exploit the same resource in similar ways.
四類糞金龜用同樣方式取用相同資源，因此不能共存

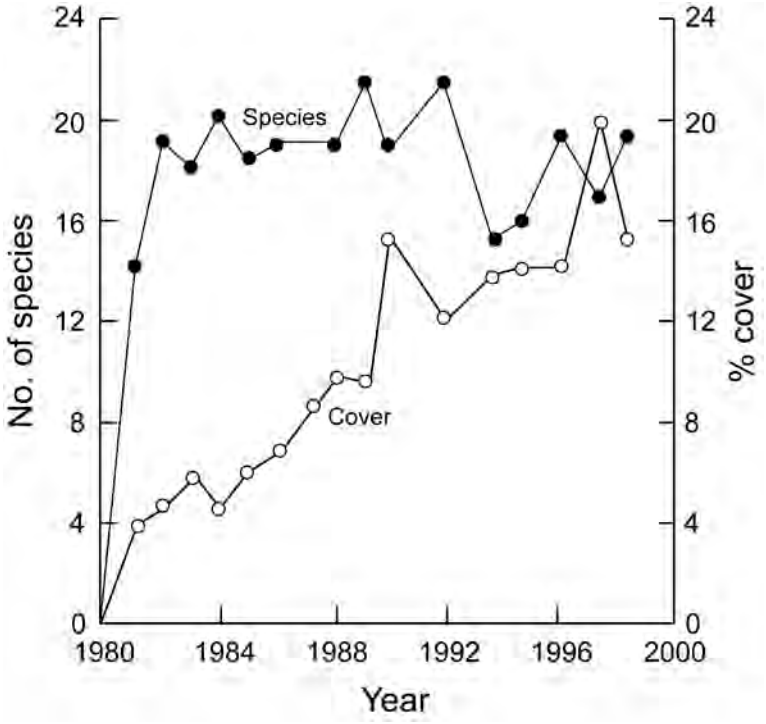
d. One or more of the groups will eventually be out-competed and eliminated in the community.
在此群落中，一種或一種以上的種類最終將無法與他種競爭而遭到淘汰

e. The results of this study support the principle of competitive exclusion and provide evidence for resource partitioning.
此結果支持競爭排他原理，並對資源的分隔提供證據

f. The 'realized niche' of each group is similar to their respective 'fundamental niche'.
每種類型的實際棲位(realized niche) 與其對應的基礎棲位(fundamental niche)是相同的

44. Mount St Helens in southwest Washington state (USA) erupted catastrophically on May 18, 1980. The eruption produced a landscape with low nutrient availability, intense drought and frequent surface movements. Permanent plots were established at several sites above the treeline around the crater to monitor recovery after the eruption. The figure below shows the number of species and percentage cover at one of the sites from 1981 to 1998.

聖海倫火山在美國華盛頓州西南處，於 1980 年 5 月 18 日爆發，爆發後造成一種艱困的地貌，可用的營養鹽少、極度乾旱以及經常的地表移動。在火山口附近超過樹所分布的高度(森林線)選擇了幾處設立了永久樣區，來監測火山爆發後的復原情形。下圖為 1981~1998 年在某一監測處植物種類數及植物覆蓋度的變化情形。



Indicate the correct conclusion(s) that can be drawn from the figure above with a tick (✓) and incorrect conclusion(s) with a cross (×). (1.2 points)

下列敘述，正確者以打勾(✓)表示， 錯誤者以打叉(×)表示。(1.2 分)

a. The eruption killed all of the vegetation above the treeline.

火山爆發時將森林線(treeline)以上的所有植物皆殺死

b. Secondary succession occurred rapidly after the eruption.

火山爆發後， 次級消長快速進行

c. Neither space nor light are limiting resources for plants in this environment.

在此環境中空間與光線皆非限制植物生長的因子

d. Only a few additional species invaded after 1982.

在 1982 年以後，只有少數幾種新加入的種類入侵

e. Total plant cover in this area has increased relatively slowly due to harsh conditions on the volcanic deposits.

