IBO 2018

Tehran, Iran

29th International Biology Olympiad

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Theory B

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 有四個敘述的問題

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 有五個敘述的問題

Number of correct statements 正確的敘述數目	**0**	**1**	**2**	**3**	**4**	五
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 AND CELL BIOLOGY
生物化學與細胞生物學

Q. 1 Linkage
連鎖

The HapMap project was designed to estimate the amount of variation among the genomes of different individuals. One of the outcomes of the project was identification of many SNPs (single nucleotide polymorphisms) in the human genome. It was observed that the vast majority (here, assume all) of SNPs exist as only one of two (not four) nucleotides.

國際人類基因組單體型圖計畫(簡稱HapMap計畫)旨在估計不同個體間的基因體變異程度。該計畫的成果之一是鑑定人類基因組中的許多SNPs(單核苷酸多型性)。結果發現絕大多數(這裡假設所有)的SNPs僅涉及2種核苷酸之間的轉變(不是4種)。

Therefore, for a region of the genome consisting of n SNPs, 2^n combinations of the SNPs are conceivable. In fact, sequencing of the SNPs in hundreds of individuals has revealed that generally a much lower number of combinations exist. The combinations of SNPs in fact observed in a region of the genome are named the SNP haplotypes of that region. The figure below is a representation of this finding. It shows the genotype of 26 neighboring SNPs in a region of human chromosome 5 from 20 individuals of different populations throughout the world. Only one copy of chromosome 5 was isolated from each individual. The chromosomes are grouped on basis of having the same combination of genotypes for all the SNPs (i.e. having the same haplotype).
所以，對於由n個SNPs組成的基因組區域，可以推知有2^n個SNPs的組合。事實上，根據數百個人的SNPs定序顯示真正存在的組合沒有這麼多。

在基因組區域中觀察到的SNPs組合，被命名為該區域的SNP單倍型。下圖是這一發現的代表。它顯示了來自全世界不同族群的20個個體，其人類第5號染色體區域中26個相鄰SNPs的基因型。

每個個體僅分析其中一個第5號染色體。具有相同SNPs基因型組合的染色體被歸類在一起(即具有相同的單倍型)。

Chromosomal haplotype	I					II				III				IV			V		VI	VI
Individual	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
SNP No.																				
1	X	X	X	X	X	O	O	O	O	O	O	O	O	X	X	X	O	O	X	X
2	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X
3	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	X	X	X	O	O
4	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X
5	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	X	X	X	O	X
6	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	X	X	X	O	X
7	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X
8	O	O	O	O	O	O	O	O	O	X	X	X	X	X	X	X	X	X	O	O
9	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X
10	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	O	O	X
11	O	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
12	X	X	X	X	X	X	X	X	X	O	O	O	O	X	X	X	O	O	X	O
13	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X
14	X	X	X	X	X	X	X	X	X	O	O	O	O	X	X	X	O	O	X	X
15	X	X	X	X	X	X	X	X	X	O	O	O	O	X	X	X	O	O	X	X
16	O	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X	O	O	X	X
17	X	X	X	X	X	X	X	X	X	O	O	O	O	X	X	X	O	O	X	X
18	X	X	X	X	X	X	X	X	X	O	O	O	O	X	X	X	O	O	X	O
19	O	O	O	O	O	X	X	X	X	X	X	X	X	O	O	O	X	X	O	X
20	O	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
21	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	X	X	X	O	X
22	O	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O
23	X	X	X	X	X	X	X	X	X	O	O	O	O	O	O	O	O	O	X	X
24	X	X	X	X	X	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X
25	O	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O
26	O	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Genotype of 26 linked SNPs in the human genome on 20 copies of chromosome 5 from 20 individuals. X and O represent the two different nucleotides at each SNP position.
來自不同族群的20個個體的，第5號染色體區域中26個相鄰SNPs的基因型
X 和 O 代表 SNP 中 2 個不同的核苷酸

