IBO 2018

Tehran, Iran

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Theory A

VIEW SUMMARY

Introduction 介紹

General Remarks 一般說明

Total time is 3 hours. You will find a personal clock counting backwards on top of the screen.

You can **choose your language** using the drop-down menu on the top right.

Raise your flag to draw the attention of the staff.

The following **marking scheme** will be applied:

總時間為3小時。你將在螢幕頂端找到一個倒數計時的個人時鐘。

你可以使用右上角的下拉選單**選擇語言** 。

如有問題，舉起旗子以引起工作人員的注意。

將採用以下**記分方案** ：

Questions with four statements 有四個陳述的問題

Number of correct statements正確的敘述數目	**0**	**1**	**2**	**3**	**4**
Points 分數	0.0	0.0	0.0	0.5	1.0

Questions with five statements 有五個陳述的問題

Number of correct statements 正確的敘述數目	**0**	**1**	**2**	**3**	**4**	**5**
Points 分數	0.00	0.00	0.00	0.25	0.75	1.25

Note: there is no negative marking. Try to answer as many questions as possible.
注意：沒有倒扣。請儘可能回答問題。

Biochemistry & Molecular biologyg
生物化學與分子 生物學

Q. 1 Pathway Reconstruction
代謝途徑的重建

Compounds X and Y are precursors in the pathway of Z synthesis. Z is essential for growth. Wild type (WT) Neurospora are prototrophs, meaning that they can grow on minimal medium (MM).
化合物X和Y是合成Z的前驅物。 Z是真菌生長的必要物質。野生型(WT)的紅色麵包黴(Neurospora)是自營性營養方式，也就是它們可以在基本培養基(MM)上生長。

Growth Experiment:
Four Z- neurospora mutants were isolated, and results of experiments with these mutants are presented below (+ = growth, - = no growth).
紅色麵包黴菌生長實驗：
4株無法合成Z物質的突變株，這些突變株的實驗結果如下所示（+ = 生長， - =無法生長）。

細胞類型	**MM**	**MM + Y**	**MM + X**	**MM + Z**	在**MM**中生長期間累積的化合物
WT 野生型	+	+	+	+	
突變株1	-	-	+	+	**Y**
突變株2	-	-	-	+	X
突變株 3	-	-	-	+	X
突變株4	-	-	-	+	**Y**

Complementation Tests:
Complementation tests were performed by testing for growth of heterokaryons in minimal medium. Results were as follows (+ = growth, - = no growth).
互補測試：
互補測試是以測試異核體在基本培養基中生長來進行。結果如下（+ =生長， - =無法生長）。

	Mutant 1			
Mutant 1	-	**Mutant 2**		
Mutant 2	+	-	**Mutant 3**	
Mutant 3	+	-	-	**Mutant 4**

Mutant 4	-	-	-	-

Mating Experiment:
Mutant strains were mated and % prototrophs among spores of each mating were determined. Results were as follows.
交配實驗：
將突變株交配並測定每次交配後的子代為野生型的百分比。結果如下。

Mating	**% prototroph spores** 野生型自營性孢子
Mutant 1 x Mutant 2	25%
Mutant 1 x Mutant 3	25%
Mutant 1 x Mutant 4	0% (many spores counted) 計數了許多孢子
Mutant 2 x Mutant 3	0.004%
Mutant 2 x Mutant 4	0.001%
Mutant 3 x Mutant 4	0.001%

Indicate if each of the following statements is true or false.
指出下列敘述是對或錯

	TRUE 對	FALSE 錯
The mutations in the mutated strains were distributed in two genes 這些突變株的突變是發生在兩個不同的基因	○	○
Considering all the mutant strains, at least five different sites of the Neurospora genome were mutated in one or more strains. 考量全部的紅色麵包黴突變株，於紅色麵包黴基因體至少有5個位點發生突變	○	○
At least two of the mutant strains were double mutants (i.e. > 1 site was mutated in each of these strains). 至少有兩個突變株是雙位點突變	○	○
The mutation site of Mutant 3 is positioned between the mutation site in Mutant 2 and the 的mutation site in Mutant 4. 突變株3的突變位點是介於突變株2與突變株4的突變位點之間	○	○
It is expected that 25 % of spores resulting from mating between Mutant 2 and wild type strain will be prototrophs. 突變株 2 與突變株 3 交配後的子代，可預期25%孢子是野生型	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 2 DNA Barcoding DNA生命條碼

Taxonomy has traditionally been based on morphology. DNA Barcoding is a new approach that aims to allow accurate and relatively simple species identification based on the nucleotide sequence of a 650-bp fragment of the mitochondrial COI gene. The Kimura-2 parameter (K2P) distance is a widely accepted index that reflects the divergence between two DNA sequences.

基礎分類學傳統上是根據形態特徵建構而成的。生命條碼的概念是使用粒線體DNA中的過氧化氫酶COI基因，大約650bp來鑑定物種。Kimura-2 parameter (K2P) distance是一種拿來反映兩股DNA序列分化程度的指數。

In a study on fish inhabiting the Persian Gulf, over 150 individuals were studied that , based on morphology, represented 83 species. The average of intraspecific K2P distances based on COI sequence was calculated to be 1.15%. The average distance reported in various reputable fish studies in the world has been 0.25% - 0.45%.

這個研究先使用形態特徵來鑑定波斯灣83種魚(150個個體)，根據COI，種內的K2P distance平均為1.15%。然而在很多使用同一種方法做出來的平均分化程度是0.25-0.45%。

In a study on fish inhabiting the Gulf of Mexico, again over 150 individuals were studied. Based on morphology, these fish represented 76 species, 56 genera, 32 families, 11 orders, and 2 classes. The table below presents K2P distances between specimens at different taxonomic levels.

另外，有一個在墨西哥灣進行的近似研究也研究了超過150隻個體的魚，根據形態特徵，這150條魚代表了76個種，56個屬，32個科，11個目，與2個綱。
下表顯示這些魚以不同分類階層看待時的的K2P差異。

	No. of comparisons 被比較的分類單元數	Min. distance (%) 最小分化程度	Mean distance (%) 平均分化程度	Max Distance (%) 最大分化程度	Standard error Distance (%) 標準差
Within species 種內	185	0	0.18	1.66	0.02
Within genus 屬內	76	6.19	12	20.23	0.42
Within family 科內	888	10.88	17.43	24.56	0.08

Within order 目內	9274	14.57	21.51	28.9	0.02
Within class 綱內	3439	16.2	22.77	34.41	0.04

Indicate if each of the following statements is true or false.
指出下列敘述是對或錯

	TRUE 對	FALSE 錯
The evolutionary rate of sequence change in a DNA fragment chosen for DNA barcoding should certainly be more rapid than the evolutionary rate of change in the H4 histone encoding gene. 被拿來當成生命條碼的DNA片段的演化速率應該要比H4這種組蛋白編碼基因還要快	○	○
The high average COI intraspecific K2P distance of the Persian gulf study compared to other fish studies could be explained by existence of relatively diverged clusters within one or a few of the nominal species studied (i.e. those based on morphology). 波斯灣的魚的COI的平均種內K2P distance比其他研究大很多，這表示那些在波斯灣被研究的"魚種"內部有隱藏種。	○	○
The data in Table support the proposal that species identification of fish can be made on the basis of COI fragment sequences. 表中的數據COI片段可以拿來鑑別魚類的"物種"	○	○
Table 1 suggests that COI based barcoding is not appropriate for genus identification. 表一顯示使用COI來鑑別"屬"並不適當	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 3 Genetic Divergence 遺傳分化

Taxonomy has traditionally been based on morphology. DNA Barcoding is a new approach that aims to allow accurate and relatively simple species identification based on the nucleotide sequence of a 650-bp fragment of the mitochondrial COI gene. The Kimura-2 parameter (K2P) distance is a widely accepted index that reflects the divergence between two DNA sequences.
傳統上，分類學基於形態學。 DNA條碼是一種新方法，旨在根據粒線體COI基因的 650bp 片段的核苷酸序列進行準確和相對簡單的物種鑑定。 Kimura-2參數（K2P）距離是被廣泛接受的指數，其反映了兩個DNA序列之間的差異。

Selected results relating to 16 species from five barcoding studies from different regions of the world are presented below. Three types of divergence values were calculated, global, intraregional, and interregional distances. Global divergence which is commonly used was the average of all pairwise comparisons of sequences belonging to the same species regardless of location of origin.

底下所顯示的是來自五個全球各地區的DNA生命條碼研究結果，而這五個獨立研究都涉及一模一樣的16個物種。我們計算三種層次的分化程度：全球角度、區域間比較、還有區域內的分化。所謂的全球角度就是評估"所有屬於該物種的該段基因序列的兩兩比較"。

Intraregional divergences were calculated by averaging the distances of all sequences belonging to the same species from the same location. Finally, interregional distances were calculated by averaging all distance values obtained from comparing each of the sequences from one location with all sequences of the same species in a second location.

"區域內的分化"就是去計算來自那個區域的該物種的序列的平均分化程度。

"區域間分化"就是去比較不同區域之間同一個物種的基因序列的分化程度。

Results of three calculations (i, ii, and iii) are given below:
三種層次的計算結果如下：

i. The average standard deviation (SD) of 17 intraregional comparisons pertaining to 10 species was 0.11% (minimum: 0%; maximum: 0.3%). The SD of divergences of an 18th intraregional comparison pertaining to one of these species was 1.26%.

一模一樣的10個物種，在17個"區域內"比較的平均標準差是0.11% (最小0%, 最大0.3%)。如果第18次針對這些物種中的其中一種進行"區域內比較"，其SD是1.26%。

ii. The intraregional divergence of *Argyrops spinifer* specimens from India was 0.20%, and the interregional divergence of specimens from India and South Africa was 0.13%.

印度的長體四長棘鯛(*Argyrops spinifer)*的區域內分化程度為0.20%，但是印度與南非族群之間的分化程度為0.13%。

iii. Global divergence for *Platycephalus indicus* was 9.46%. Interregional divergences for this species were as follows:

牛尾魚(*Platycephalus indicus)*的全球分化程度為9.46%，而區域之間的分化程度請見下表

India/China 15.78%	China/Australia 12.05%
India/Australia 10.61%	China/ S Africa 16.05%
India/S Africa 4.05%	Australia/S Africa 10.95%

Indicate if each of the following statements is true or false
指出下列敘述是對或錯

	TRUE 對	FALSE 錯
The SD value of the 18th comparison in calculation i above is consistent with the suggestion that the fish compared in fact do not all belong to the same species. 第十八個比較(就是上面那個"i"的計算結果)的SD值支持"某些被拿來比較的魚隻其實並不全屬於同一種"。	○	○
The K2P divergence values reported in calculation ii is consistent with the proposal that *A. spinifer* populations of India and South Africa arose from a common source population, but that there is greater variation in the ecological niches of India as compared to South Africa . 第ii個計算中，K2P divergence的值會支持這個主張："印度與南非的高體四長棘鯛有共同的來源族群，但是印度族群的棲位多樣性高於南非族群"。	○	○
The divergence values in calculation iii show that, as compared to interregional divergence values, global divergence values are more informative of extent of divergence that exists for *P. indicus* in the world 計算iii的分化程度顯示，相較於牛尾魚的區域間分化值，全球性分化值較能說明其物種在全球的分化。	○	○
With reference to calculation iii, the difference between global divergence value (9.46%) and average of interregional divergence values (11.58) can be explained by unequal number of specimens from different regions. 根據計算iii，"不同區域間的取樣數差異" 可以解釋為何全球分化程度(9.46%)與區域間平均分化程度(11.58%)有如此大的差異。	○	○

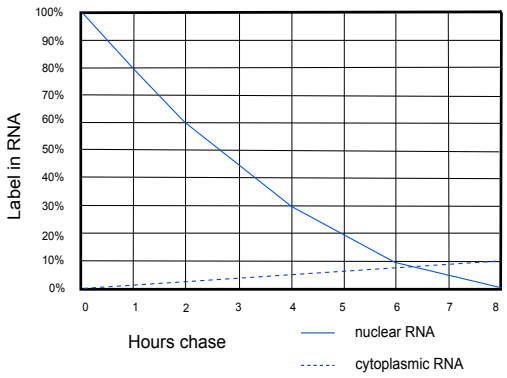
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 4 Pulse-Chase Experiment
脈衝追踪分析實驗

Pulse- chase experiments performed in cells are experiments in which cells are first exposed to labeled precursors of specific molecules for a short period of time (the pulse), unincorporated labeled precursors are then washed away, and presence of label in molecules of interest are followed through time (the chase). In an experiment designed to study gene expression, cells were exposed to labeled UTP during the pulse, and results of the chase part of the experiment are summarized in the figure below:

所謂的”脈衝追踪分析實驗”為將選定的細胞暴露於有標記的前驅化合物（ Chase 脈衝），該化合物將被引入研究的分子或系統中。未被引入與過量的有標記的化合物則會被洗掉，所以留在細胞內有標記的化合物就可用來追踪分析(Pulse)感興趣的分子。

以下利用脈衝追踪分析實驗來研究基因表現，將細胞短暫時間暴露於有標記的UTP(Pulse)，於不同時間”追踪分析” (Chase)的結果如下:



Indicate if each of the following statements is true or false.
指出下列敘述是對或錯

	TRUE 對	FALSE 錯
Based on the data presented, most (~ 90% of mass) of RNA that is synthesized in the nucleus is degraded in the nucleus without ever entering the cytoplasm. 依據所呈現的數據,大多數約 90%的 RNA在細胞核內合成與水解,從不會進入細胞質中	○	○
Based on data presented, the complexity of RNA (which refers to number of different sequences) in the nucleus is higher than in the cytoplasm. 依據所呈現的數據, 在細胞核內的RNA複雜度(即不同序列RNA種類)高於在細胞質中	○	○
Assuming that introns constitute 60% of primary transcripts, splicing can account for the observed difference in amount of label in the nucleus at start of chase and amount of label in the cytoplasm after eight hours of chase. 假設有一初級轉錄物，其內含子佔 60%，於脈衝追踪分析實驗之脈衝開始時即可觀察到標記量的差異而須在脈衝8小時後才能於細胞質中觀察到	○	○

	TRUE 對	FALSE 錯
It is expected that chases of longer than 8 hours would have ultimately shown a much higher amount of label in the cytoplasm than seen at 8 hours. Chase於8小時後會比在8小時時，呈現較高量的標記物	○	○

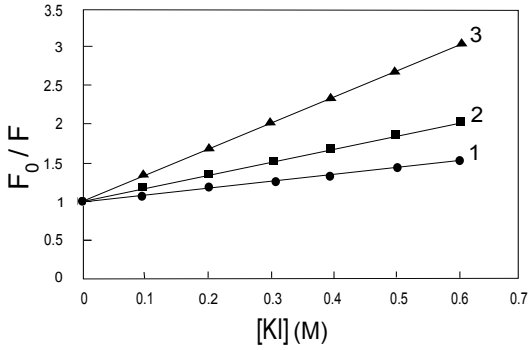
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 5 Fluorescence Quenching
螢光猝滅 (減少) 實驗

Enzyme activity usually correlates with its conformational flexibility, such that higher flexibility (lower rigidity) is usually accompanied with higher activity. Tryptophan residues which emit fluorescence are most commonly located within the nonpolar interior environment of the proteins. An excellent way to experimentally determine the exposure of tryptophan residues to solution is by measuring the quenching (decrease) of their fluorescence. The effect of mutations on the accessibility of tryptophan residues can be studied by measuring amount of fluorescence quenching by potassium iodide (KI). Iodide ions selectively quench fluorescence emitted by exposed tryptophan residues.
酶的活性通常與其結構可塑性有關，因此較高的可塑性（較低的剛性）通常伴隨較高的活性。發出螢光的色氨酸殘基最常位於蛋白質的非極性內部環境中。透過實驗確定色氨酸殘基暴露於溶液的一種極好方法是測量其螢光的猝滅（降低）。可以測量碘化鉀（KI）的螢光猝滅量來研究突變對色氨酸殘基的影響。碘離子藉由暴露的色氨酸殘基，選擇性地猝滅所發出的螢光。

In the experiment whose results are presented below, fluorescence quenching on equal amounts of three mutated forms of an enzyme (mutant forms 1, 2, and 3) was measured after addition of various concentrations of KI (0-0.6 M). Excitation and emission wavelengths used were specific for tryptophan. Quenching data were analyzed in terms of the Stern–Volmer constant, K_{SV}, which can be calculated from the ratio of the unquenched and the quenched fluorescence intensities, F_o/F, using the relationship
$$\mathbf{F_o/F = 1 + K_{SV}[Q]}$$
[Q] = the molar concentration of the quencher.

如下所示的實驗結果中，在加入各種濃度的KI（0-0.6 M）後，測量等量的三種突變型的酶（突變型1,2和3）的螢光猝滅。所使用的激發和發射波長是特別針對色氨酸的。根據Stern-Volmer常數 (K_{SV})分析猝滅數據，其可以使用來計算猝滅螢光強度的比率 (F_o :未猝滅；F: 猝滅)。
$$\mathbf{F_o / F = 1 + K_{SV}[Q]}$$
[Q] =猝滅劑的莫耳濃度。



Based on the results, indicate if each of the following statements is true or false
根據結果，指出下列敘述是對或錯

	TRUE 對	FALSE 錯

	TRUE 對	FALSE 錯
Among the three mutated proteins, protein 1 is expected to have the lowest enzymatic activity. 在三種突變蛋白質中，蛋白質1預期具有最低的酶活性。	○	○
Iodide ions have higher accessibility to the tryptophan residues of protein 2 as compared to protein 3. 與蛋白質3相比，碘離子對蛋白質2的色氨酸殘基具有較高的觸及性。	○	○
Protein 3 has the highest K_{SV}. 蛋白質 3 有 最大值Ksv	○	○
Protein 1 does not have tryptophan residues. 蛋白質1不含色氨酸殘基。	○	○

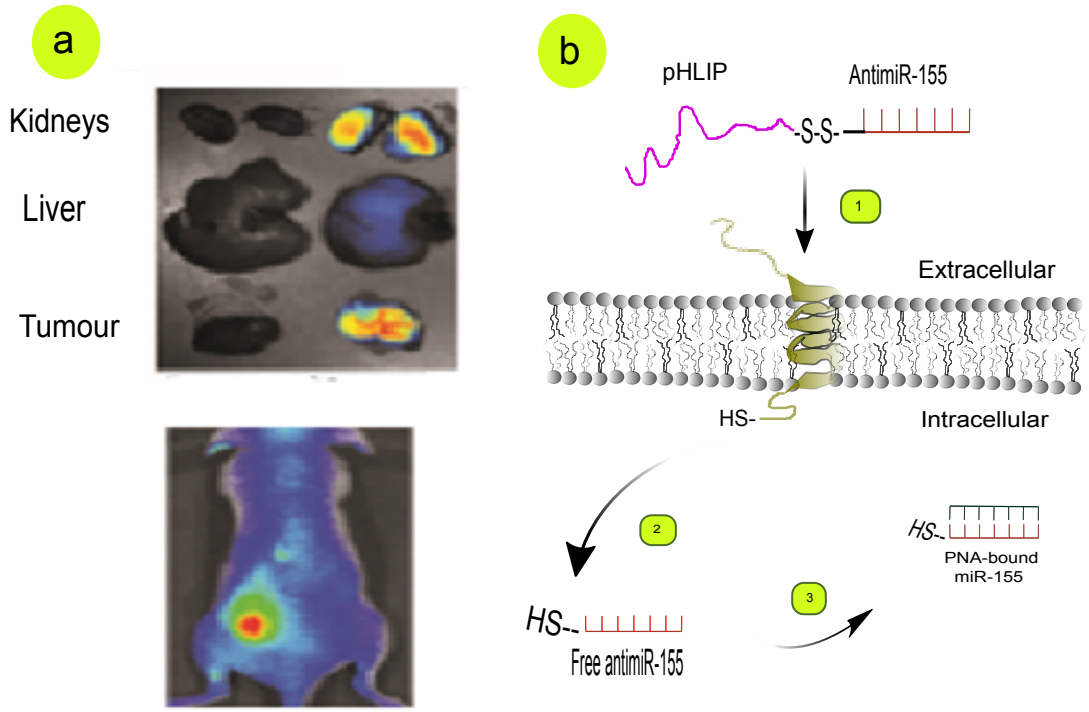
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 6 AntimiRs
抗微型 RNA

MicroRNAs are short non-coding RNAs expressed in various tissues and cell types that suppress the expression of target genes. MicroRNAs involved in cancer are called oncomiRs. Inhibition of oncomiRs using antisense oligomers (that is, antimiRs) is an evolving therapeutic strategy. However, the in vivo efficacy of current antimiR technologies is hindered by physiological and cellular barriers for delivery into targeted cells.
微型RNA是在各種組織和細胞類型中表現之短的非編碼RNA，其抑制標的基因的表現。參與癌症的微型RNA被稱為oncomiRs。使用微型RNA的反義寡核酸（即: 抗miR）可抑制oncomiRs的表現，是一種日益發展的治療策略。然而，目前此種 抗miR 技術在活體內遞送至標的細胞的效率 會受生理和細胞屏障的阻礙。

A novel antimiR delivery platform that specifically targets tumour microenvironment makes use of synthetic molecules called peptide nucleic acid (PNA) antimiRs attached to a peptide called pHLIP. PNA antimiRs are antimiRs whose nucleotides are connected by peptide bonds instead of the normal phosphodiester bonds. The structure of pHLIP is pH dependent. At low pH, a transmembrane structure is induced in pHLIP that facilitates transport of attached PNA into tumour cells (Fig. 1). pHLIP mediated transport of antimiR-155 effectively inhibited the miR-155 oncomiR in cultured cells (Fig. 2).