由於火山爆發物沉積造成艱困的環境，故此環境中植被覆蓋度的增加相對地緩慢

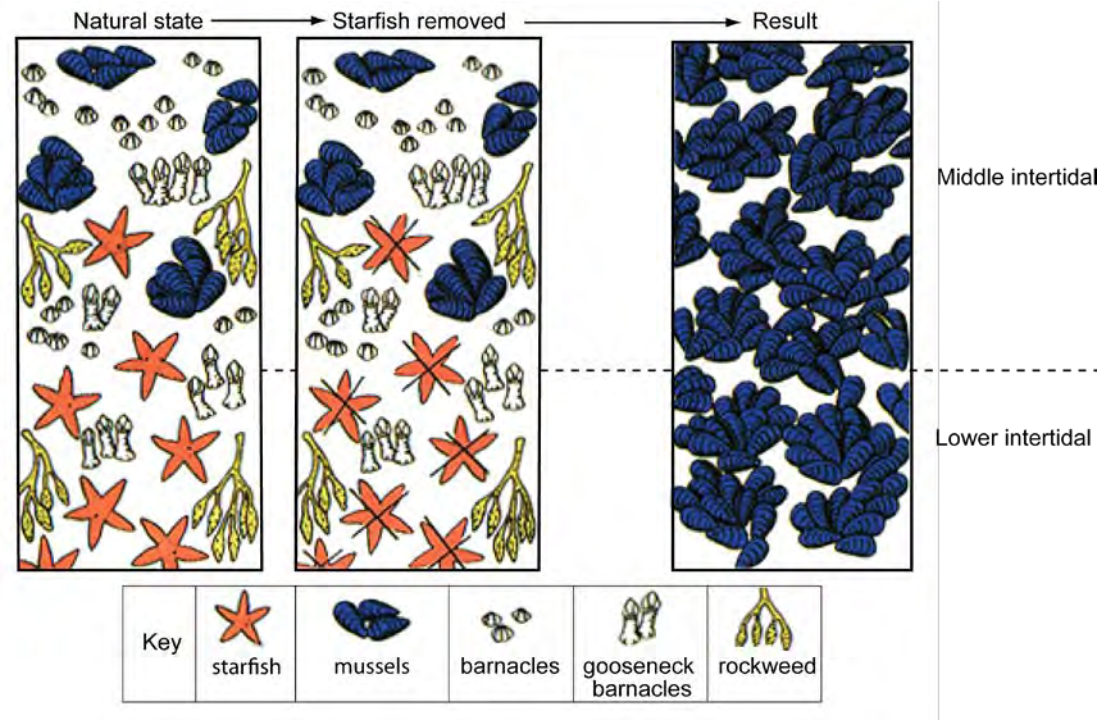
f. A stable plant community of 20 species has been reached at the study site indicating ~~that~~ the climax stage in the succession process.

當研究地點的植物達到 20 種植物的穩定群落時，顯示此處已達到消長過程的極相

45. The schematic figure below shows a simulation of a marine community done with the objective to study the relationships between its populations.

下列示意圖為研究族群間的關係所作的海洋群落模擬圖

自然狀態 海星移除 結果



海星 貽貝 藤壺 鵝頸藤壺 海藻

Starfish-Asteroidea; Mussels-Lamellibranchia; Barnacles-Cirripedia; Gooseneck barnacle-Cirripedia; Rockweed-Phaeophyta

Based on the above figure, indicate correct statement(s) with a tick (✓) and incorrect statement(s) with a cross (×). (1.8 points)

根據上圖判斷，下列敘述，正確者以打勾(✓)表示， 錯誤者以打叉(×)表示。(1.8 分)

a. The community, in its natural state, includes four species of the Kingdom Animalia.

在自然環境，此群落包括動物界 4 種物種

b. All the animals of this community have three germ layers and are deuterostomates.

在此群落中，所有的動物皆有三個胚層並皆是後口動物

c. Phyla of animals represented here are Echinodermata, Mollusca and Arthropoda.

在此具有的動物分屬棘皮動物門、軟體動物門及節肢動物門

d. In their natural environment, starfish is a keystone species

在此自然環境，海星為關鍵種

e. In their natural environment, mussel density is larger in the middle intertidal zone than in the lower intertidal zone because starfish live in the lower intertidal zone.

在此自然環境，貽貝在中潮間帶的密度大於低潮間帶的原因是：海星居住在低潮間帶

f. At the end of the study, the community collapses and only one population increases its ecological niche.

在研究結束後，此群落瓦解，只有一種族群增加了牠的生態棲位

g. The competitive exclusion of the other populations by the mussels was demonstrated.

此實驗驗證了貽貝藉由競爭排除了其他物種的族群

h. Mussels occupy the fundamental niche including both the middle intertidal zone and lower intertidal zone.

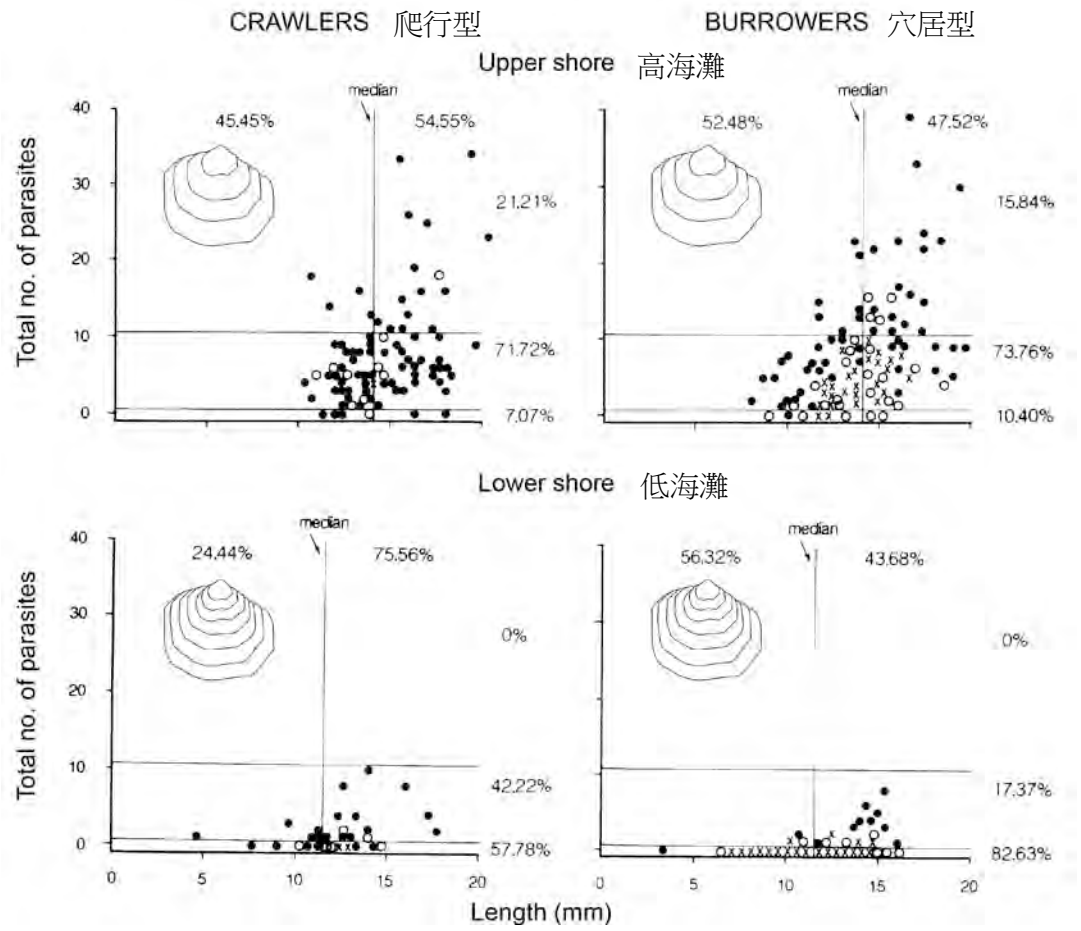
貽貝佔有基礎棲位包括中潮間帶及低潮間帶

i. Natural conditions include biotic interactions like inter-specific competition and predation.