一種新穎性標靶至腫瘤微環境的新型抗miR 遞送平台，利用稱為肽核酸（PNA）抗體的合成分子附著於稱為pHLIP的肽上。 PNA antimiRs是一類antimiRs，其核苷酸透過肽鍵連接，而非與正常的磷酸二酯鍵。 pHLIP的結構取決於pH。在低pH下，跨膜構造會在pHLIP中被誘導，其促進附著的PNA轉運到腫瘤細胞中（圖1）。 pHLIP協調antimiR-155的轉運能有效抑制培養細胞中的miR-155 oncomiR（圖2）。



Subcutaneous Tumour 皮下腫瘤

Fig. 1: Targeting miR-155 in a mouse lymphoma model using PNA- antimiR-155-pHLIP a: Distribution of pHLIP (yellow and red zones) 36 h after injection into tail. b: Schematic presentation of pHLIP-mediated PNA antimiR delivery.
圖1：使用PNA-antimiR-155-pHLIP靶向小鼠淋巴腫瘤中的miR-155。 a：注射到尾部36小時後，pHLIP（黃色和紅色區域）的分佈。 b：pHLIP協調的PNA antimiR遞送的示意圖。

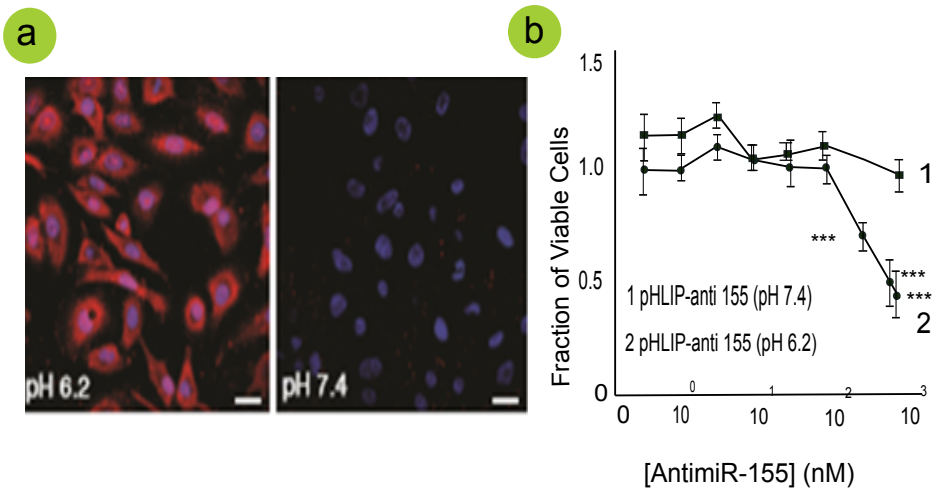


Fig. 2: pH dependent transport and activity of PNA- antimiR-155-pHLIP. a: Microscopy images of A549 cells incubated with labelled PNA- antimiR-155-pHLIP (red fluorescence) at two pHs; the label for the nucleus is blue. b, Effects of pHLIP-antimiR-155 on cell viability at two different pHs.

圖2：PNA-抗miR-155-pHLIP之pH依賴的轉運和活性。
a：A549細胞在兩個pH下與標記的PNA-抗miR-155-pHLIP（紅色螢光）作用後的顯微圖像；核的標記是藍色的。 b：在兩種不同pH下，pHLIP-antimiR-155對細胞活力的影響。

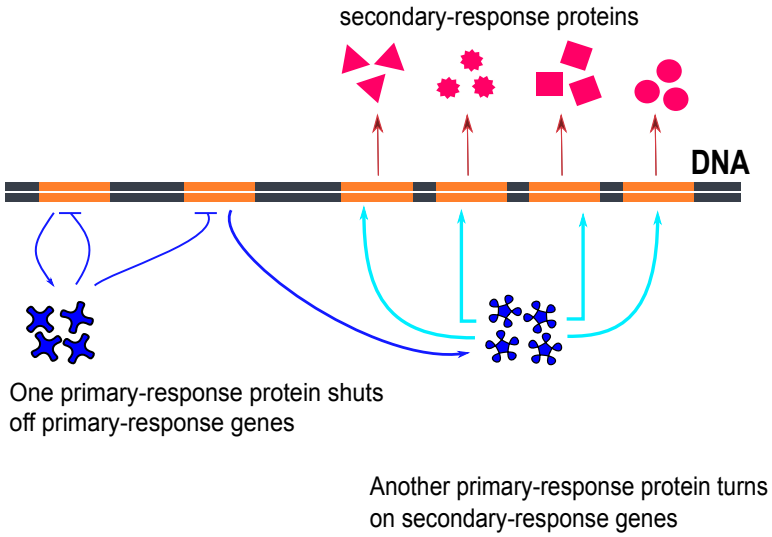
Indicate if each of the following statements is true or false.
指出下列敘述是對或錯

	TRUE 對	FALSE 錯
Based on the data, you can conclude the liver does not function in clearing the pHLIP-antimiRs from the body. 根據這些數據，肝臟不能從體內清除 pHLIP-antimiRs。	○	○
At pH less than 7, pHLIP inserts into the lipid bilayer and thus facilitates delivery of attached 在pH小於7時，pHLIP可插入細胞膜脂質雙層中，從而促進附著的antimiR-155的遞送。	○	○
The acidic microenvironment of tumours is responsible for intracellular release of antimiR-155. antimiR-155 會在細胞內腫瘤的酸性微環境中釋放。	○	○
The antimiR cargo will be trapped within endosomes. antimiR 運送將被困在胞內體中。	○	○
Transition from random coil to helix of pHLIP enhances cell death. pHLIP的構型從無規則捲曲轉變成螺旋型會促進細胞死亡。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 7 Steroid Hormones
類固醇激素

Steroid hormones affect expression of primary response genes and secondary response genes in cells as schematically shown in the figure below.
類固醇激素影響細胞中初級反應基因和次級反應基因的表現，如下圖所示。



Primary and secondary response genes can be distinguished by
初級和次級反應基因可以區分

	TRUE 對	FALSE 錯
Inhibition of DNA replication simultaneously with hormone administration 同時投予激素會抑制DNA複製	○	○
Inhibition of transcription simultaneously with hormone administration 同時投予激素會抑制轉錄	○	○
Inhibition of translation simultaneously with hormone administration 同時投予激素會抑制轉譯	○	○
Inhibition of transcription and translation simultaneously with hormone administration 同時投予激素會抑制轉錄和轉譯	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 8 Uncoupling Drugs
解偶聯藥物

Drugs that render the inner mitochondrial membrane permeable to H^+ a”re called “uncouplers”
藥物可使粒線體內膜通透H^+稱為“解偶聯藥物"。

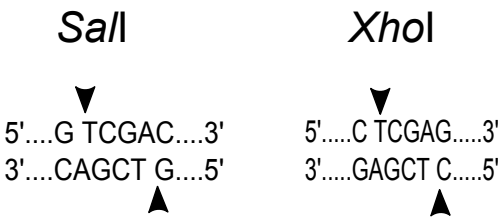
Indicate whether the following statements are true or false.
指出下列敘述的對或錯

	TRUE 對	FALSE 錯
These drugs will increase oxygen consumption. 這些藥物會增加氧氣消耗。	○	○
These drugs will reduce body carbohydrate catabolism. 這些藥物會減少體內碳水化合物分解代謝。	○	○
These drugs will decrease body temperature. 這些藥物會降低體溫。	○	○
These drugs may cause death upon overdose because of severe weight loss. 因嚴重減肥而過度服用這些藥物會導致死亡。	○	○
These drugs may cause death upon overdose because of severe ATP loss. 過量服用這些藥物可能因嚴重的ATP丟失而導致死亡。	○	○

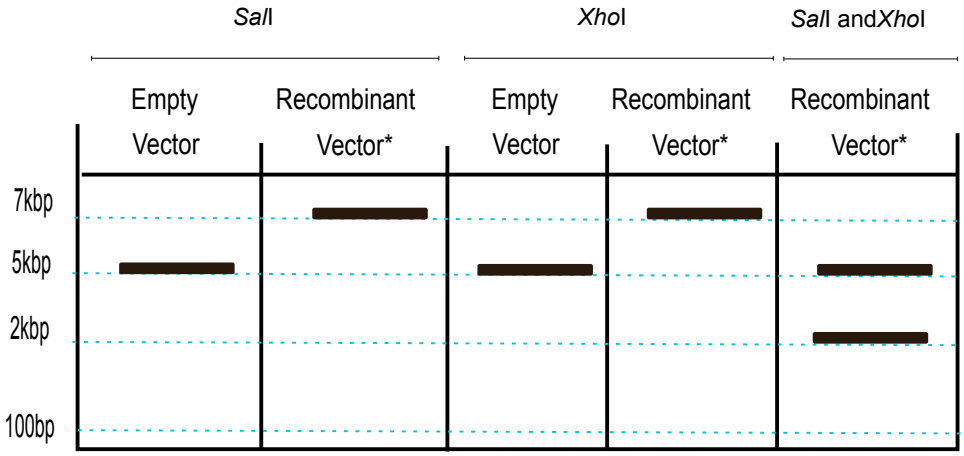
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 9 Restriction Enzyme Digestion
限制酶切割反應

Some restriction enzymes have different recognition sequences but create the same sticky ends, as shown below for *Sal*I *and Xho*I.
一些限制酶具有不同的辨識序列但會產生相同的粘性末端，如下文*Sal* I *和Xho* I所示。



The following gel electrophoresis image shows linearized DNAs obtained after complete restriction enzyme digestion of non-recombinant (empty vector) and recombinant (containing gene x) expression plasmid vectors. The expression vector includes a strong promoter near its cloning site. The insert of the recombinant plasmid was a product of *Sal*I digestion. The insert was ligated into the vector which had been cut with *Xho*I.
以下凝膠電泳圖顯示在限制酶完全切割非重組（空載體）和重組（含有基因x）表現質體載體後獲得的線型DNA。表現載體在其選殖位點附近包括強啟動子。重組質體的插入片段是*Sal* I切割後的產物。將插入片段連接到已用*Xho* I切割的載體中。



**** All recombinant vectors gave the same pattern in the gel***
全部重組載體都呈現相同的膠體電泳圖像

Indicate if each of the following statements is true or false.
指出下列敘述是對或錯

	TRUE 對	FALSE 錯

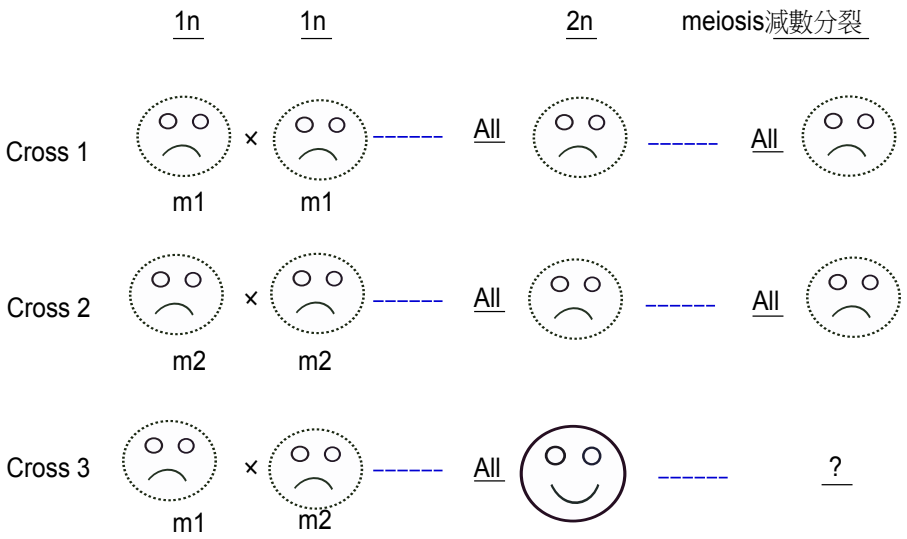
	TRUE 對	FALSE 錯
The data indicate that two copies of the insert were cloned in the expression vector. 數據顯示有兩個拷貝的插入片段被選殖於表現載體中	○	○
Half of the clones are expected to be able to transcribe the mRNA of gene x. 可預期有半數的選殖株(clones)會表現基因x的mRNA	○	○
An *Xho*I site exists outside of the insert in the recombinant vector of the experiment. *Xho*I的切割位點在此實驗的重組載體質體的外圍	○	○
The 2-kb fragment seen in the gel can be used as probe to screen for the recombinant vectors 在膠片中所見2-kb的片段可被利用作為篩選重組載體的探針	○	○
the insert produced by If *Sal*I digestion was ligated into a vector that had been cut with both *Xho*I and *Sal*I enzymes and the recombinant plasmid subsequently cut with *Xho*I, a 4-kb product would be obtained. *Sal*I 切割產生的插入片段可與利用*Xho*I and *Sal*I雙切割的載體接合形成重組質體, 再以*Xho*I切割後可得到4-kb片段	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 10 Mating in Yeast
酵母菌的接合生殖

Mating experiments with a yeast species that has 16 chromosomes of equal length were performed. Results of mating between two mutant yeast strains (shown with an unhappy phenotype), each with a mutation in a single gene, are shown below. The mutated allele of each gene is recessive with respect to the wild type allele. Unhappy is a polygenic and many genes affect the phenotype. Recombination does not occur in these yeast strains.

對具有16條相同長度染色體的酵母菌進行接合交配實驗。兩種酵母菌突變株（圖中的"哭臉"）之間的交配結果，每種都具有單基因突變，如下所示。每個基因的突變是隱性的。"哭臉"代表多基因表型而且許多基因會影響該表型。在這些酵母菌株中不發生重組。



Indicate if each of the following statements is true or false
指出下列敘述是對或錯

	TRUE 對	FALSE 錯
If mutations of m1 and m2 were in the same gene, it is possible that all products of meiosis of cross 3 will be unhappy. 如果m1和m2的突變位於同一基因中，則Cross 3 的減數分裂產物都將會是"哭臉"。	○	○
If 1 happy to 3 unhappy yeasts were produced from meiosis of cross 3, then the mutation of m1 and the mutation of m2 were in different genes. 如果從 Cross 3 的減數分裂中產生3個"哭臉"的酵母菌，那麼 m1的突變和 m2 的突變在不同的基因中。	○	○
If 1 happy to 1 unhappy yeasts were produced from meiosis of cross 3, then the mutation of m1 and the mutation of m2 can suppress each other. 如果從 Cross 3 的減數分裂產生1個"笑臉"的酵母菌和1個"哭臉"的酵母菌，則 m1 的突變和 m2 的突變可以相互抑制。	○	○

	TRUE 對	FALSE 錯
If the experiments were performed with various pairs of unhappy mutants, the most frequently observed ratio of happy to unhappy yeasts among meiosis products of cross 3 would be 1:3. 如果用各種"哭臉"的酵母菌突變株進行實驗，則在Cross 3的減數分裂產物中，最常觀察到的"笑臉" 與"哭臉"的酵母菌的比例將是1：3。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 11 Thalassemia
地中海貧血症

Thalassemia, the most common inherited disorder of hemoglobin, is caused by loss or substantial reduction of one of the globin chains. This results in lowered levels of functional hemoglobin and decreased function of red blood cells, which lead to anemia. In α-thalassemia, the α chain of hemoglobin is not produced in sufficient quantity and consequently, hemoglobin tetramers form that contain only the β chain. In β-thalassemia, the β chain of hemoglobin is not produced in sufficient quantity and the α chains form insoluble aggregates that precipitate inside immature red blood cells and prevent differentiation into mature cells.
地中海貧血症是最常見的血紅素蛋白異常的遺傳性疾病，是因一條球蛋白鏈的丟失或大量減少引起的。這導致功能性血紅素蛋白量降低和紅血球細胞功能降低而引起貧血。在α-地中海貧血症中，血紅素蛋白的α鏈不能以足夠的量產生，因此形成僅含有β鏈的血紅素蛋白四聚體。在β-地中海貧血症中，血紅蛋白的β鏈不能以足夠的量產生，而α鏈形成不溶性聚集體，其在未成熟的紅血球細胞內沉澱並阻止其分化為成熟細胞。

The normal haploid human genome has one β chain and two α chain coding genes. Presence of four alleles for α chain compared to two alleles for β chain in the cells of normal individuals is expected to results in excess amounts of α chain and production of α aggregates. However, α aggregates do not exist in the cells of normal individuals. One mechanism for maintaining α chains in soluble form was revealed by the discovery of an 11-kDa protein in red blood cells called α-hemoglobin stabilizing protein (AHSP). This protein forms a soluble complex specifically with α chain monomers as they are synthesized. The crystal structure of a complex between AHSP and α-hemoglobin reveals that AHSP binds to the same face of α-globin as does β-globin and ensures the proper folding of α-globin as it is produced. β-globin displaces AHSP when it is expressed.
正常單倍體人類基因組中具有一個β鏈和兩個α鏈編碼基因。與正常個體細胞中β鏈的兩個等位基因相比，α鏈的四個等位基因的存在，預計會導致過量的α鏈形成α聚集體。然而，α聚集體不存在於正常個體的細胞中。在紅血球細胞中發現稱為α-血紅素穩定蛋白（AHSP）的11kDa 蛋白，揭示了維持可溶性α鏈的一種機制。該蛋白質在合成時與α鏈單體特異性地形成可溶性複合物。 AHSP和α-血紅素蛋白形成複合物的晶體，其結構顯示AHSP與β-鏈蛋白的同一面結合，並確保α-鏈蛋白產生時可以正確折疊。當表現時，β-鏈蛋白取代AHSP。

Indicate if each of the following statements is true or false
指出下列敘述是對或錯

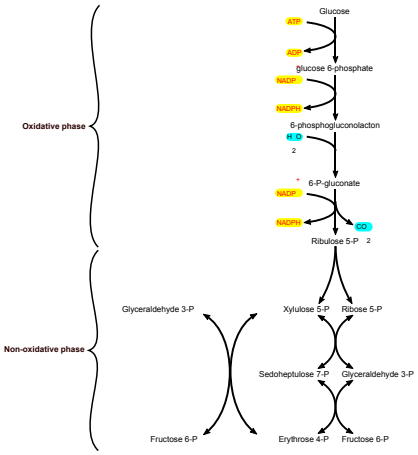
	TRUE 對	FALSE 錯
Higher incidence of severe β-thalassemia compared to severe α-thalassemia could be explained by difference in copy numbers of α and β genes. 與重度α-地中海貧血症相比，嚴重β-地中海貧血症的發生率更高，可由 α 和β基因拷貝數的差異來解釋。	○	○
α-globin/β-globin ratio is an appropriate marker for screening of β-thalassemia. α-球蛋白/β-球蛋白比率是篩選β-地中海貧血症的適合標記物。	○	○
α-Hemoglobin has a higher affinity for β-hemoglobin than for AHSP α-血紅素蛋白對β-血紅素蛋白的親和力高於對AHSP的親和力。	○	○

	TRUE 對	FALSE 錯
AHSP deleterious mutations are expected to mimic β-thalassemia phenotype with respect to α- chain aggregation. 預期AHSP的有害突變在α-鏈聚集時模擬β-地中海貧血症表型。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

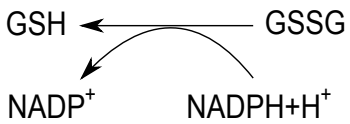
Q. 12 Pentose Phosphate Pathway
磷酸戊糖途徑

Pentose sugars and NADPH are synthetized through the pentose phosphate pathway.
通過戊糖磷酸途徑合成戊糖和NADPH。



Reduced glutathione (GSH) acts to neutralize reactive oxygen specie (ROSs) in the body. The reaction for GSH generation is shown below:
穀胱甘肽還原酶(GSH) 可以中和體內的活性氧(ROSs)。產生GSH的反應過程如下所示:

Glutathione reductase穀胱甘肽還原酶



Individuals with glucose-6-phospho dehydrogenase (G6PD) deficiency have decreased level of NADPH which can cause the favism disorder. Compared to other populations, frequency of G6PD deficiency s higher in Africans, and its prevalence in Africa positively correlates with the prevalence of malaria.