自然狀態包括生物間之交互作用如不同種間的競爭和掠食

46. Growth rate of most intertidal organisms generally declines in an upshore direction. Lim and Green (1991) studied a population of the Baltic clam *Macoma balthica* (a common bivalve), from two levels of the shore at Hudson Bay, Canada. Annual shell growth rings are distinct in the two sub-populations (see figure below) and the clams from the two zones do not differ genetically. The Baltic clam normally buries itself and is generally hidden from predators. It is the intermediate host to trematodes; the daughter sporocysts of the parasites are found mainly in the gonads of the clam, causing partial or total disappearance of the gonads. Shorebirds, the definitive host of these trematodes, are present in large numbers at the upper shore during ebb tide. The clams in Hudson Bay have been observed to make conspicuous tracks on the sand flats at ebb tide. The number of metacercariae (the next stage in the parasite's life cycle) encysted on the inner shell surface of crawling and burrowing clams from the two shore regions were counted.

大多數的潮間帶動物生長率一般隨其生活處的高度而遞減。 Lim 及 Green (1991) 研究一種常見的雙枚貝稱為 波羅的海貝 (*Macoma balthica*) 分布在加拿大哈德遜灣海岸的族群, 又因其分布於兩個不同高潮位而細分為兩個次族群。 貝 殼上的年生長環在此兩個不同的次族群間有明顯差異 (參閱下圖) , 但牠們的遺傳特徵並無差異。波羅的海貝通常為穴居, 埋在泥沙中來躲過天敵, 牠是吸蟲類的中間宿主; 而此寄生蟲的子代孢狀幼蟲主要出現在 此貝類 的卵巢中, 造成卵巢部分或全部消失。此吸蟲的終寄主為潮間帶的鳥, 會在退潮時 大量聚集在海灘的高處。此外, 退潮時哈德遜灣的 波羅的海貝也會在沙灘上爬行並留下明顯的痕跡。為比較爬行型與穴居型之 波羅的海貝在高、低兩處海灘的個體之差異, 研究人員對寄生於此貝類殼的內表面之囊狀幼蟲(此吸蟲生活史的下一階段)之數目進行計算。結果如下圖:



Symbols represent number of clams: ○, 1; ●, 2; x, ≥ 3. The vertical line divides clams that were smaller and larger than their median length at their respective tidal level.

圖中的符號代表貝類的數目: ○, 1; ●, 2; x, ≥ 3。直線將貝類依其中間數的長度分為小型及大型個體。

Indicate valid conclusion(s) about the behaviour and biology of the Baltic clam with a tick (✓) and invalid conclusion(s) with a cross (✗). (2.8 points)

判斷下列有關 波羅的海貝 的敘述: 正確者以(✓)代表; 錯誤者以(✗)代表

a. The growth rate of *Macoma balthica* in Hudson Bay conforms to the general rule observed for most intertidal organisms that lower intertidal organisms grow faster than those at the upper shore.

   在哈德遜灣的 波羅的海貝之生長率符合一般在潮間帶所觀察的規則, 即在低處生活的個體長得比高處者要快

b. A relatively higher proportion of clams was parasitized higher up the shore.

   生活在越高處潮區的貝類被寄生的比例相對高於生活在低處者

c. Crawling behaviour of the clams could enhance the completion of the parasite's life cycle.

貝類的爬行行為有助於寄生蟲完成其生活史

d. Clams that are buried in the sand generally have more metacercaria cysts regardless of shore level.

不論海灘高低, 埋藏在沙中的貝類通常有較多的囊狀幼蟲

e. Increased exposure of the clams at the upper shore to shorebirds, the final host of the trematodes, could probably account for the difference in parasite load between the two sub-populations.

在高海灘生活的貝類, 其與潮間帶活動鳥類(即吸蟲最終寄主)的接觸增加, 可能會造成此二種次族群之貝類遭寄生蟲感染量的差異

f. High parasite load promotes increased somatic growth as reproductive output is reduced due to host castration by the trematodes.

高寄生蟲感染量促使貝類的個體長大, 係因吸蟲使寄主喪失生殖能力, 生殖投資下降所致

g. Environmental factors probably played a greater role in determining clam growth rate of the sub-populations than heredity.