缺乏葡萄糖-6-磷酸脫氫酶（G6PD）的個體會降低NADPH的量，將會導致蠶豆症。與其他人類族群相比，在非洲人中，缺乏G6PD較為盛行，其患病率與瘧疾的患病率呈正相關。

Indicate if each of the following statements is true or false.
指出下列敘述是對或錯

TRUE 對 FALSE 錯

TRUE 對 FALSE 錯

The high prevalence of G6PD deficiency in regions with high incidence of malaria can be explained by high susceptibility of *Plasmodium falciparum* to oxidative agents.

G6PD缺乏的盛行與瘧疾的患病率呈正相關，可以由惡性瘧原蟲對氧化劑有高度易感性來解釋。

Increase in levels of cell division is accompanied by increase in the ratio of fructose-6 phosphate/ ribose-5 phosphate production by the pentose phosphate pathway.

細胞分裂的增加，磷酸戊糖途徑產生的果糖-6磷酸 / 核糖-5磷酸之比例 也會增加。

G6PD deficiency affects catabolism more than anabolism in individuals with the deficiency.

G6PD缺乏症患者其影響分解代謝大於合成代謝。

It is expected that the cause of favism in some affected individuals may be glutathione reductase deficiency.

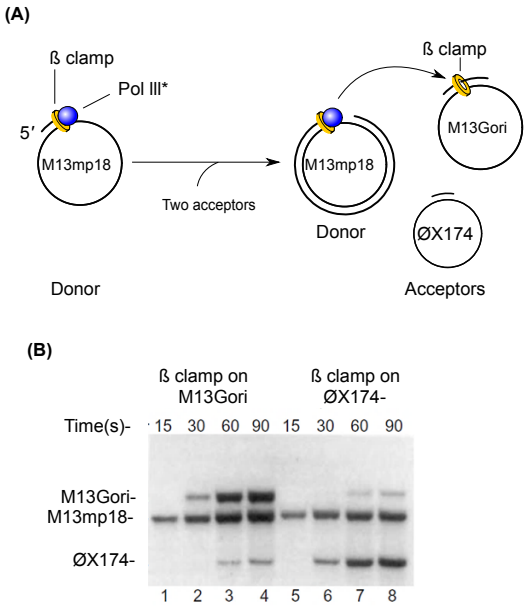
預期一些蠶豆症患者是因缺乏穀胱甘肽還原酶而引起的。

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 13 DNA Polymerase III
DNA聚合酶 III

DNA polymerase III holoenzyme consists of the pol III* and the β-clamp which hold pol III* and DNA template together. You are investigating whether during lagging strand synthesis, the pol III* synthesizing the lagging strand dissociates from the β-clamp as it finishes one Okazaki fragment and re-associates with another β-clamp to begin making the next Okazaki fragment. You prepared a primed M13 phage (a single stranded DNA and a primer) template (M13mp18) as a donor and loaded a β-clamp and pol III* onto it.
DNA聚合酶 III 由pol III* 和 β-clamp組成，β-clamp的功用是將pol III* 和DNA模板夾在一起。你想知道當合成DNA的延遲股(lagging strand)時，合成延遲股的pol III* 是否會在完成一個Okazaki片段後，和β-clamp分離，然後再和另一個β-clamp結合，開始合成下一個Okazaki片段。你準備了M13 phage病毒(由單股DNA及引子組成) 模板 (M13mp18) 作為donor，然後加入一個β-clamp 和 pol III*。

As acceptors, you then added two more primed phage DNA templates, one (M13Gori) preloaded with a β-clamp and the other (φX174) lacking a β-clamp (Figure A). You incubated the templates together under replication conditions for 90 min – long enough for the donor and acceptors to be replicated – then performed gel electrophoresis (Figure B, lane 1-4). You then repeated the experiment but now loading a β-clamp on φX174 instead of M13Gori (Figure B, lane 5-8).
接著你加入其他兩種也是有引子的噬菌體作為 acceptor ，其中一個是有先加入 β-clamp的M13Gori，另一個則是沒有加入 β-clamp的 φX174 (圖A)。你讓donor和acceptor的DNA模板加在一起，進行複製反應 90分鐘 (這時間足以讓donor 和 acceptor 進行複製)，然後進行電泳 (圖 B, lane 1-4)。接著重複相同的實驗，只是這次相反，將一個β-clamp加入φX174，並沒有把 M13Gori 加入β-clamp，這次電泳得出的結果如圖 B, lane 5-8。



Indicate if each of the following statements is true or false.
指出下列敘述是對或錯

	TRUE 對	FALSE 錯

	TRUE 對	FALSE 錯
After replication has finished, Pol III* dissociates from its original β-clamp. 複製完成後，Pol III* 會和原本的β-clamp分離。	○	○
The data are consistent with the notion that the β-clamp is not absolutely required for replication. 所得的結果與 β-clamp不是複製時絕對必要 的觀念一致。	○	○
Pol III* prefers an acceptor template preloaded with a β-clamp. Pol III* 偏好已預先裝有 β-clamp 的acceptor模板。	○	○
Based on the results, one β-clamp is enough to synthesize all Okazaki fragments on the lagging strand of each replication fork. 根據所得結果，一個 β-clamp就足以在每個複製叉(replication fork) 的延遲股合成所有Okazaki片段。	○	○

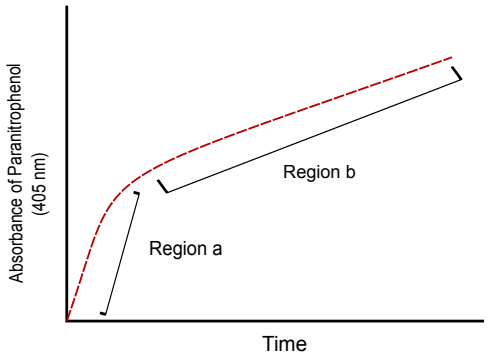
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 14 Para-Nitrophenol
二硝基苯酚

The enzymatic reaction below includes two steps.
下面的酵素反應包括兩個步驟

Para-nitrophenyl-peptide→para-nitrophenol + peptide

Para-nitrophenol has maximum absorbance at wavelength 405 nm. The progress curve of the reaction is shown below.
Para-nitrophenol在波長405 nm時有最大的吸光度。反應的進展曲線如下圖。



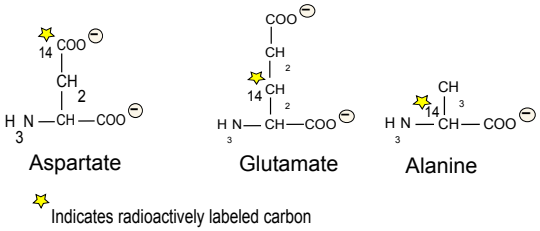
Indicate if each of the following statements is true or false.
指出下列敘述是對或錯

	TRUE 對	FALSE 錯
The release of para-nitrophenol occurs during the first step of enzymatic mechanism. para-nitrophenol的釋放發生在酵素反應的第一階段	○	○
The rate limiting step of this enzymatic mechanism is the second step. 決定酵素反應速率取決於第二階段	○	○
Enzyme activity can be determined from the slope of region “a” of the curve. 酵素活性可由區域"a"的曲線斜率來決定。	○	○
One of the reaction products activates the enzyme. 其中一個反應產物會活化酵素。	○	○

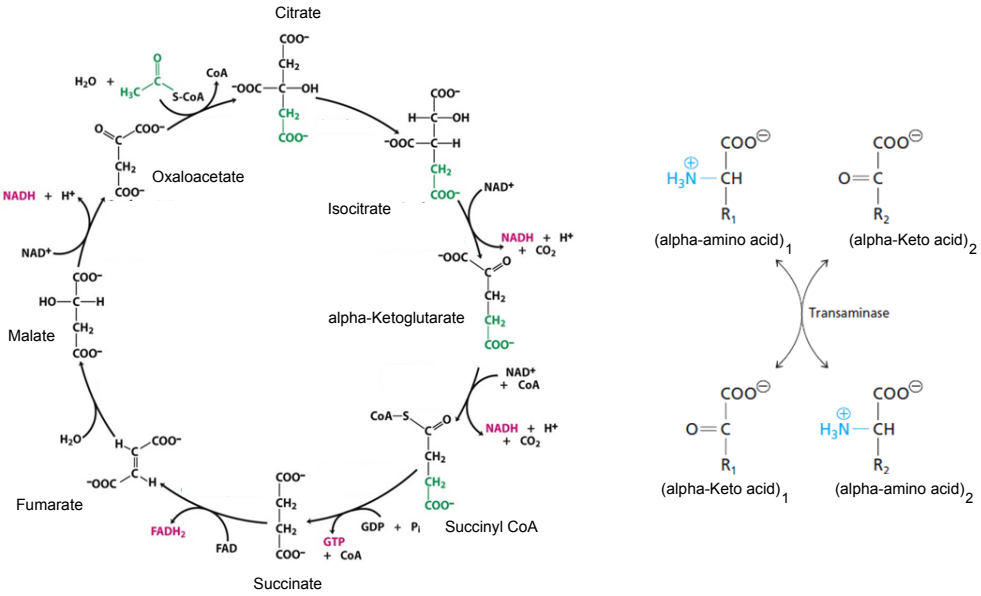
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 15 Amino Acid Metabolism
胺基酸代謝

Amino acids resulting from the degradation of proteins can be further metabolized by conversion to intermediates of the citric acid cycle. The following labeled amino acids are obtained by degradation of a labeled protein.
蛋白質分解後的胺基酸可以再被轉換成檸檬酸循環(citric acid cycle) 的中間產物。下面被標記的胺基酸，是由分解被標記的蛋白質來的。



The Krebs cycle is below. Note that most α-amino acids can be directly converted into their corresponding α-keto acid by transamination reaction as also shown below.
下圖為克式循環(Kreb cycle)。如下圖所示，透過轉胺反應(transamination)，大部分胺基酸可以直接轉換成對應的 α-keto acid。



Indicate if each of the following statements is true or false.
指出下列敘述是對或錯

TRUE 對 FALSE 錯

	TRUE 對	FALSE 錯
Upon introduction of the aspartate into the Krebs cycle, label will first appear in oxaloacetate. 一旦aspartate進入克式循環，被標記物將會第一個出現在 oxaloacetate	○	○
Upon introduction of the alanine into the Krebs cycle, label will first appear in citrate. 一旦alanine進入克式循環，被標記物將會第一個出現在citrate	○	○
Labeled alanine will yield $^{14}CO_2$ during the first turn of the cycle. 被標記的alanine在第一圈循環會產生$^{14}CO_2$	○	○
Labeled glutamate will yield $^{14}CO_2$ in the second turn of the cycle. 被標記的glutamate在第二圈循環會產生$^{14}CO_2$	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

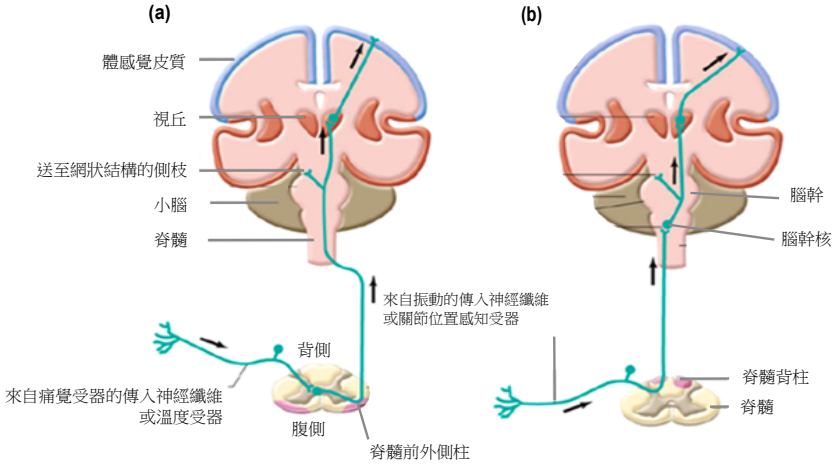
ANIMAL PHYSIOLOGY AND ANATOMY
動物生理學和解剖學

Q. 16 Pain Transmission 痛覺的傳遞

In figure a, the pain and temperature sensory pathway is depicted. The first-order neuron enters the spinal cord and forms a synapse with the second-order neuron, which its axon ends in the thalamus. The third-order neuron transmits the information to the brain cortex. Figure b shows the vibration and proprioception (joint position) sensory pathway. The axon terminals of the first-order neurons are located in the brain stem and form synapses with second-order neuron, which crosses the midline and their axons end in the thalamus. finally, the sensory information is conducted to the cortex via the third-order neurons.

圖a顯示疼痛和溫度感覺傳遞的路徑。第一級神經元進入脊髓後與第二級神經元形成突觸，接下來第二級神經元之軸突將訊息送至視丘。 第三級神經元再將訊息送到大腦皮質。圖b顯示了振動和本體感覺(關節位置的感覺傳遞路徑。第一級神經元將其軸突送到腦幹並與第二級神經元形成突觸，第二神經元在腦幹穿過中線並將軸突送至視丘，最後再透過第三級神經元將訊息送到大腦皮質。

Following a spinal injury, the right ventral and left dorsal sides of the white matter in thoracolumbar spinal cord are damaged.
脊髓損傷導致胸腰段脊髓右腹側和左背側的白質受到損傷。



Indicate if each of the following statements is true or false.
指出下列敘述是對或錯

	TRUE 對	FALSE 錯
The patient has impaired temperature sensation in right hand 患者右手無法感覺溫度。	○	○
The patient has impaired vibration sensation in left leg. 患者左腿無法感覺振動。	○	○
The patient has impaired joint position sensation in left leg and temperature sensation in right leg. 患者左腿無法感覺關節位置而右腿無法感覺溫度。	○	○

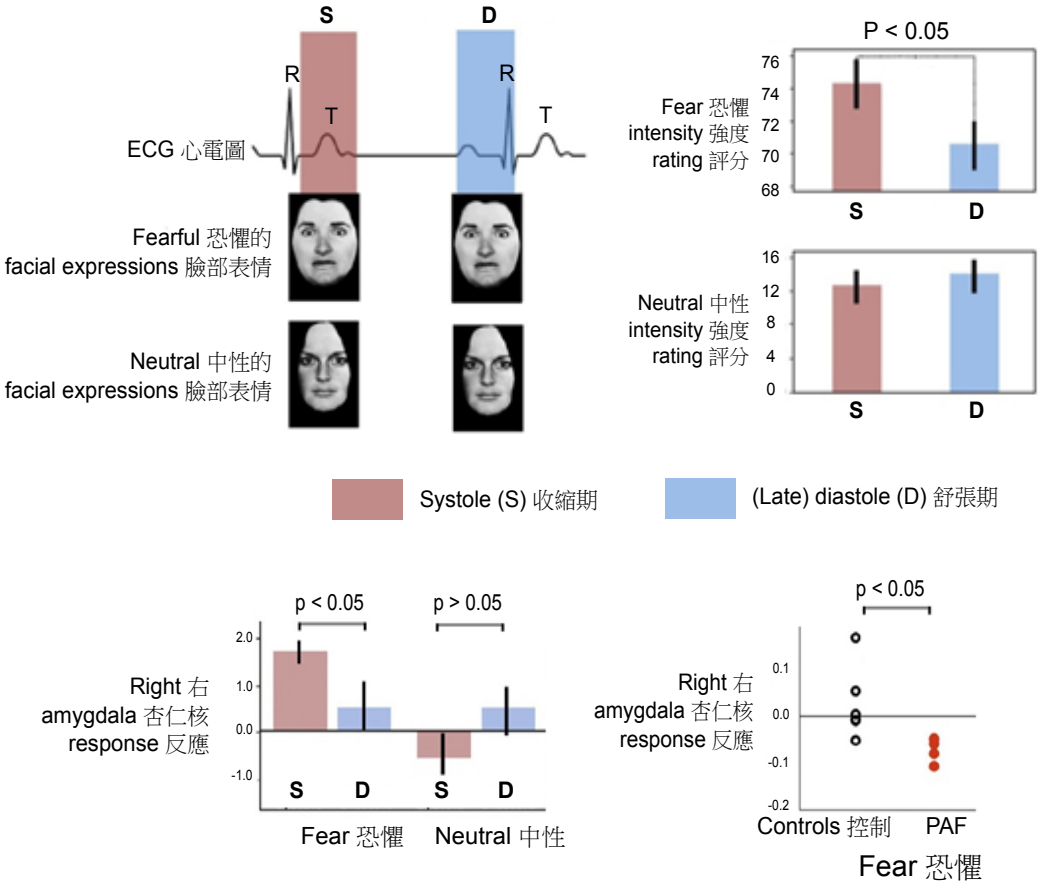
TRUE 對 FALSE 錯

The patient has impaired pain sensation in left leg.
患者左腿無法感覺疼痛。

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 17 Cardiac Response to Emotional States
心臟對情緒的反應

Perception of the emotional stimuli is a reciprocal process between the brain and the heart. In an experimental task, pictures depicting facial expressions were quickly and sequentially presented to the subjects at different phases of the cardiac cycle. Participants then rated the emotional intensity of the faces in a scale of 0 to 100. Given the role of the amygdala in the process of fear, the amygdala response was measured in normal individuals and subjects with pure autonomic failure (PAF) at the time of presenting facial expression images (using the fMRI method). The results of the study are as follows. (Consider p<0.05 indicates significant difference between groups).
目前已知心臟和大腦之間具相互作用。下列實驗想證實此現象。在心動週期的不同階段，給予受試者表現不同臉部表情之圖像，而後請受試者評估面部表情的情緒強度(由0到100)。由於杏仁核在恐懼形成過程中扮演重要角色，本實驗同時利用fMRI (功能MRI)，紀錄正常受試者及自主神經衰竭（PAF）患者杏仁核的反應。研究結果顯示如下。(p <0.05 表示組間有顯著差異)。



Indicate if each of the following statements is true or false.
指出下列敘述是對或錯。

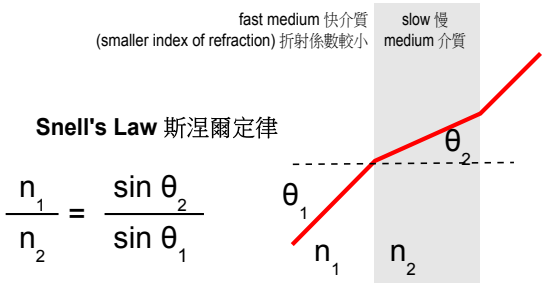
	TRUE 對	FALSE 錯
Perception of the fear face in the systolic phase is higher than the diastole phase. 處於收縮期時對恐懼表情的感知高於舒張期。	○	○

	TRUE 對	FALSE 錯
The difference between systolic and diastolic response of the amygdala to neutral face images is the opposite of facial expressions of fear. 杏仁核在收縮期和舒張期時對中性臉部表情與對恐懼的臉部表情的反應相反。	○	○
Increasing the arterial baroreceptors sensitivity in the carotid and aorta may cause a significant reduction in the perception of the fear. 增加動脈壓力受器對頸動脈和主動脈的敏感性可能導致受試者對恐懼的感知顯著下降。	○	○
Increased blood flow to amygdala in the systolic phase compare to the diastole phase **cannot** explain the results of this study. 收縮期杏仁核增加的血流量較舒張期為多的現象，無法解釋這項研究的結果。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 18 Light Refraction
眼球晶體結構與光折射的關係

When a light beam enters another medium in an oblique angle, its direction will change. This phenomenon is called light refraction. The amount of this change in beam direction can be calculated by Snell's law, where "n" is the refraction index.
當光束以傾斜方向進入另一介質時，其路徑將會改變，這種現象稱為光折射。光束路徑的改變量可以透過斯涅爾定律(Snell's law)計算，其中"n"是折射係數



This phenomenon is also the principle of conversion and diversion of beams in lenses. Power of a lens can be calculated by the following formula. Optical power of a lens demonstrates the degree of convergence or divergence of the light beam.

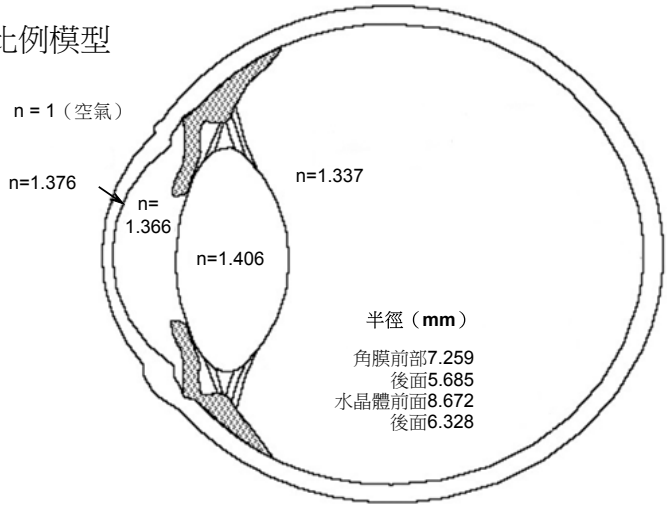
(D: Power of lens, r: radius of curvature)

$$D=(n1-n2)/r$$

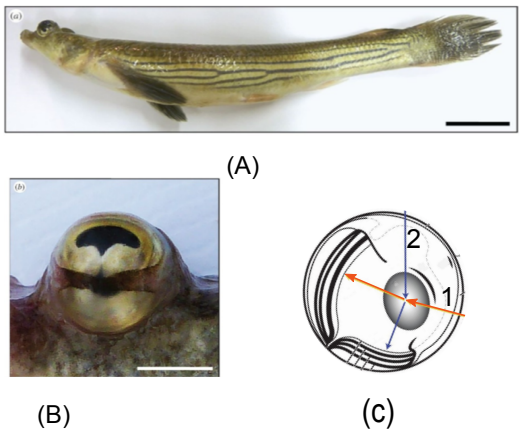
這種現象也是鏡頭(或水晶體)中光束轉換和轉向的原理。鏡頭(或水晶體)的功率可以透過以下公式計算;隨著絕對功率增加，轉換或轉移的功率將增加。水晶體之視覺能力可透過對光束之匯聚或發散角度而定（D：鏡頭或水晶體功率，r：曲率半徑）

$$D = (n_1 - n_2) / r$$

眼睛的比例模型



The figure below shows the eye structure of Anableps sp. which can simultaneously see objects in both aquatic and terrestrial scenes.
下圖顯示了Anableps sp的眼睛結構。它可以同時看到水上和陸地場景中的物體。



A）Anableps sp　B）Anablebs sp的眼睛　C）Anableps sp 眼睛的示意圖

Indicate if each of the following statements is true or false.
指出下列每個敘述是對或錯。

	TRUE 對	FALSE 錯
The largest refraction index belongs to the lens. 水晶體具最大的折射常數。	○	○
The largest amount of refraction belongs to the lens. 水晶體具有最大的光線折射量。	○	○
The light beam would be more divergent when passing through the aqueous humor than the cornea. 當光束通過眼房液時其路徑會比角膜更加發散。	○	○
Considering the different diameters of the lens of *Anableps* fish, light ray 1 and 2 belong to terrestrial and aquatic spaces, respectively. *Anableps* sp具有不同直徑的水晶體，故可以同時看到空氣 - 水邊界的水生和陸地介質的場景(光束1來自陸地，光束2來自水生環境)。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 19 Tyroid Hormone Transport
甲狀腺素在體內之運輸

Thyroid hormones are transported in blood by proteins. The TBG (thyroid hormone binding globulin) is the main thyroid hormone transporting protein. Many factors affect TBG concentration such as estrogen and OCP (oral contraceptive pill), etc. OCP increases TBG concentration. T3RU (T3 resin uptake) assay is a method of quantification of unbound TBG in the blood. It indirectly measures the capacity of patients TBG to bind radioactive labeled T3. The less patients thyroid hormone level is the more radioactive labeled T3 will bound to TBG. Thus, since radioactive T3 is only detectable in unbound form, the T3RU assay result will be lower.
甲狀腺素與蛋白質結合以在血液中運輸。 TBG（甲狀腺素結合球蛋白）是主要的甲狀腺素運送蛋白。許多因素影響TBG濃度，如雌激素和OCP（口服避孕藥）等，OCP可增加血液中TBG濃度。 T3RU (T3 resin uptake)可用以量化血液中未結合的TBG。主要是間接測量患者體內TBG與放射性標記T3的結合能力。患者體內的甲狀腺激素越少，越多放射性標記的T3將會與TBG結合，因為只能測定游離態之放射性T3，所以如果患者體內甲狀腺素越少，T3RU所得結果會越低。所以T3RU之結果可用以顯示體內甲狀腺素含量。

According to the above sentences and the principle of feedback in physiology, indicate which statement is true or false.
根據上述和生理回饋原則，說明哪種敘述是對或錯。

	TRUE 對	FALSE 錯
In primary hypothyroidism, the thyroid function test would be like below: TSH increased T4 decreased T3RU decreased 原發性甲狀腺功能低下症的患者，其甲狀腺功能檢查之結果可能如下： 體內TSH含量增加 ，T4含量減少，T3RU下降	○	○
A person who use OCP and is euthyroid (normal functioning of thyroid) the thyroid function test would be like below: TSH normal T4 decreased T3RU decreased 甲狀腺功能正常的人若服用OCP，其甲狀腺功能檢查結果可能如下： 體內TSH含量正常，T4含量減少，T3RU下降	○	○
In primary hyperthyroidism the thyroid function test would be like below: TSH increased T4 Increased T3RU increased 原發性甲狀腺功能亢進的患者，甲狀腺功能檢查結果可能如下： 體內TSH濃度增加，T4含量增加，T3RU增加	○	○
In secondary hypothyroidism (pituitary dysfunction) the thyroid function test would be like below: TSH decreased T4 decreased T3RU decreased 罹患繼發性甲狀腺功能低下症（腦垂體功能障礙）的患者，甲狀腺功能檢查結果可能如下： 體內TSH濃度增加，T4含量下降，T3RU下降	○	○
In tertiary hypothyroidism (hypothalamic dysfunction) the thyroid function test would be like below: TSH normal T4 decreased T3Ru decreased 罹患三級甲狀腺功能低下（下視丘功能障礙）的患者，甲狀腺功能檢查結果可能如下： 體內TSH濃度正常，T4含量下降，T3RU下降	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

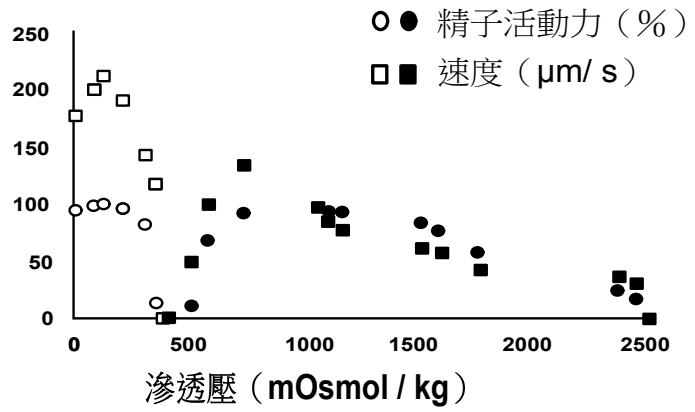
Q. 20 Sperm Motility
精子運動

Spermatozoa motility is essential for the fertilization of an oocyte. In most animals, including fish, spermatozoa are immotile in the male reproductive organ (testis or sperm duct). Spermatozoa motility is triggered after being ejaculated into the female reproductive tract (in animals with internal fertilization) or after it is released into the aquatic environment (in animals with external fertilization). Ionic composition and osmolality of freshwater, seawater, and seminal plasma of pike (*Esox lucius*), sturgeon (*Acipenser ruthenus*), and cod (*Gadus morhua*) are shown in the table. Pike and sturgeon spawn in freshwater, and cod spawns in seawater.

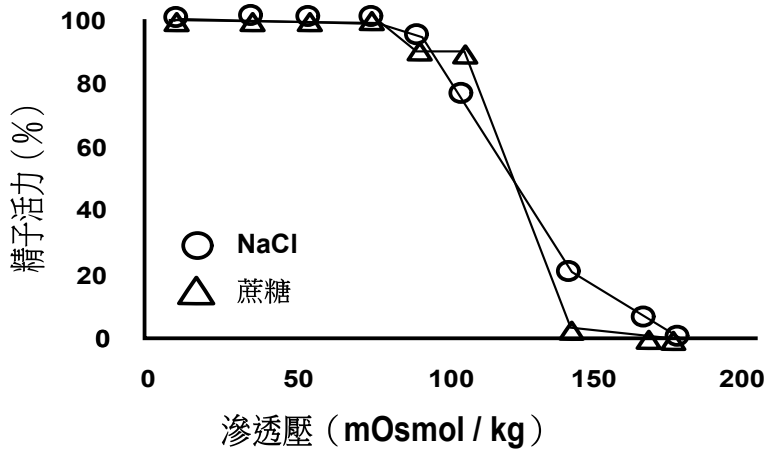
精子的運動對卵細胞的受精至關重要。在大多數動物中，包括魚類，精子在雄性生殖器官（睾丸或輸精管）中都是不動的。精子在進入雌性生殖道（體內受精的動物）或釋放到水生環境（體外受精的動物）後，才被誘發開始運動。表中顯示了梭魚（ ***Esox lucius*** ），鱘魚（ ***Acipenser ruthenus*** ）和鱈魚（ ***Gadus morhua*** ）所在水生環境(包括淡水，海水)和精液中的離子組成和滲透壓。(梭魚和鱘魚在淡水中產卵，鱈魚在海水中產卵)。

	淡水	海水	梭魚	鱘	鱈魚
Na^+ 鈉離子(mM)	0.26	469	75	20	197
氯離子 Cl^- (mM)	0.22	546	112	6	179
鉀離子K^+ （mM）	0.07	10	82	1	6
鈣離子Ca^{2+} (mM)	0.38	10	2	0.2	3
滲透壓 (mOsmol / kg）	<1-5	1000	302	51	385

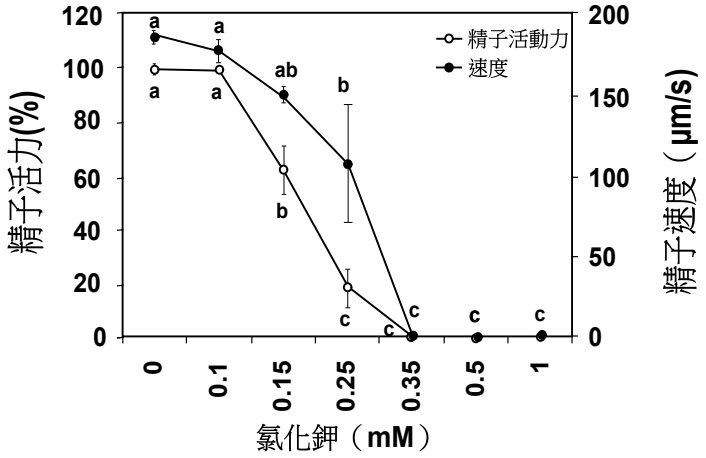
(A)



(B)



(C)



(A) 滲透壓對梭魚(空心圓)和鱈魚(實心圓)精子活動誘發之影響。 NaCl 和蔗糖用以配製梭魚精子活化介質，而 NaCl and 人造海鹽則用於配製鱈魚精子活化介質
(B)滲透壓對鱘魚(空心圓)精子活動誘發之影響。 NaCl 和蔗糖用以配製鱘魚精子活化介質
(C) 鉀離子對鱘魚精子活動之誘發及精子游動速度的影響。KCl(mM)添加於由NaCl或蔗糖配製滲透壓為 40mOsmol/kg的精子活化介質中

Use table and figures to indicate if each of the following statements is true or false.
使用表格和圖形來指出下列敘述是對或錯。

	TRUE 對	FALSE 錯
Sperm motility in pike and cod become triggered in a hypo-osmotic and hyper-osmotic environment, respectively. 梭魚和鱈魚的精子活力分別在低滲透壓和高滲透壓之環境中被誘發。	○	○

	TRUE 對	FALSE 錯
Under physiological condition, osmolality is the main factor that inhibits sperm motility initiation in sturgeon. 在生理條件下，滲透壓是抑制鱘魚精子活動被誘發的主要因素。	○	○
Sperm motility in sturgeon become triggered after discharged into a hypo-osmotic environment with lower K+ ions. 鱘魚的精子活力會被具低濃度K^+離子的低滲環境誘發。	○	○
Environmental osmolality is a key signal to trigger sperm motility initiation after release from reproductive system into aquatic environment in marine fish 環境滲透壓是海水魚將精子自生殖系統釋放到水生環境中引發精子開始活動的關鍵信號	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 21 Epstein-Barr Virus Screen 人類皰疹病毒第四型病毒的篩檢

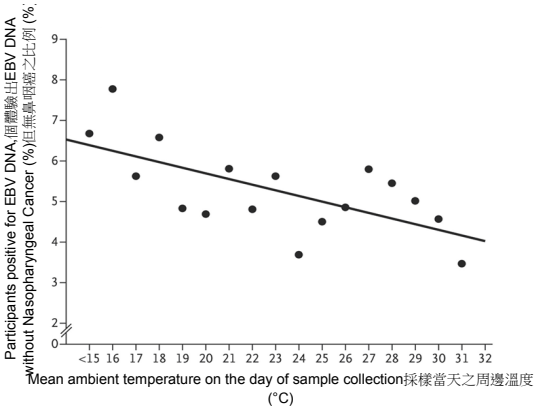
Nasopharyngeal carcinoma is closely associated with the Epstein–Barr virus (EBV) infection. In a recent prospective study involving more than 20,000 participants, detection of EBV DNA in plasma was shown to be useful in screening for nasopharyngeal carcinoma. However, 5.4% of participants without nasopharyngeal carcinoma had detectable EBV DNA in plasma at recruitment. Figure below shows the effect of ambient temperature on test results.

鼻咽癌與人類皰疹病毒第四型病毒（EBV）感染密切相關。在最近一項涉及超過20,000名受試者之前瞻性研究中，偵測血液中 EBV DNA 的含量可用於篩檢鼻咽癌。然而，其中5.4%受試者雖沒有鼻咽癌，但仍可在血液中測得 EBV DNA。

下圖顯示了環境溫度對測試結果的影響。

Sensitivity refers to the test's ability to correctly detect affected patients who do have the condition. It is calculated as: number of affected patients with positive tests/total number of affected individuals studied.
- Specificity relates to the test's ability to correctly identified those without disease. It is calculated as: number of healthy individuals with negative tests/total number of healthy individuals studied.

- 敏感性是指是否可正確檢測出患有該病症的患者的能力。
  計算方法如下：檢測出陽性結果之患者數目/病患總數。
- 專一性是指此種測試是否可正確確認不具此疾病之健康個體之能力
  其計算方法為：檢測為陰性之健康受試者數目/所研究的健康個體總數。



Based on the data above determine which of the statements is correct
根據上面的數據，判定敘述是對或錯

	TRUE 對	FALSE 錯
Based on Figure above, performing the test in warmer places will increase the specificity. 根據上圖，在較溫暖的地方進行測試將提高檢測專一性。	○	○

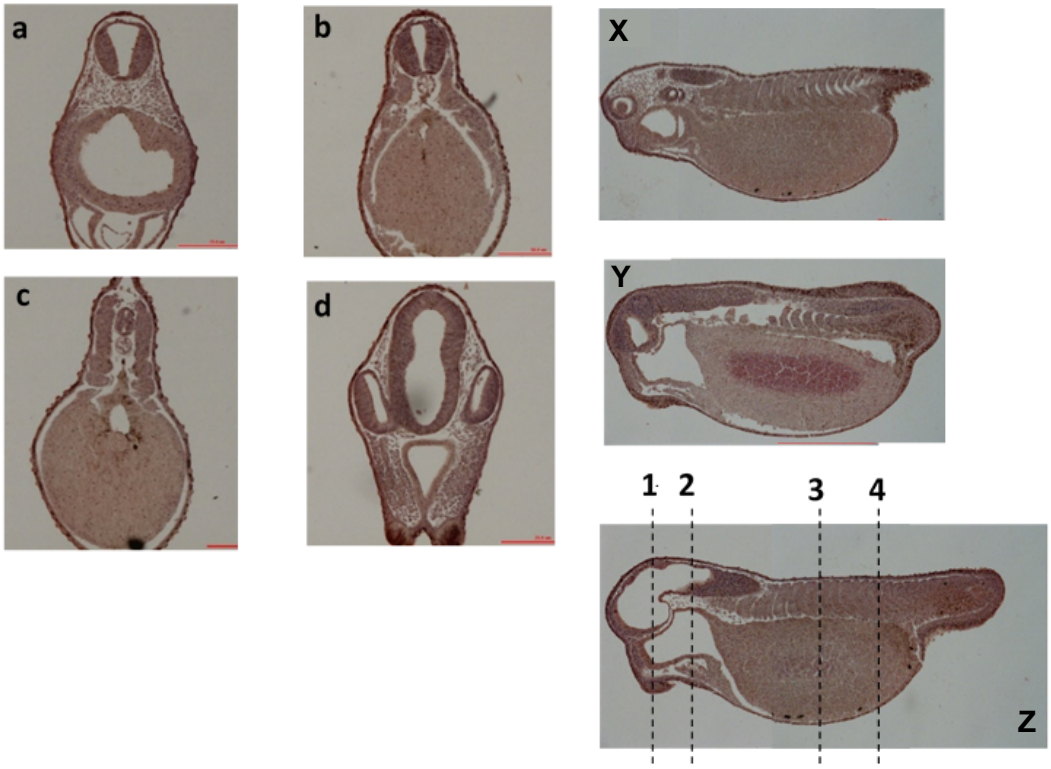
	TRUE 對	FALSE 錯
When a test becomes more sensitive, the specificity of the test will increase. 當測試變得更敏感時，測試的專一性將增加。	○	○
A 100% specific test will be 100% sensitive. 若檢測專一性為100%表示其敏感性亦為100%。	○	○
To rule out a disease, it is better to use a test with high sensitivity instead of a test with high specificity. 為了排除是否罹患特殊疾病，最好使用具有高敏感性之測試方法而不是高專一性之測試方法。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 22 Frog Embryo Morphology
蛙類的胚胎形態

Figures X, Y , Z show the sagittal sections (the plane which divides body into left and right parts) of a frog embryo from the surface to the depth, respectively. Figures a-d are cross sections of the same embryo shown in Figure Z.