環境因子可能對貝類在不同次族群之生長率表現的影響明顯的大於遺傳

BIOSYSTEMATICS 生物系統分類學

47. Match the following characteristic features with the correct organisms. (1.2 points)

將下列特徵對應到正確的生物

Features: 特徵

I. book lung, claws formerly made of three parts, but now reduced to only two, gizzard

具書肺; 原先由 3 部分所組成但現在退化僅剩 2 部分的螯爪; 砂囊

II. reduced ribs, undergoes a metamorphosis during ontogenesis

退化的肋骨; 在個體發生時進行變態

III. hind extremities covered with scales, respiration organ using ventillating air bags, movable upper jaw (maxilla) and lower jaw (mandibula)

後肢末端有鱗片覆蓋; 以通風氣囊作為呼吸器官; 可移動的上顎及下顎

IV. thin, tube-like excretion organs ending between mid- and hind-gut, body made of three parts (tagmata), a pair of antennae.

細管狀的排泄器官, 且開口位在中腸與後腸之間; 軀體(tagmata)分為三部分; 具一對觸角

V. specialized epithelic muscle cells, nettle cells, radial symmetric body

特化的上皮肌肉細胞; 刺絲胞; 體制輻射對稱

VI. uses ampullae of Lorenzini to sense electric fields and temperature differences, cartilage skeleton, spiraculum

利用羅蘭氏囊來感覺電子磁場及溫度差異; 軟骨; 通氣孔

Organisms:

a. white shark (*Carcharodon carcharias*) 白鯊

b. house fly (*Musca domestica*) 蒼蠅

c. bird, common redstart (*Phoenicurus phoenicurus*) 水鶇

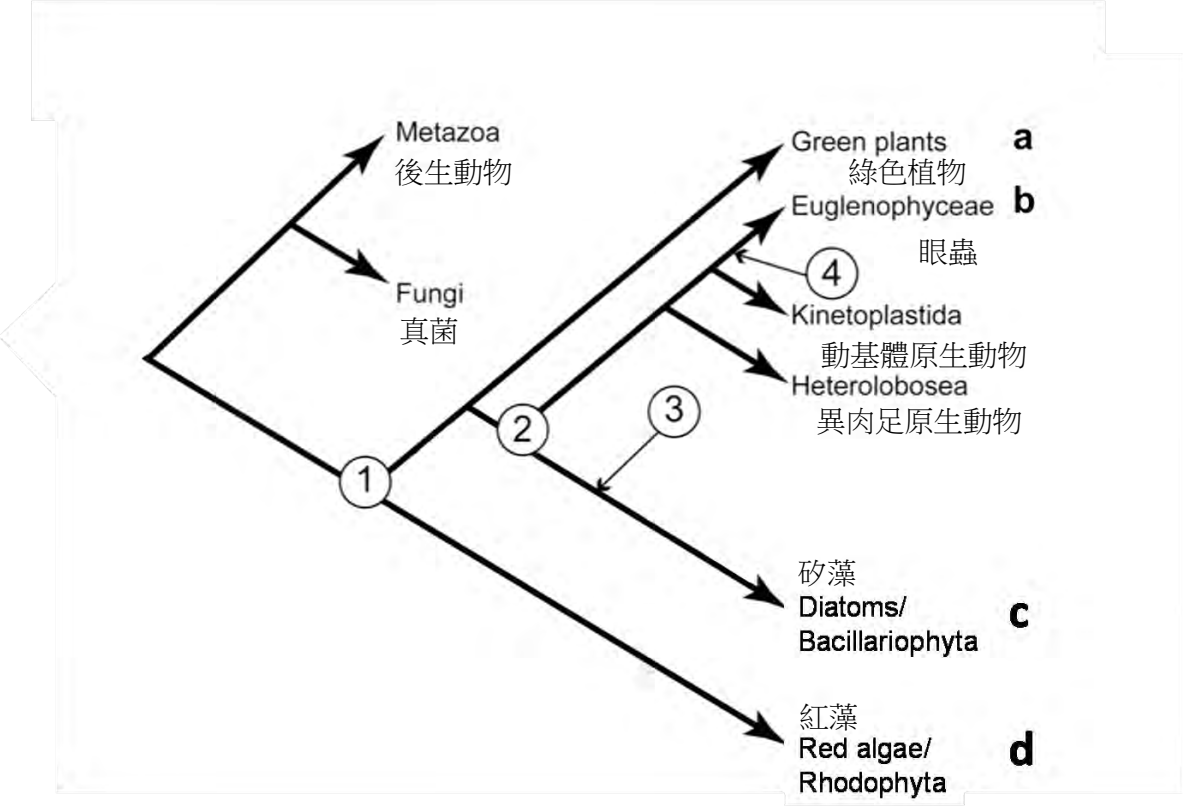
d. brain corals (Faviidae) 腦紋珊瑚

e. european garden spider (*Araneus diadematus*) 蜘蛛

f. common frog (*Rana temporaria*) 青蛙

48. One of the known hypothesis of the origin and evolution of plastids is shown in the Figure below.

下圖為質體(plastids)之起源及演化的假說:



The processes that facilitated evolution are represented by the numbers (1 to 4) in the diagram above: (1) for primary endosymbiosis, (2) for loss of primary plastids, (3) and (4) for secondary endosymbiosis. These processes resulted in the presence or absence of certain plastids in various taxa.

上圖中的數字(1 ~4)代表所發生的演化事件, 分別為: (1)初級的內共生現象; (2)喪失初級的質體; (3) 及 (4) 次級的內共生現象。這些過程導致在不同分類群中出現具有或缺乏部分質體。

Match the taxa (a – d) with the corresponding type of plastids **in the Answer Sheet**. (1.2 points)

在答案紙上將分類群(a – d)與不同種質體作示當配對

49. Cladistic systematic researchers apply comparisons among groups in order to differentiate derivative characters and shared primitive characters. In doing this, they use an external group, closely related with the one they are studying.

支序系統分類的研究人員用類群間的比較來區別後裔衍生特徵及共享原始祖先型特徵。他們還用一個與所研究的材料親源相近的類群來當作 外群 。

Condition: The external group is less related to any member of the studied group than the members of the last one are between themselves.

條件: 外群 是比所研究對象中的任何成員彼此之親源關係 都較不相近的類群

Supposition: The primitive characters that precede the divergence of both groups are homologies.

假設: 所有參與分歧為兩群的原始祖先型特徵 皆屬於同源性特徵。

Taking into account these theoretical concepts, some researchers studied a group and the information they obtained is presented in the following table.

基於上述理論概念, 研究人員將所研究類群的特徵資料列如下表中。

	Animals represented by double digit codes 雙編碼的動物種類					
Characters 特徵	A1	A2	A3	A4	A5	A6
a. Hair 毛髮	0	0	0	0	1	0
b. Amniotic egg with extra embryonic membranes 多了額外的胚膜之 羊膜卵	0	1	0	0	1	0
c. Four legs for locomotion 以四肢運動	0	1	0	0	1	1
d. Jointed jaws 下顎具關節	0	1	1	0	1	1
e. Vertebral spine 脊椎	0	1	1	1	1	1
f. Notocord 脊索	1	1	1	1	1	1

Note: 0: absence of character; 1: presence of character

注意: 表中的 0 代表沒有該特徵; 1 代表具有該特徵

49.1. After analyzing the information above, identify the external group. (0.2 points)

經由分析上表之資訊後, 指出哪一個動物編碼是 外群?

49.2. Identify the characters (a – f) that are shared between the external and internal groups. (0.2 points) 哪個特徵(a – f)是 外群 與研究的內群 所共有的?

49.3. Identify the primitive character present in all members of the internal group alone. (0.2 points)

指出僅在 內群 中的所有成員共同具有的一個原始特徵

49.4. Identify the last point of divergence of the cladogram given in the Answer Sheet using the most appropriate character. (0.2 points)

指出在答案紙上的支序圖中最後分歧點的特徵, 寫出一最適當者。

49.5. Fill in the cladogram which best represents the relationships between A1 to A6 was derived using the information analyzed. **In the Answer Sheet**. (1.8 points)

根據所分析的資訊, 最能代表物種A1 ~ A6 之親緣關係的支序圖如答案紙上所示, 在空格中填入物種的編碼。

END OF PAPER