Figures X, Y, Z 顯示縱切面(剖成兩半)，Figures a-d顯示Z圖中四個點的橫切面(沒有照順序)。



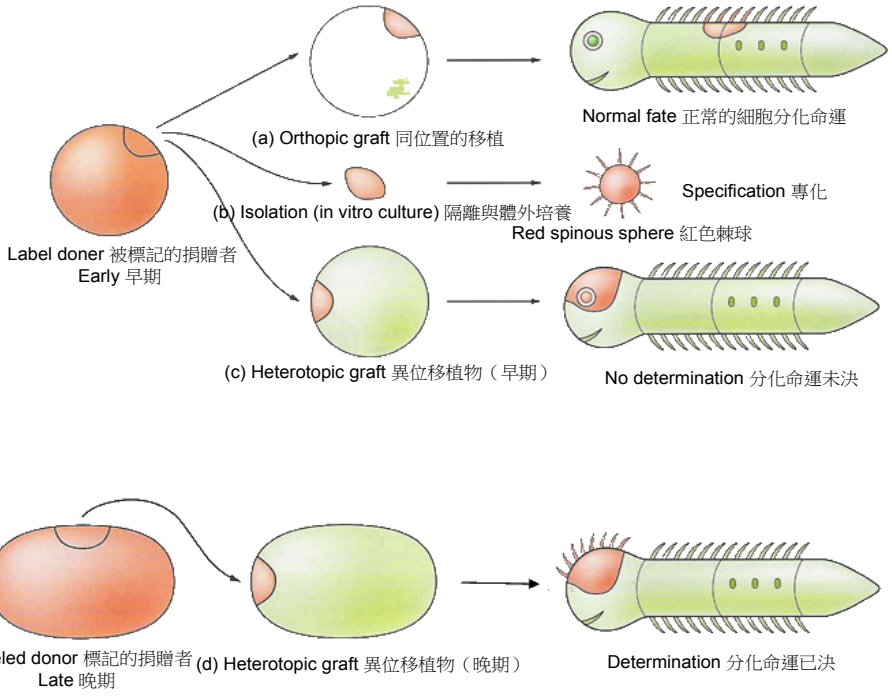
Based on the above figures, indicate if each of the following statements is true or false.
根據上面的圖片，指出下列敘述是對或錯

	TRUE 對	FALSE 錯
Figure “a” is the cross section from region “1 “. a = 1	○	○
Figure “b” is the cross section from region “3 “. b = 3	○	○
Figure “c” is the cross section from region “4 “. c = 4	○	○
Figure “d” is the cross section from region “2 “. d = 2	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 23 Heterotopic Grafting
異源細胞移植

The early embryonic cells pass through two stages of differentiation: specification and determination.
早期胚胎細胞經歷兩個分化階段：細胞分化的專化和與細胞分化命運的決定。



Based on the results of the experiments a-d, indicate if each of the following statements is true or false.
根據實驗結果，指出以下列敘述是對或錯。

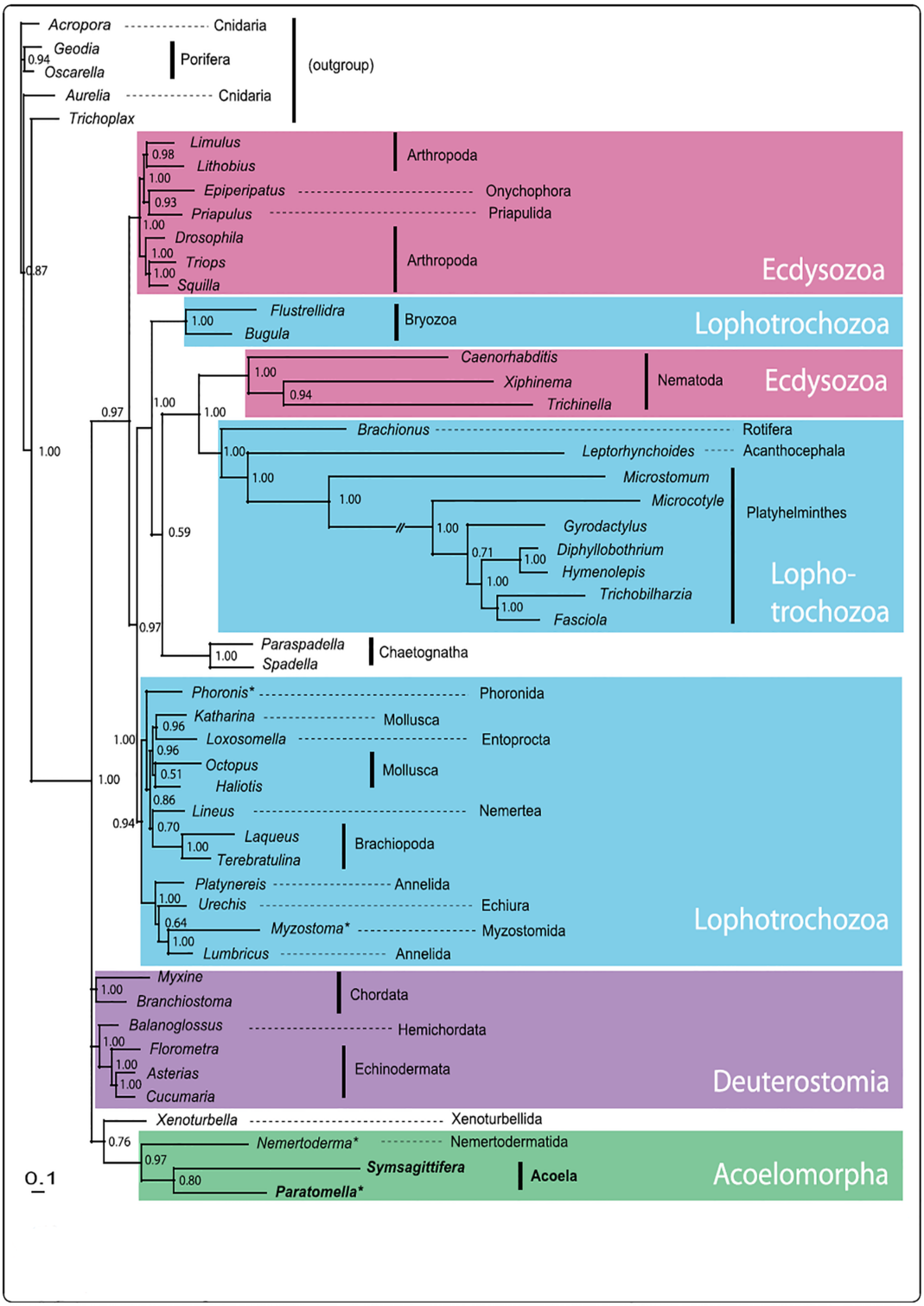
	TRUE 對	FALSE 錯
This data supports that the fate of the determined cell is not reversible. 這些數據支持細胞的分化命運是不可逆的。	○	○
The cell that is specified loses its other differentiation potentials 已經專化的細胞就會失去其他分化潛能	○	○
If the graft is removed at the late stage and cultured in isolation, it will give rise to the red spinous sphere (shown in the picture) 如果移植物在晚期移除並隔離培養，則會產生紅色棘球（如圖所示）	○	○
If the graft is removed at the late stage and cultured in the presence of the eye including factors, the eye-like structure will be developed. 如果移植物在晚期移除，並在具有眼睛誘導因子存在下培養，則將形成類似眼的結構。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 24 Phylogenetic position of *Symsagittifera* 薄荷醬蟲的親緣關係地位

Uljanin in 1870, discovered a group of marine, soft-bodied, unsegmented hermaphroditic worms without hindgut and coelom. The mouth in these worms opened to a central digestive parenchyma. They moved with their multiciliated epidermis, although, many were ‘surprisingly muscular’. Most of the species were free-living and some were ectocommensals. It has now been showed that several species form obligate symbioses with green algae, making them functional photoautotroph organisms. Later, phylogenetic position of these multicellular animals was studied using the complete mitochondrial genome of a member of this group (*Symsagittifera roscoffensis*) which has been given in the figure below.

Uljanin於1870年發現了一群沒有後腸和體腔、無體分節、身體軟趴趴、還雌雄同體的蠕蟲。牠們的嘴巴開口朝向中央消化道薄壁組織。牠們使用多纖毛的表皮移動，有時候肌肉發達。大多數種類都是自由生活的，有些是外共棲性的。有些物種與綠藻形成專一性共生，使它們成為光合自營生物。薄荷醬蟲（*Symsagittifera roscoffensis*）的完整粒線體基因體資訊提供了這類動物的系統發育位置資訊，見下圖。



Indicate if each of the following statements is true or false:
指出下列敘述是對或錯

	TRUE 對	FALSE 錯
Based on this tree, Acoelomorpha is a sister group of Deuterostomia. 無腔動物門是後口類的姊妹群	○	○
Based on the above given description, the identified worm is a triploblastic acoelomate. 薄荷醬蟲具有三胚層	○	○

	TRUE 對	FALSE 錯
Based on the above given text, the identified worm has incomplete digestive system. 薄荷醬蟲具有不完整的消化系統	○	○
The provided data is consistent with the hypothesis that the identified worm belongs to the earliest diverging lineage of Bilateria. 薄荷醬蟲是兩側對稱動物最早就分化出來的支系	○	○

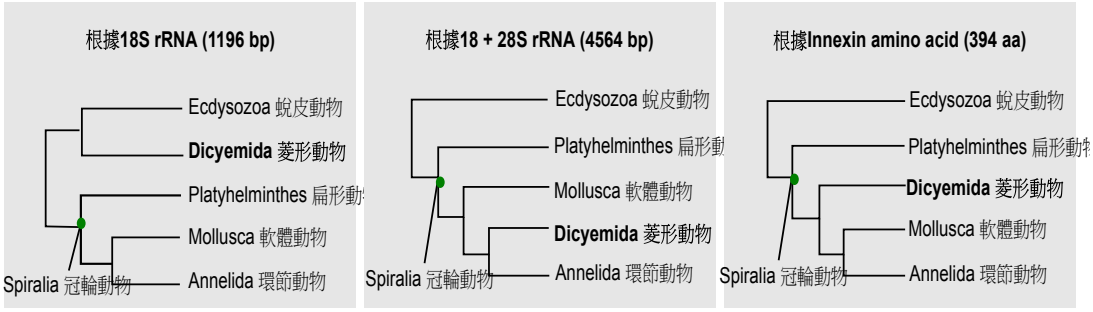
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 25 Phylogenetic Position of Dicyemids
菱形動物門在動物界內的親緣關係

In 1876, van Beneden, found a group of microscopic ciliated wormlike organisms that inhabited the renal sacs of cephalopods, mainly octopuses and cuttlefishes and named them as Dicyemids. They have long fascinated biologists because of their highly-simplified body organization and enigmatic life cycles of asexual (under normal condition producing vermiform larva in host kidney) and sexual (under crowded condition producing infusiform larva excreted in host urine). These ciliated animals are composed of approximately 20-30 (or 40) cells arranged in two layers, and they lack coeloms, circulatory systems, and other differentiated tissues and their embryos employ spiral cleavage. Due to their simple body plans, it can be considered as intermediates between the Protozoa and the Metazoa.

菱形動物(dicyemids)是在1876年所發現的一群有纖毛的動物。牠們寄生在頭足類的腎囊中。牠們的身體高度簡化且行無性生殖。在一般情況下，會在宿主腎臟中產生蠕蟲狀幼蟲，但也會行有性生殖(會產生由宿主尿中排泄出去的滴蟲型幼蟲）。

牠們由約 20-30（或40）個細胞排列成兩層，沒有體腔，循環系統和其他組織，它們的胚胎是螺旋卵裂。因為牠們長得很簡單，所以在19世紀曾經被認為是多細胞動物與原生動物(現已不存在類群)的中間型。



The phylogenetic position of dicyemids suggested by previous phylogenetic studies remains controversial
先前數個研究指出菱形動物的親緣關係仍有爭議

Based on these data and Figure, indicate if each of the following statements is true or false.
根據上圖，指出下列敘述是對或錯

	TRUE 對	FALSE 錯
Based on the above explanations, infusoriform larva is a mean of dispersal for these animals. 根據以上的解釋，菱形動物的滴蟲型幼蟲有利物種擴散	○	○
Based on the above molecular data, these animals are missing link between Metazoa and protozoa. 根據以上的分子證據，菱形動物是多細胞動物與"原生動物"的缺失的環。	○	○
Based on the data, these described animals faced a regression evolution during its evolutionary history. 根據這些數據，菱形動物在演化過程中經歷了許多器官的退化。	○	○

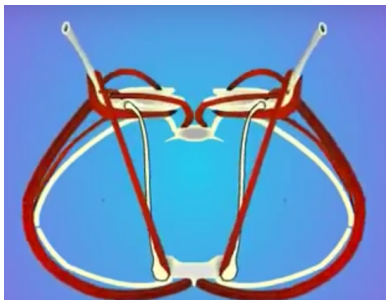
	TRUE 對	FALSE 錯
Based on the given data, it is more likely that Dicyemida is more closely related to Mollusca than to Ecdysozoa. 根據以上資訊，菱形動物相對來說比較接近軟體動物，而不是蛻皮類動物	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

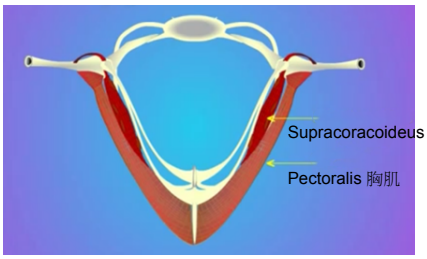
Q. 26 Flight Apparatus of Birds and Bats 鳥類與蝙蝠的飛行結構

The figures 1-4 illustrate the schematic cross-sectional anatomy of bones and flying muscles of a bird and a bat.
Figures1-4 顯示鳥與蝙蝠飛行肌與相關骨骼的橫切面解剖圖示。

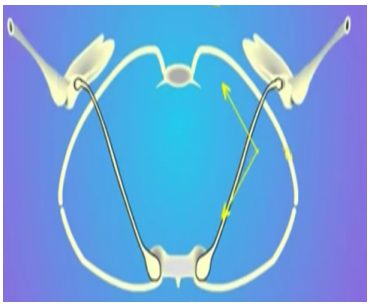
(1)



(3)



(2)



(4)

According to the structures in the figures, indicate which of the following statements are true or false:
根據圖中所示結構，指出下列敘述是對或錯

	TRUE 對	FALSE 錯
Figure 1 and 2 are the bat structures. 圖1與2是蝙蝠結構	○	○
The animal of figure 1 and 2 has seven cervical vertebrae. 圖1與2中的動物有七塊頸椎	○	○
In figure 1 and 2 the only mobile joint, which is involved in wing's flapping is scapula-humoral. 圖1與2中，與翅膀拍動有關的可動關節只有肩胛骨-肱骨	○	○
The muscle supracoracoideus in figure 3, is responsible for downstroke movement in flapping cycle. 振翅運動中的下拍只由圖3的胸小肌負責	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

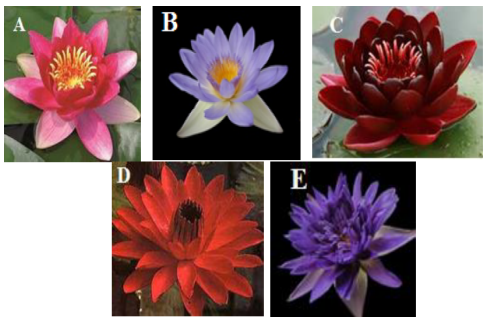
PLANT PHYSIOLOGY 植物生理

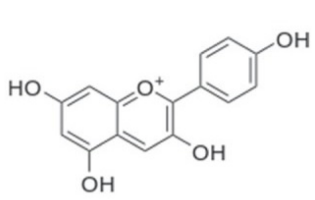
Q. 27 Anthocyanins 花青素

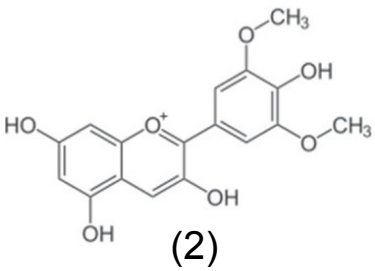
Anthocyanins are vacuolar pigments that consist of two phenyl rings and one heterocyclic ring. They are the source of red to blue colors of flowers and fruits. Changes of vacuolar and soil pH, formation of complexes with metal ions, and introduction of -OH groups particularly at 3′ and 5′ positions and subsequent methylations at these positions all result in production of variations in the colors of the pigments.

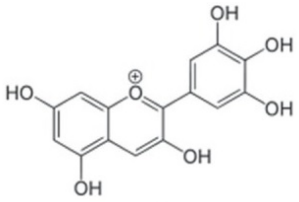
花青素是液泡色素，由兩個苯環和一個異環組成。它們是花和果實的紅色到藍色的來源。液泡和土壤pH的變化、與金屬離子形成的複合物、特別是在3'和5'端引入-OH基，以及隨後在這些位置的甲基化，都導致色素顏色變化的產生。

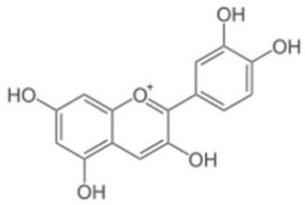
For example, increase in the number of hydroxyl groups or complex formation with metal ions shifts absorption of the pigments to longer wavelengths, whereas methoxyl groups (OCH3) shift absorption to a slightly shorter wavelengths. Given that plargonidin (1) is the most abundant pigment in the variety A of Tropical Water Lily flowers (*Nymphaea* spp.) indicate if each of the following statement is true or false.
例如，羥基或與金屬離子形成複合物的數量增加會讓色素的吸收轉移到更長的波長，而甲氧基（OCH_3）則將其吸收轉移到稍短的波長。由於plargonidin(1) 是熱帶睡蓮品種A中最豐富的色素，指出下列敘述的對錯。

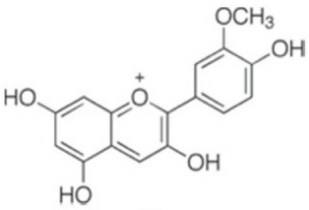


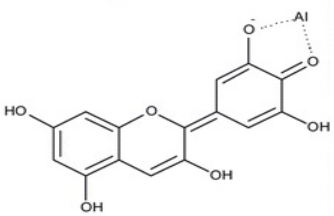

(1)


(2)


(3)


(4)


(5)


(6)

Indicate if each of the following statement is true or false.
指出下列每個敘述是對或錯

	TRUE 對	FALSE 錯
Pigment 3 is the most abundant pigment in flower E. 在品種E的花中，色素 3是最豐多的色素。	○	○
In *Nymphaea* variety C, pigment 4 is more abundant than 5. 在熱帶睡蓮品種C中，色素4比5更豐多。	○	○
Compared to the other flowers, pigment 6 is mostly abundant in flower D. 與其他品種的花相比，品種D中的色素6最豐多。	○	○
The color of flower B is explained by presence of higher levels of pigment 2 as compared to pigment 1. 與色素1相比，品種B的花色是由於色素2的量較多之故。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 28 Boron as Micronutrient
硼是微量營養素

Boron (B) is an essential micronutrient for plants. Its uptake, transport, and function in plants appear to be dependent on the formation of B complexes with sugars, such as sorbitol in phloem sap (Fig. 1) and a specific dimerized form of pectin in growing cell walls. Yokota and Konishi (1999) studied the effect of various exogenously supplied sugars including sucrose, glucose, and fructose on promotion of pollen tube growth by formation of sugar-borate complexes. Pollens were cultivated at different concentrations of B for 20 hours. Effect of sugars on the pH of the media is shown in Table 1, and the length of pollen tubes incubated with the various sugars is shown in Fig. 2.
硼（B）是植物必需的微量營養素。它在植物中的攝取、轉運和功能似乎取決於B與糖形成的複合物，例如韌皮部汁液中的山梨糖醇(sorbitol)（圖1）和在生長中的細胞壁裡特定之二聚形式的果膠。
Yokota和Konishi（1999）藉由糖 - 硼酸鹽複合物之形成，來研究不同之額外添加的糖（包括蔗糖、葡萄糖和果糖）對促進花粉管生長的影響。將花粉在不同濃度的B下培養20小時。糖對培養基pH的影響如表1所示，而與不同糖一起培養的花粉管所生長的長度如圖2所示。

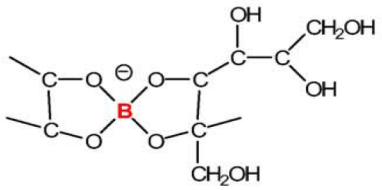
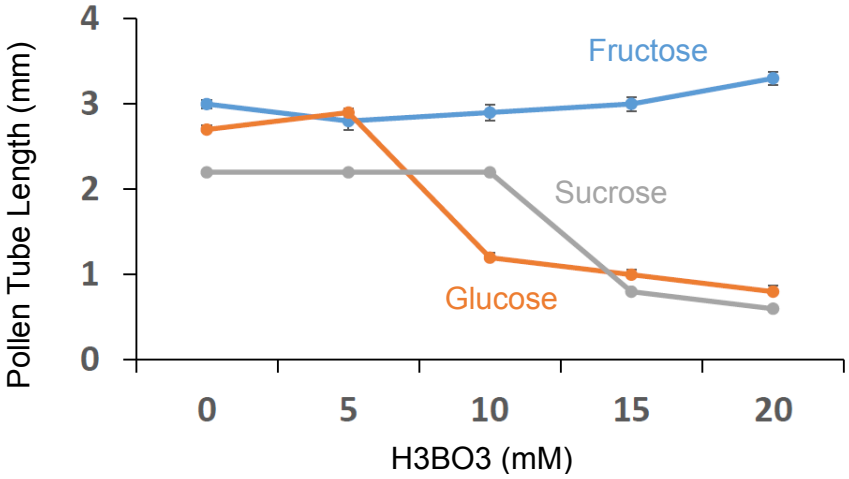


Figure 1. Boron-Sorbitol complex 硼 - 山梨醇複合物

Table 1. Changes of the pH values of the pollen culture media containing different sugars after adding boric acid at different concentrations (first row).
添加硼酸後，含有不同糖的花粉培養基之pH值變化。所添加之硼酸鹽濃度不同 (第一列)。

H_3BO_3 硼酸 (mM)	**0**	**5**	**10**	**20**
Sucrose 蔗糖	5.2	5.2	5.0	4.9
Glucose 葡萄糖	5.2	4.7	4.5	4.3
Fructose 果糖	5.0	3.7	3.5	3.4



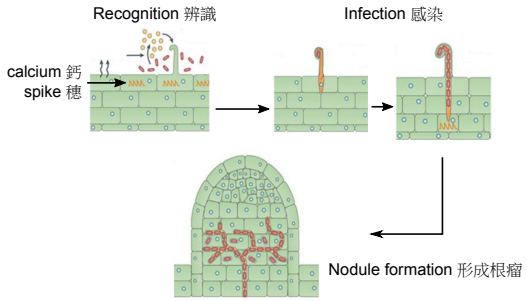
Indicate if each of the following statement is true or false.
指出下列每個敘述是對或是錯。

	TRUE 對	FALSE 錯
Growth inhibition of pollen tubes by high concentrations of B is more pronounced in medium containing sucrose as compared to fructose. 與果糖相比，高濃度的B對花粉管生長之抑制在含有蔗糖的培養基中更明顯。	○	○
At lower B concentrations (5 mM), growth inhibition of pollen tubes was more pronounced in medium containing glucose as compared to the other sugars. 在低的B濃度 (5 mM)下，與其他糖相比，含有葡萄糖的培養基中花粉管之生長抑制更明顯。	○	○
Inhibitory effects of fructose on pollen tube growth increased with increasing concentrations of B. 隨著 B濃度的增加，果糖對花粉管生長的抑製作用增強。	○	○
Based on effects of sugar on pH of the media, relative levels of sugar-B complex formation is as follows: Sucrose < Glucose< Fructose. 根據糖對培養基pH的影響，糖-B複合物形成的相對含量如下：蔗糖<葡萄糖<果糖。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 29 Nitrogen Fixation 固氮作用

Nitrogen is an important nutrient for all plants. While there is an abundance of nitrogen (N_2) in the atmosphere, most plants are unable to convert N_2 into a usable form. Fixation of nitrogen gas into ammonia is an ability restricted to nitrogen-fixing bacteria. The figure below shows prerequisite step for nitrogen fixation through symbiosis between these bacteria and some plant species.
氮是所有植物的重要營養素。雖然大氣中有大量的氮（N_2），但大多數植物不能將N_2轉化為可用的形式。只有固氮細菌才能將氮氣固定到氨中。下圖顯示這些細菌與某些植物間的共生步驟，此即固氮作用的過程。



ndicate if each of the following statements is true or false.
指出下列每個陳述是對或是錯。

	TRUE 對	FALSE 錯
Between two major inorganic nitrogen forms, NH_4^+ and NO_3^- which the former is mobile in the plant, while the latter is not. 兩種主要的無機氮離子，NH_4^+和NO_3^- ，前者可在植物中移動，而後者則不能。	○	○
Immediately after recognition of plant by bacteria and recognition of bacteria by host plant, a calcium spike occurs in the root cells. 在通過細菌識識植物及宿主植物識識細菌之後，立即在根細胞中發生鈣穗。	○	○
The plant hormone cytokinin is needed for initiation of nodule formation. 植物激素細胞分裂素是引起結節形成所必需的。	○	○
Release of bacterial exopolysaccharides is the necessary and sufficient condition for a functional symbiosis between rhizobia and its appropriate host. 細菌胞外多醣的釋放是根瘤菌與其適當宿主之間功能性共生的必要和充分條件。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 30 Photosynthesis 光合作用

Arabidopsis thaliana was used in a study on photosynthesis. *A. thaliana*plants of same age, with leaf blades of equal shape and size, were placed under various light sources that emitted different colors. Three plants were exposed to each light source. The groupings of were as follows:

阿拉伯芥（*Arabidopsis thaliana* ）是研究光合作用的材料。 將具有相同形狀和大小的葉片之同年齡阿拉伯芥植株放置在不同色光下。將三株植物暴露於每種光源。其分組如下：

Group a: blue light 藍光	Group d: blue and red 藍及紅光
Group b: green light 綠光	Group e: yellow and green 黃及綠光
Group c: red light 紅光	

After 5 days of illumination at equal intensity comparable to normal day light, in terms of total amount of photons and duration, the plant's physiological parameters were compared. The compensation point was measured using sunlight.
相較於一般日照，在相同強度照光5天後，就光子總量和照射時間而言，比較植物的生理參數。在太陽光下，測量植物之光補償點。

Indicate if each of the following statement is true or false.
指示下列每個敘述是對或是錯。

	TRUE 對	FALSE 錯
The plants of group “a” showed the highest photosynthesis rate. “a”組的植物顯示出最高的光合作用速率。	○	○
Among the various groups, the light compensation point for CO_2 fixation was the lowest for group “b”. 在各組中，“b”組之固碳作用的光補償點最低。	○	○
The biomass of group “d” plants was higher than group “c” plants. “d”組植物的生物量高於“c”組植物。	○	○
At light intensities just above the compensation point, the rate of photosynthesis of group “e” is expected to increase linearly with light. 在剛好高於補償點的光強度下，“e”組的光合作用速率應該會隨光呈線性增加。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 31 Aquatic Flowering Plants 水生開花植物

Some flowering plants are aquatic and have adapted to live in aquatic environments. They are divided into 3 types, depending on how much of the plant is normally positioned inside or outside of the water. These groups include emergent, floating, and submerged plants. The organs of submerged aquatic plants grow completely under water.
有些開花植物是水生的，且適於生活在水生環境中。它們依通常位於水中或高出水面而分為3種類型。這些類群包括出水性、漂浮性和沈水性植物。沈水植物的器官完全在水中生長。

Indicate if each of the following statements is true or false for submerged plants.
指出下列每個對沉水植物的敘述是對或是錯。

	TRUE 對	FALSE 錯
They do not have xylem as they can absorb water from all of their surfaces. 它們沒有木質部，因為它們可以從其所有體表吸收水分。	○	○
Given that some species do have stomata, their opening and closing of the stomata is not expected to be driven by circadian rhythm. 由於某些物種確實有氣孔，氣孔的開與閉應該不會受到晝夜節律的驅動。	○	○
These plants are heterophyllous, with thin and dark green leaves. 這些植物具有因應水下生活而產生的異型葉，其具有薄而深綠色的葉子。	○	○
These plants have a well-developed supporting mechanical tissues with thick walls. 這些植物具有發育良好的機械性支撐組織，其具有厚壁。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 32 Speciation and Extinction in Saxifragales
虎耳草目植物的種化和滅絕

An important question in the evolution of angiosperms is the influence of life form and habit on speciation and extinction. In a phylogenetic study of the morphologically highly diverse plant order Saxifragales, the effect of habit and life history on speciation and extinction was investigated. Figures A-F illustrates estimates of speciation (λ) and extinction (μ) rates in annual, perennial, herbaceous, and woody lineages (Soltis et al., 2013). The results are given as posterior probability density, which reflect the uncertainty associated with parameter estimates. Dashed lines represent the median values of each distribution. Net diversification rate, $r = \lambda - \mu$.

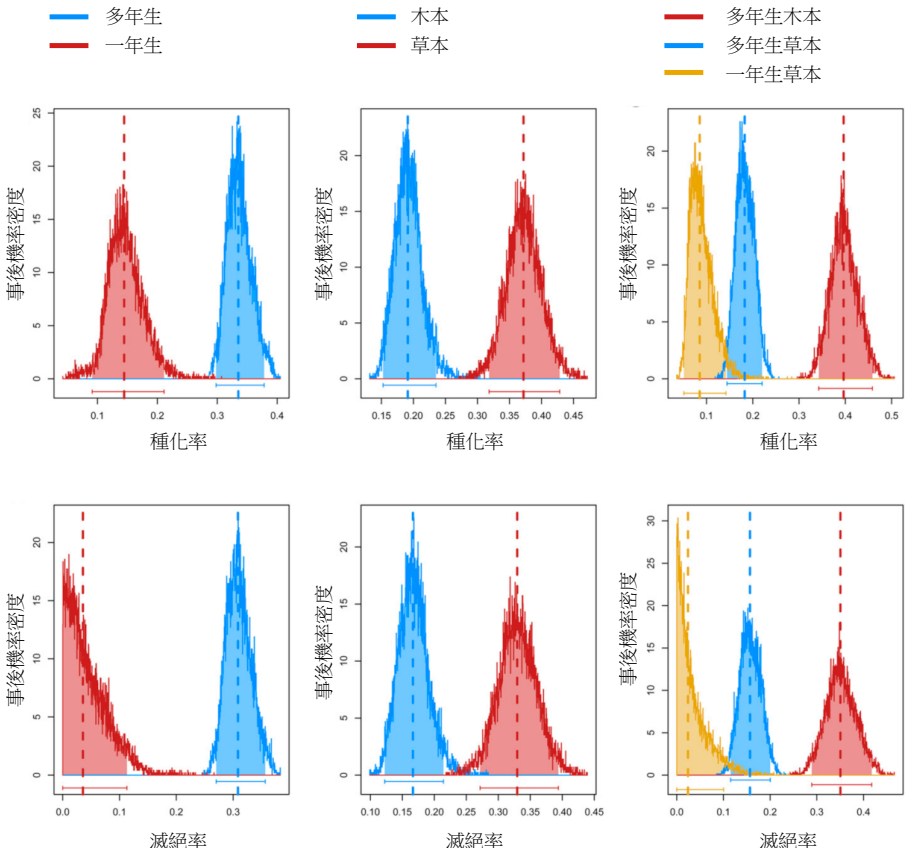
Posterior probability density is a function that use to specify the probability of the random variable falling within a particular range of values. Range of value, as oppose to taking on any one value.

被子植物演化過程中的一個重要問題是生活史型式和習性對種化和滅絕的影響。在形態高度多樣的虎耳草目之系統發生研究中，學者研究了習性和生活史對種化和滅絕之影響。

圖A-F顯示了一年生、多年生、草本和木本支系的種化率（λ）和滅絕率（μ）（Soltis等，2013）。而這些演化事件的事後機率密度 (posterior probability density)一併被提供，這個參數的功能是反映出變量估計的不確定性。

虛線代表每個分佈的中位數。淨分歧率 $r = \lambda - \mu$。

”事後機率密度”是用來檢定逢機變量落在特定範圍值內的機率，該值的範圍非任何特定值。



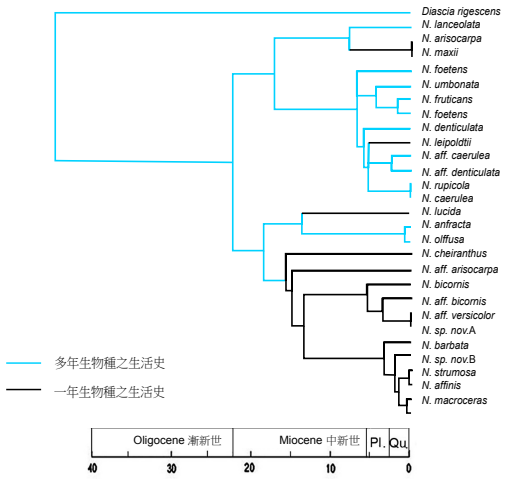
Indicate if each of the following statements is true or false.
指出下列每個敘述是對或是錯。

	TRUE 對	FALSE 錯
Among different lineages, woody lineages have higher speciation (λ) and extinction (μ) rates. 在不同的支系中，木本支系具有較高的種化率（λ）和滅絕（μ）率。	○	○
Results are consistent with the idea that shorter generation time causes higher speciation rate. 實驗結果與較短世代會導致較高種化率的觀點一致。	○	○
As compared to the other groups, herbaceous perennial lineages have higher rates of net diversification. 與其他類群相比，草本多年生的支系具有較高的淨分歧率。	○	○
Generation time and breeding systems affect rates of diversification. 世代時間和繁殖系統會影響分歧率。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 33 Evolution of Annual vs Perennial Life-Histories
一年生與多年生活史的演化

Phylogenetic relationship among several species of the genus *Nemesia* (Scrophulariaceae), accompanied with geological time scale, is shown below. Predicted states for annual/perennial life-history have been mapped to the tree. Annual life-history is shown in black and the perennials are shown in blue (from Datson et al., 2008).
Nemesia 屬（玄蔘科 Scrophulariaceae）幾個物種之間的親緣關係，連同地質時代，如下圖所示。一年生/多年生的生活史的預測狀態已被標定在樹狀圖上。一年生之生活史以黑色表示，多年生者以藍色表示（Datson等，2008）。



Indicate if each of the following statements is true or false.
指出下列每個敘述是對或是錯。

	TRUE 對	FALSE 錯
The phylogenetic tree suggests that *Nemesia* originated during the Miocene, but the majority of extant *Nemesia* species radiated during the Pliocene and Quaternary. 該樹狀圖顯示 *Nemesia* 起源於中新世 (Miocene)，但大部分現存的 *Nemesia*物種是在上新世 (Pliocene) (Pl.) 和第四紀(Quaternary) (Qu.) 期間發生輻射種化。	○	○
The phylogenetic tree suggests that the most recent common ancestor of *Nemesia* had an annual life form. 該樹狀圖顯示 ， *Nemesia*的最近共同祖先是一年生的形式。	○	○
The phylogenetic tree does not show shift from annual to perennial habit. 該樹狀圖沒有表現出從一年生轉移到多年生的習性。	○	○
Diascia rigescens is the ancestral species of all other taxa in this phylogenetic tree. *Diascia rigescens*是該樹狀圖中所有其他分類群的祖先物種。	○	○

COMMENTS MAXIMUM POINTS STUDENT POINTS

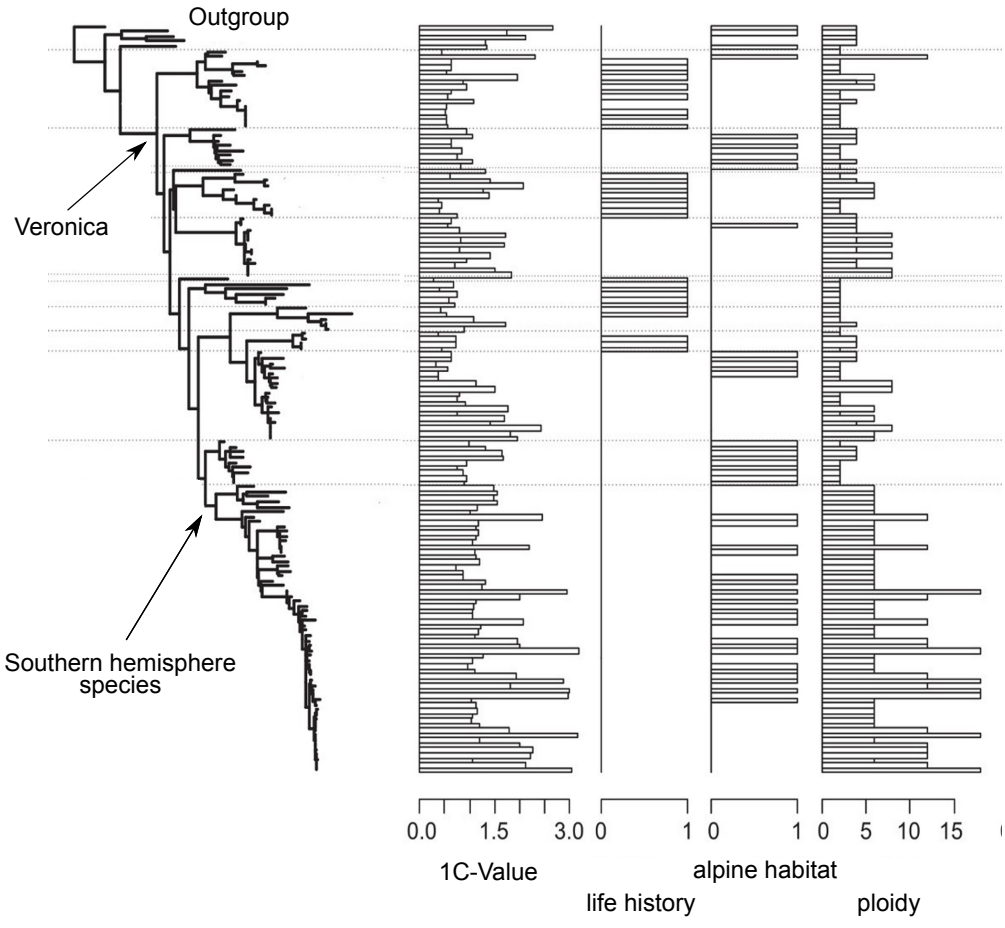
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 34 Polyploidy in *Veronica*
*Veronica*屬植物的多倍體性

Correlation between genome size in polyploid and diploid lineages and life history and occupation of alpine habitat for the genus *Veronica*(Plantaginaceae) were investigated (Meudt et al., 2015). The genus primarily originated in northern hemisphere. The phylogenetic tree below includes variables of interest including:
研究了多倍體和二倍體支系的基因組大小與 *Veronica* 屬（車前草科；Plantaginaceae）在高山棲地的生活史之間的相關性（Meudt等，2015）。該屬主要起源於北半球。下面的系統發生樹涵蓋不同的變種，包括：

1C-value (amount of DNA contained in a haploid genome)
life history (annual: bar; perennial: no bar)
habitat (non-alpine: no bar; alpine: bar)
ploidy (2*x* to 18*x*).

1C-值（單倍體基因組中含有的DNA量）
生活史（一年生：橫條；多年生：無橫條）
棲息地（非高山：無橫條；高山：橫條）
倍體數（2 *x* 至 18 *x* ）。



Based on the above Phylogenetic tree and data indicate if each of the following statements is true or false.

根據上述樹狀圖及數據，指出以下每個陳述是對或是錯。

	TRUE 對	FALSE 錯
All the Southern hemisphere species are polyploid. 所有南半球物種都是多倍體。	○	○
Polyploidy is always accompanied by genomic upsizing. 多倍體性總是伴隨基因組的增大化。	○	○
Transitions from annual to perennial life history can be accompanied by migration to the higher elevations or cooler climates. 從一年生到多年生生活史的轉變可伴隨著遷移到更高海拔或更涼爽的氣候。	○	○
Annual species are never found in alpine habitats. 在高山棲息地中從未發現一年生物種。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 35 Kleptoplasty 竊取葉綠體的共生行為

Chloroplast symbiosis or kleptoplasty refers to a naturally occurring process that results in maintenance of chloroplasts of one species in host cells of another species. This process has occurred in sacoglossan sea slugs (Figure 1: Pierce and Curtis, 2012). Cells that line the digestive diverticula of the slugs maintain chloroplasts that originated from algal food. Sea slug species with these chloroplasts are able to tolerate starvation for periods up to one year. It has been shown that some sea slugs are able to retain functional plastids for a year or more, or even to the end of their life.

"葉綠體共生"或"竊取葉綠體的共生行為"(kleptoplasty)乃指在天然狀況下，葉綠體能在其"宿主"中維持功能的現象。這個現象出現在"囊舌類"的海蛞蝓體內（圖1：Pierce & Curtis，2012）。

海蛞蝓在啃食藻類以後，其消化憩室中的細胞還保有來自藻類的葉綠體。具有這些葉綠體的海蛞蝓物種變能夠忍受飢餓長達一年。有一些海蛞蝓能夠保留功能性質體長達一年或更長的時間，甚至可以終身保留。

Several hypotheses were tested to find the mechanisms behind this kind of symbiosis. All earlier attempts to locate algal nuclei in such sea slugs failed. However, recent studies have demonstrated presence of *Vaucheria litorea* algal nuclear genes in genomic DNA of the larvae of the slug *Elysia chlorotica* which have never fed on *V. litorea.* Note that use of animal proteins by chloroplasts seems implausible.

為瞭解這種機制，科學家已經檢測了多套假說。其中一個假說就是"藻類是否有可能因此與動物產生內共生"，早期的研究並沒有在海蛞蝓細胞找到藻類的細胞核。

但是最近的研究發現，從未吃過無隔藻(*Vaucheria litorea*)的綠葉海天牛(*Elysia chlorotica)* 幼體的基因組中居然有該種藻類的的核基因。

請注意，葉綠體無法利用動物蛋白來維持其存在。

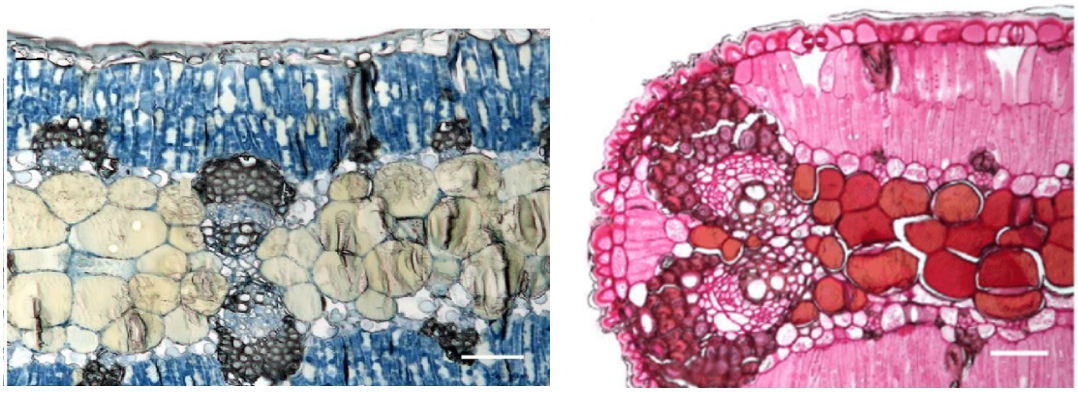
Based on the given data indicate true/false statements.
根據所提供的數據判斷下列敘述的對或錯。

	TRUE 對	FALSE 錯
Horizontal gene transfer might have resulted in transfer of certain genes of the harvested chloroplast into the genome of some slugs, particularly in slugs that have maintained chloroplasts for long periods of time. 海蛞蝓基因體中之所以有藻類核基因是因為水平轉移的關係，尤其是長期保留葉綠體的海蛞蝓。	○	○
Activity of lysosomal enzymes in host cells must be minimal in order to prevent chloroplast ingestion. 海蛞蝓細胞中溶體酵素的活性必須很小才能防止攝入後破壞葉綠體。	○	○
The sea slugs with algal chloroplasts also need algal mitochondria to ensure a source of energy during periods of starvation. 具有藻類葉綠體的海蛞蝓也需要藻類的粒線體，以確保在飢餓期間的能量來源。	○	○
Nuclear algal RNA present in ingested chloroplasts could somehow persist for as long as one year in the sea slug. 被攝入的葉綠體中所存在的藻類核RNA，可能會在海蛞蝓體內以某種方式持續長達一年。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 36 Angiosperm Morphology 被子植物形態學

The following figure shows two histological sections of an organ from an angiosperm plant. The tissue section on the left was prepared from the medial part of the organ, whereas the section on the right was from the lateral part.
下圖顯示被子植物器官的兩個組織切片。左側的組織切片是取自器官的中段部分，而右側的部分則取自側面部分。



ndicate whether the following statements are true or false.
指出以下敘述是對或是錯。

	TRUE 對	FALSE 錯
The sections were prepared from a monocotyledonous plant. 切片取自單子葉植物。	○	○
The sections represent a modified stem. 這些切片代表一變態莖。	○	○
Transpiration occurs in this organ. 此器官有蒸散作用。	○	○
The vascular bundles are of bicolateral type, meaning that phloem is present on both sides of xylem. 維管束是複並列型的，亦即其韌皮部存在於木質部的兩側。	○	○

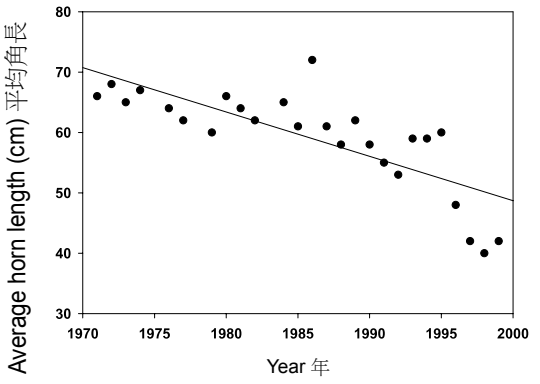
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

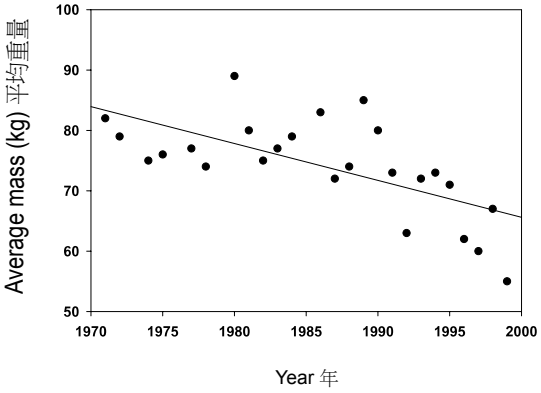
ECOLOGY AND EVOLUTION
生態與演化

Q. 37 Trophy Hunting in Bighorn Sheep 大角羊的戰利品狩獵政策

Bighorn sheep (*Ovis canadensis*), the males of which are famous for their magnificent curl of horns, live in North America. Their hunting was restricted in 1970. This restriction made trophy rams (males with large and fully-curved horns) extremely valuable, sometime costing over $100,000 to be hunted. Funds raised in this way were used for preserving bighorn habitats.
大角羊(*Ovis canadensis*)，其雄性以其壯麗的角狀捲曲而聞名，生活在北美洲。他們的狩獵在1970年被限制。這種限制使得可獲得獎牌等級的公羊(具有大而完全彎曲的角的雄性)非常有價值，有時需要花費超過10萬美元才能被獵殺。以這種方式籌集的資金用於保護大角野棲息地。

Coltman and his colleagues (2003) showed that there is a relationship between year and decrease of mean mass and mean horn length of bighorn sheep in Alberta, Canada where trophy hunting was conducted over 30 years.
Coltman等人發現，加拿大艾伯塔省的大角羊被狩獵了超過30年，年份與大角羊的平均重量以及平均角長度減少之間有關連。





Indicate if each of the following statements is true or false.
指出下列敘述是對或錯。

	TRUE 對	FALSE 錯
The observed changes in the mean mass and horn length imply a reduction in the bighorn sheep population. 觀察到的平均重量和角長度的變化意味大角羊群數量在減少。	○	○

	TRUE 對	FALSE 錯
Phenotype-based selective harvest can change population characters if it targets heritable traits. 選擇性捕捉移除具有特定表型特徵的動物，會改變該族群的這個表型特徵，如果這表型特徵是會遺傳的。	○	○
If variation in horn size is mainly due to additive genetic interactions, the heritability (the portion of the phenotypic variance explain by genotype variance) for this trait would decrease over time. 如果角大小的變化，主要是由加成性(additive)遺傳交互作用所決定，則該性狀的遺傳力(表型變異可被遺傳變異解釋的程度)會隨著時間的推移而降低。	○	○
By hunting males with longest horns, the variance in the reproductive success of the males increases. 捕獵具有最長角的雄性，雄性繁殖成功的變異程度(variance)會增加。	○	○
The trends establish genetic correlation between horn length and mass. 這樣的趨勢變化代表角長和重量之間有遺傳相關性。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 38 Haldane's rule
霍爾登式遺傳法則

J. B. S. Haldane (1892 - 1964), one of founders of the modern evolutionary biology, stated that if among hybrid offspring one sex is absent, rare, or sterile, that sex is the heterogametic one, i.e., in an X-Y sex-determination system, XY hybrids are preferentially sterile or inviable. Presgraves and Orr (1998) decided to test Haldane's rule on taxa lacking a hemizygous X.

霍登是現代演化生物學的創始人之一。他曾指出如果如果在雜交後代中其中一個性別完全消失、罕見，或不孕，那個性別決定模式就是"異型配子"。

例如在XY性別決定系統中， XY雜交後代會不孕。所以Presgraves & Orr（1998）就決定利用沒有X的分類群來測試霍登的遺傳法則。

They focused on the mosquitoes from the genera *Aedes* and *Anopheles*. In *Aedes*, males are XY and females are XX, but both X and Y chromosomes carry complete sets of homologous genes, while in *Anopheles* Y chromosomes are degenerate. They compiled the available data on the sterility of the hybrids resulted from crossing pairs of species in these taxa (Tables below).

他們聚焦在斑蚊和瘧蚊屬。斑蚊屬是XY系統(雄XY，雌XX)，但是瘧蚊屬的Y染色體退化。下表就是雜交實驗的結果。

Hint: Assume each character is controlled by many loci.
提示：假設每個特徵都由許多基因座控制。

***Data on Aedes** 斑蚊的數據*

A	B	A crossed with B A與B雜交
Ae. zoosophus	*Ae. triseriatus*	Only males are sterile 只有雄性不孕
Ae. triseriatus	*Ae. brelandi*	Only males are sterile. 只有雄性不孕
Ae. sollicitans	*Ae. taeniorhynchus*	Both sexes are sterile. 兩性皆不孕
Ae. taeniorhynchus	*Ae. nigromaculatus*	Both sexes are sterile. 兩性皆不孕

***Data on Anopheles** 瘧蚊的數據*

A	**B**	**A crossed with B** **A與B雜交**

An. albitarsus	*An. daeneorum*	Only males are sterile. 只有雄性不孕
An. crucians	*An. bradleyi*	Only males are sterile. 只有雄性不孕
An. freeborni	*An. occidentalis*	Only males are sterile. 只有雄性不孕
An. freeborni	*An. atroparvus*	Only males are sterile. 只有雄性不孕

Indicate if each of the following statements is true or false.
指出下列敘述是對或錯

	TRUE 對	FALSE 錯
If the males in genus *Anopheles* were under strong selection, we would expect the same pattern of hybrid sterility as presented here. 如果瘧蚊屬中的雄性遭受強大選汰壓力，那牠們的雜交後代也會呈現一樣的現象。	○	○
The hybrid sterility patterns observed in both genera are consistent with the idea that alleles involved in hybrid sterility are recessive. 在兩個屬中所觀察到的雜交不孕狀況與"涉及雜交不孕的等位基因是隱性"的觀點是一致的。	○	○
If the pattern of sterility in *Aedes* were identical to that of *Anopheles*, it would disprove Haldane's rule. 如果斑蚊與瘧蚊的不孕性狀況是一模一樣的，則會否定霍爾法則。	○	○
The pattern of hybrid sterility in *Aedes* suggest variation in Y chromosome functionality in this genus. 斑蚊屬的雜交不孕性狀況可以說明Y染色體的功能在該屬內是有種間差異的。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 39 Selection in Humans
人類的天擇

Bustamante et al. (2005) analyzed the pattern of polymorphism in the human genome by sequencing over 11,624 genes from 39 humans. The table below shows the distributions of synonymous (changes that does not result in amino acid replacement) and non-synonymous (changes that result in amino acid replacement) *s*ingle *n*ucleotide *p*olymorphism (SNPs - variation within species):

Bustamante et al.（2005）測序39個人，超過11,624個基因，來分析人類基因組中的多態性模式。下表顯示了同義(synonymous即單核苷酸改變不會造成胺基酸改變)和非同義(non-synonymous其改變會造成胺基酸改變)單核苷酸多態性的分佈(SNPs-種內變異)：

	Divergence 分化	**SNPs** 單核苷酸多態性
Synonymous 同義	34099	15750
非同義 **Non-synonymous**	20467	14311

In the table, divergence refers to the fixed differences between the humans in this study and the chimpanzee genome.

在上表中，所謂的"分化"意指被測序的人類之間的差異，還有與黑猩猩基因體的比較。

Indicate if each of the following statements is true or false.
指出下列敘述是對或錯

	TRUE 對	FALSE 錯
Greater ratio of non-synonymous to synonymous SNPs relative to ratio of non-synonymous to synonymous divergent sites suggest the effect of negative selection in human. "非同義性對同義性SNPs的比值"較"非同義性對同義性分化位點"的比值為高，顯示其在人類族群中發生了負向天擇。	○	○
The ratio of synonymous/non-synonymous SNPs is higher in genes involved in chromatin structure. 參與染色質結構的基因中同義/非同義SNPs的比例較高。	○	○
Arms races caused by host-specific pathogen would decrease the ratio of synonymous/non-synonymous substitutions in divergent sites between human and chimpanzee. 由對宿主專一的病原體所引起的軍備競賽，會將降低人與黑猩猩之間不同位點的同義/非同義替換的比例。	○	○
SNPs present within chimpanzee population cannot result in any level of reproductive isolation in chimpanzee population. 黑猩猩族群中存在的SNPs才不是由黑猩猩族群中任何程度的生殖隔離所造成的呢。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 40 Evolution of Sex 性的演化

The evolution of sexual reproduction has remained in certain aspects a puzzle which is yet to be fully pieced back together. Over the years many hypotheses have been proposed to explain this phenomenon.
有性生殖的演化在某些方面仍然是一個尚未被完全拼湊起來的難題。多年來，有許多假說已經被提出來解釋這個現象。

Indicate if each of the following statements is true or false.
指出下列敘述是對或錯。

	TRUE 對	FALSE 錯
The effect of sexual reproduction on the association between alleles is expected to improve the fitness of co-adapted genes. 有性生殖對等位基因間關聯性的影響應該會改善共適應基因的適性。	○	○
Given that the majority of mutations are deleterious, sex is expected to counter the loss of mutation-free individuals in small populations. 由於大多數突變是有害的，性交在小族群中應該可以抵消無突變個體的喪失。	○	○
Avoiding inbreeding in sexually-reproducing organisms is expected to be advantageous when deleterious mutations are co-dominant. 當有害突變為共顯性時，避免與具生殖力生物間的近親交配應該會是有利的。	○	○
One would expect a greater proportion of sexually reproducing species in stable regions, as compared to unstable regions. 相較於不穩定的環境，穩定的環境中，應該會有更高比例的物種行有性生殖.	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 41 Gut Microbiota and Cancer
腸道菌相與癌症的關聯性

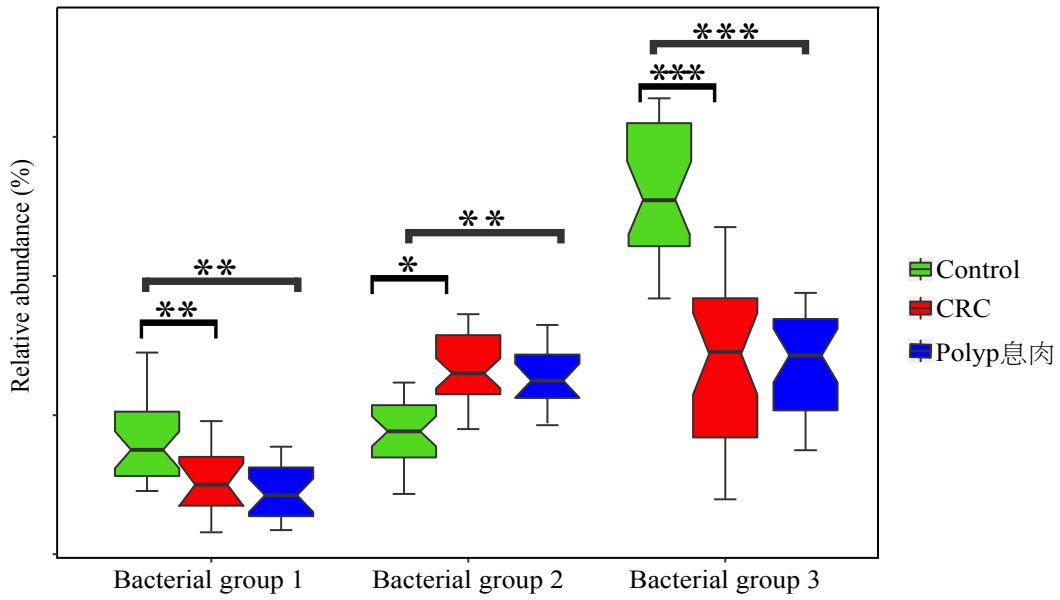
According to the evolutionary concepts, symbiosis is a general characteristic of living organisms and can help to understand complex features and phenotypes. Gut microbiota and host evolve in symbiosis and developed an integrative circuitry essential for their survival. This complex relationship resulted in a personal evolutionary adapted ecosystem. Recently developed genomics and metagenomics approaches helped to discover the link between the gut microbiota alteration with the host health and disease.

根據演化概念，共生是生物體的常見特性，其有助於理解複雜的特質和表型。

腸道菌相和宿主在共生中演化，並發展出一套對其生存至關重要的綜合循環。此複雜的關係產生一套個人化的演化適應與生態系統。

最近所開發的基因體學和總體基因組學研究法，有助於發現腸道菌相改變與宿主健康和疾病之間的關聯。

Gagnière and his colleagues (2016) highlighted the unexpected role of human gut microbiota in colorectal cancer. More recently in a study conducted by Flemer and his colleagues (2018) it has been emphasized that the heterogeneity of colorectal cancer might be related to the types of gut microbiota that either predispose or offer resistance to the disease.
Gagnière等（2016）指出了人類腸道菌相在結直腸癌中的意外角色。最近在Flemer等（2018）進行的一項研究中，強調結腸直腸癌的異質性可能與易患病或對疾病有抗性的腸道菌相之類型有關。



*Boxplots show the relative abundances of three bacterial groups from individuals with colorectal cancer (CRC), individuals with polyps (the intermediate stage between healthy and cancerous tissue which does not always turning to CRC) and healthy control (HC). An asterisk represents the significant p value which represented as ***p value<0.001; **p value<0.01; *p value <0.05; p value >0.05.*

這些點圖顯示來自三個細菌群在健康的對照組、罹患直腸癌（CRC）、還有具有腸息肉(polyps)患者腸道內的相對豐度。息肉是健康與腫瘤之間的中間狀態，但未必一定會轉為腫瘤。

*星號表示顯著p值：*** p值<0.001; ** p值<0.01; * p值<0.05; p值> 0.05。*

Indicate if each of the following statements is true or false.
指出下列敘述是對或錯。

	TRUE 對	FALSE 錯
The microbiota compositional differences between patients with CRC and the control are secondary to the onset of cancer. CRC患者和對照組之間的菌相組成差異僅次於早期罹癌者。	○	○
Changes in the abundance of the bacteria group 2 compared to the control are restricted to polyp. 與對照相比，細菌群2的豐度變化限於息肉組。	○	○
Any bacterial group that populates the gut is in association with an increased risk of CRC. 任何在腸道的細菌群體都會增加罹患CRC的風險。	○	○
The polyp-associated microbiota can be used as an indicator for individuals with higher risk of developing CRC. 與息肉相關的菌相可作為具較高CRC發病風險的個體之指標。	○	○

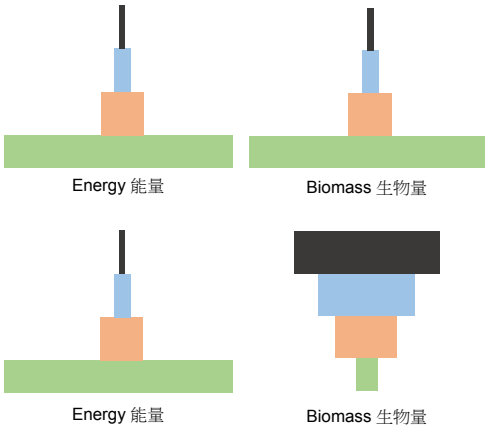
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 42 Trophic Relationships
營養階層間的關係

One of the basic ways to illustrate trophic relationship in an ecosystem is to use pyramids of energy and biomass, which are the stack of rectangles. Each represents the amount of energy or biomass within one trophic level. We know a proportion of energy and biomass is lost from the ecosystem when transferring from one to the next level. Therefore, the size of each rectangle decreases when we move from one level to the level above it.

在生態系統中說明營養關係的基本方法之一是使用能量和生物量的金字塔，它們是矩形的堆疊。每個代表一個營養級別內的能量或生物量。

我們知道，當從一個層級轉移到另一個層級時，能量和生物量的比例會由生態系中流失。因此，當我們從一個層級移動到它上面的層級時，每個矩形會減小。



Examples of pyramids schemes in different ecosystems. As you can see biomass pyramid can be inverted in some ecosystems.
不同生態系統中金字塔型的例子。如所見，生物量金字塔可以在某些生態系統中倒置。

Indicate if each of the following statements is true or false.
指出下列敘述是對或錯。

	TRUE 對	FALSE 錯
Inverted biomass pyramids are caused by low density of heterotrophs at any given time. 生物量金字塔會倒置是由低密度的異營性生物所造成。	○	○
We can't have regular energy pyramid when biomass pyramid is inverted, thus the energy pyramid for the inverted biomass must be inverted as well. 當生物量金字塔倒置時，我們不會有一般型式的能量金字塔，因此倒置生物量的能量金字塔也必須倒置。	○	○
Biomass of autotroph are usually greater than biomass of heterotroph in terrestrial ecosystems. 在陸域生態系中自營性生物的生物量通常大於異營性生物的生物量。	○	○

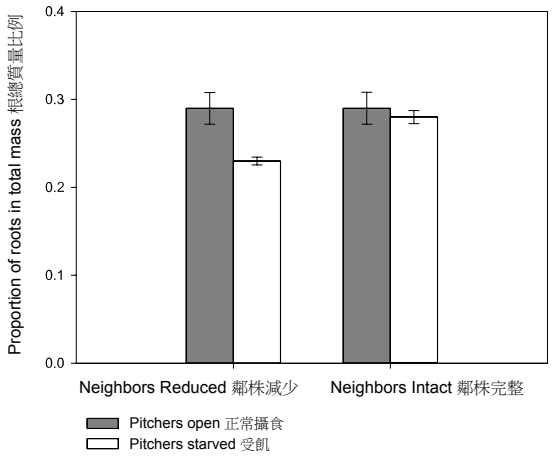
	TRUE 對	FALSE 錯
Given that phytoplankton has more rapid turnover, the biomass pyramid is more likely to be inverted. 假設浮游植物的轉化更新速度更快，則生物量金字塔更有可能會倒置。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 43 Competitive Exclusion
競爭排斥

The competitive exclusion principle states that whenever two or more species compete for same set of limiting resources the superior competitors can drive inferior competitors extinct. On the other hand, some species coexist in naturally nutrient-poor systems while they need same limited resources. For example, pitcher plants (carnivorous plants) are considered inferior competitors. Brewer (2003) investigated an example of interaction between pitcher plants and another species.

競爭排斥原則指出，當兩個或更多物種競爭相同的有限資源時，弱勢競爭者會滅絕。另一方面，在自然狀況下，一些物種在營養資源貧乏的環境中能夠共存，儘管它們利用相同的有限資源。例如，豬籠草(食肉植物)被認為是弱勢競爭者。 Brewer（2003）研究豬籠草與另一物種之間的交互作用。



Effect of pitchers starving and neighbor removal on production of total dry mass in pitchers' roots. Error bars are ± 1 standard error (Pitcher open means the pitcher plant can easily feed. after Brewer, 2003).
*豬籠草受飢和鄰株減少對豬籠草根部總乾質量的影響。誤差範圍是**±1**標準誤差（豬籠草打開意表示其可容易進食。據**Brewer，2003**）。*

Based on the graph above, indicate if each of the following statements is true or false.
根據上圖，指出下列敘述是對或錯。

	TRUE 對	FALSE 錯
When using the same resources, inferior competitors fail to coexist with superior competitors. 當使用相同的資源時，弱勢競爭者一定無法與優勢競爭者共存。	○	○
Inferior competitors can coexist with superior competitors if periodic disturbance remove or reduce population of superior competitors. 如果可以週期性地消除或減少優勢競爭者的數量，弱勢競爭者可以與優勢競爭者共存。	○	○

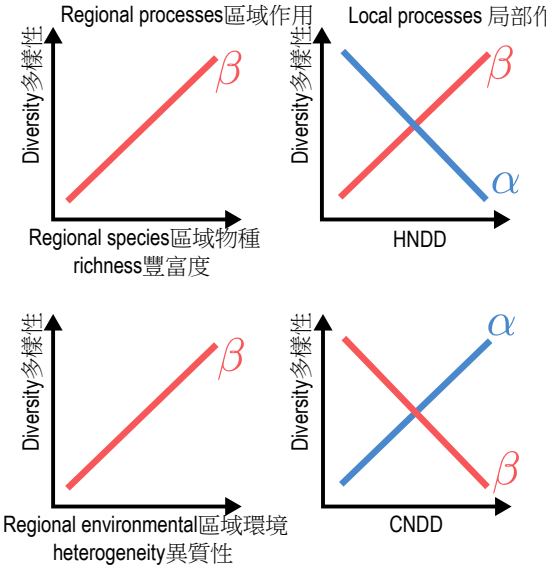
	TRUE 對	FALSE 錯
Intense competition can result in competing species to diversify so they can coexist while reducing the intensity of competitions. 激烈的競爭可能導致互相競爭的物種走向多樣化，因此它們可以共存，同時降低競爭的強度。	○	○
When pitcher plants are starved their ability to coexist with their superior competitor is significantly decreased. 當豬籠草飢餓時，它們與其優勢競爭者共存的能力顯著降低。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 44 Species Diversity 物種多樣性

Regional species diversity in ecosystems usually increases with primary productivity while local species diversity does not show any defined relation with primary productivity. It suggests that different processes have distinctive influence on species diversity at regional and local scale.
大區域(reginonal)的物種多樣性通常隨著初級生產力而增加，但局部小地方(local)的物種多樣性與初級生產力則沒有任何關係，代表決定區域和局部的物種多樣性的因子不同。

Figure illustrates four hypothesized mechanisms and their influence on α-diversity (mean local diversity) and β-diversity (diversity in species composition between local sites). (HNDD : Interspecific negative population density dependence. CNDD: Intraspecific negative population density dependence.).
圖說明了四種想像的機制及其對α-多樣性(局部樣點的平均物種多樣性)和β-多樣性(不同局部樣點間，物種組成的差異程度)的影響。(HNDD：族群增長會因為其他物種族群密度變高而受到抑制。CNDD：族群增長會因為同種族群密度變高而受到抑制)。



According to the above hypothesis, indicate each of the following statements is true or false.
根據以上假說，指出以下敘述是對或錯。

	TRUE 對	FALSE 錯
Predators or pathogens specific to the dominant species will decrease α-diversity. 出現專門捕食或感染優勢物種的捕食者或病原體，會降低α-多樣性。	○	○
Increasing CNDD has a homogenizing effect on community composition among sites. 增加CNDD會同質化不同局部樣點的群聚組成。	○	○
Regions with weak HNDD are expected to have higher degree of community differentiation. HNDD較弱的區域會有較高的群聚分化程度。	○	○

	TRUE 對	FALSE 錯
Environmental perturbation acts in a fashion similar to effect of increasing CNDD on alpha and beta diversity. 環境干擾的影響類似於增加CNDD對α和β多樣性的影響。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 45 Predator Evasion in Adélie penguins
阿德利企鵝的避敵行為

In Adélie penguins when both parent leave the nest to find food, three-weeks-old chicks group together for protection. In this species, social defense behavior can occur in unusual ways. When adult Adélie penguins reach the coast, they gather in groups before diving into the ocean, where usually their predator (leopard seal) could be lurking. The penguins have two choices, first to dive together, or wait until one of penguins dives so they could make sure if there is a predator or not.

阿德利企鵝的父母雙方離開巢穴尋找食物時，三週大的雛鳥會聚集在一起尋求保護。在這個物種中，社會防禦行為以非常特別的方式進行。當成年阿德利企鵝到達海岸時，它們會聚集成群體，然後潛入海洋，通常它們的捕食者（豹紋海豹）也會在場等候。

企鵝有兩個選擇，首先是一起潛水，或者等到一隻企鵝潛水後，牠們才能確定是否有捕食者在場。

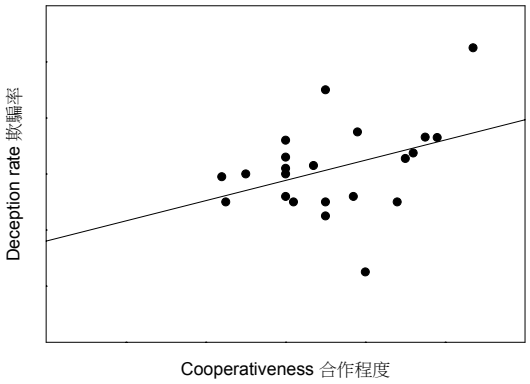
Indicate if each of the following statements is true or false.
指出下列敘述是對或錯。

	TRUE 對	FALSE 錯
This is an example of altruism behavior as the penguin that jump first could be hunted by possible predators while transferring its genes by helping its relatives. 這是利他行為的一個例子，因為首先入水的企鵝可能會被捕食者獵捕，牠的犧牲保存了其親屬的性命，間接的傳遞了牠的基因。	○	○
According to above example we can say one individual have influence on what other penguins are doing. 根據上述事例，我們可說一個個體的行為會對其他企鵝個體所要做的事是有影響的。	○	○
If a new strategy arose which would make a penguin trip another one into the ocean without retaliation from others, everyone in the population would adopt this new strategy in the long run. 如果出現了一種新策略，這種策略是使一隻企鵝讓另一隻絆倒跌入海洋而不會遭到其他個體的報復，那麼從長遠來看，族群中的每個個體都會採用這種新策略。	○	○
A mutation that results in postponing to jump as long as possible would eventually go to fixation. 若一個體產生延遲跳躍的突變,其最終會使此一行為被固定。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 46 Conditional Cooperation
有條件的合作

Cooperation is a complicated behavior that has evolved in animals. Conditional cooperation, such as direct and indirect reciprocity and partner choice, are some of these complicated behaviors. The simple rule which can illustrate how such behavior evolves is the correlation between the behavior of interacting individuals(graph below)). In fact, such correlation results in cooperative individuals receiving more cooperation, so if there is a cheater, it receives less cooperation, which is a kind of punishment.
合作是一種複雜的行為，已經在動物中呈現。有條件的合作，例如直接和間接互惠以及夥伴選擇，都是這些複雜行為中的一部分。可以說明這種行為如何演變的簡單規則是相互作用個體的行為之間的相關性(下圖)。事實上，這種相關性導致合作者接受更多的合作，所以如果有作弊者，它就會得到較少的合作，這是一種懲罰。



The relationship between deception and cooperation in non-human primates (After McNally, et al., 2013).
非人類靈長類動物的欺騙與合作之間的關係（After McNally, et al., 2013）。

Indicate if each of the following statements is true or false
指出下列敘述是對或錯

	TRUE 對	FALSE 錯
Conditional strategies and mechanisms that enforce cooperation make the evolution of deception less likely. 條件策略和機制強化了合作使欺騙的演化較不可能發生。	○	○
Although overall net benefit of the cooperative behavior is higher than the cost of being deceived, the existence of defectors doesn't allow cooperation to persist. 雖然合作行為的總體淨收益高於被欺騙的成本，但被叛者的存在不允許合作持續存在。	○	○
We can expect deception to evolve as long as it does not significantly increase the cost of cooperation. 只要欺騙不會顯著地增加合作的成本，我們可以預期欺騙的發展。	○	○
Deceptive behavior can occur only in novel habitats as there is no time to adapt to the new environmental conditions. 欺騙行為只會發生在新的棲息地，因為沒有時間來適應新的環境條件。	○	○

	TRUE 對	FALSE 錯
The relationship between cooperativeness and deception rate in primates can be explained by the relatively large social group size in this taxon. 靈長類動物的合作性和欺騙率之間的關係可以通過該分類群中相對較大的社會群體大小來解釋。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 47 Senescence
老化

Organismal senescence is the aging of the whole organism. It is a widespread phenomenon in nature but the exact etiology is still largely unclear. An evolutionary theory was proposed by George C. Williams which involves the following assumptions:
個體老化是整個個體的衰老。這在自然界中是一種普遍存在的現象，但確切的病因仍然很不清楚。喬治·威廉斯提出了一個演化理論，涉及以下假設：

1. Soma (referring to all somatic cells in the body) is essential for reproductive success, but it does not pass on to the offspring.
2. Alleles are affected by Natural selection.
3. Pleiotropic genes can have opposite effects on fitness at different ages or somatic environments.
4. The probability of reproduction decreases with increasing age.

1.體細胞(指身體上所有的體細胞)對繁殖成功至關重要，但它不會傳給後代。
2.等位基因受天擇的影響。
3.多效性基因對不同的年齡或體細胞環境的適應性會有相反的影響。
4.繁殖的可能性隨著年齡的增長而降低。

Williams suggested the following example: Perhaps a gene was selected for because it codes for calcium deposition in bones, which promotes juvenile survival, but the same gene promotes calcium deposition in arteries.
威廉斯提出了以下例子：也許一個基因被篩選,是因為它控制骨骼中的鈣增長，促進少年存活，但同一基因促進了動脈中的鈣沉積。

Indicate if each of the following statements is true or false.
指出下列敘述是對或錯。

	TRUE 對	FALSE 錯
Lower adult death rates can be associated with lower rates of senescence, according to the theory. 根據該理論，較低的成年人死亡率可能與較低的衰老率有關。	○	○
Where there is a sex difference, the sex with higher rate of decrease in fecundity after maturation (but with equal death rate to the other sex) should undergo the more rapid senescence, according to the theory. 根據該理論，如有性別差異存在，成熟後生殖力下降率較高（但與另一性別的死亡率相同）的性別,應該會經歷更快的衰老。	○	○
The frequencies of an allele in a gene that behaves similar to the aforementioned calcium deposition gene in a cohort will be smallest at early age and greatest at late age. 基因中與上述鈣沉積基因相似的基因，其等位基因的頻率在早期的年齡層中最小，在晚年的年齡層中最大。	○	○
This model views senescence as an adaptation. 該模型將衰老視為一種適應。	○	○

COMMENTS MAXIMUM POINTS STUDENT POINTS

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

MAXIMUM POINTS	STUDENT POINTS
	0