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

	TRUE 對	TRUE 錯
Recombination events are not expected to affect the number of haplotyes observed in a population. 重組事件不會影響族群的單倍型數量	○	○
If in fact all conceivable haplotypes of the 26 SNPs analyzed were present in the human population, one would not expect any two of the 20 chromosomes analyzed to have the same haplotype. 呈現人類族群的所有 26 SNPs的單倍型，無法期望在20對染色體中有任何兩對染色體可以分析到相同的單倍型	○	○

	TRUE 對	TRUE 錯
Based on data presented in the table, knowledge of the nucleotide at only SNP 19 and SNP 23 of chromosome 5 of newly investigated individuals from the same cohort would allow prediction of the most likely nucleotides present at the remaining 24 SNP positions of chromosome 5 of those individuals. 根據表中的數據, 如果來自同一群之新個體在第5對染色體上僅有SNP19與SNP23的資訊，我們便可預測第5對染色體上的其餘24個SNP位置。	○	○
The data on the 20 chromosomes suggest that among the four major haplotypes, haplotype IV has the minimum number of sequence variations. 由20對染色體的數據可以推測在4個主要單倍型中，第 4個單倍型是含有最小量的序列變異	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 2 Berk-Sharp mapping
基因圖譜定位

A protocol that can be used for identification of gene structure with respect to exons and introns involves isolation and denaturation of a dsDNA fragment that includes a gene of interest, isolation of mature mRNA pertaining to gene of interest, hybridization of complementary single stranded nucleic acid molecules, performance of three types of chemical or enzymatic reactions, and electrophoresis on non-denaturing gels. Relevant factors pertaining the chemical or enzymatic reactions are as follows:

Berk-Sharp基因圖譜定位是用於鑑定外顯子和內含子的基因結構的操作技術之一。該操作涉及：

(1) dsDNA片段的分離和變性，包括找到目標基因、分離與目標基因有關之成熟mRNA、
(2) 與互補的單鏈核酸分子的進行雜合、進行三種類型的化學物質或酵素的反應，以及
(3) 在非變性凝膠上進行電泳。

與化學物質或酵素的反應有關的因素如下：

S1: a nuclease that degrades single stranded (ss) nucleic acid molecules or regions that are single stranded. It does not degrade double stranded (ds) molecules or do

S1：降解單鏈（ss）核酸分子或單鏈區域的核酸酶。它不會降解雙鏈（ds）分子或雙鏈區域。

Exonuclease VII: an exonuclease that degrades ss nucleic acids or ss ends of hybridized nucleic acids in both 5′ to 3′and 3′ to 5′ directions. It does not degrade ds molecules or ds portions of molecules.

外切核酸酶VII：外切核酸酶，其在5′至3′和3′至5′個方向上降解ss核酸或ss末端的雜合的核酸。它不會降解分子的ds分子或ds部分。

Alkali conditions degrade RNA and do not degrade DNA.
鹼性環境會降解RNA，但不會降解DNA。

Experiments pertaining to a gene that does not experience alternative splicing were as follows; appropriate size markers were included in the electrophoresis steps:
若要進行未被選擇性剪接基因的實驗，其步驟如下：。注意：在電泳步驟中，須含有適當大小的標誌：

A. Hybridization of denatured DNA with excess mRNA, followed by S1 treatment, followed by alkali treatment, followed by electrophoresis
將變性的DNA與過量的mRNA雜合，然後進行S1處理，接著進行鹼處理，然後進行電泳。

B. Hybridization of denatured DNA with excess mRNA, followed by S1 treatment, followed by electrophoresis
變性DNA與過量mRNA雜合，接著進行S1處理，然後進行電泳。

C. Hybridization of denatured DNA with excess mRNA, followed by Exonuclease VII treatment, followed by alkali treatment, followed by electrophoresis
把變性DNA與過量mRNA雜合，然後進行外切核酸酶VII處理，接著進行鹼處理，然後再進行電泳

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

	TRUE	FALSE
Observation of three bands in electrophoresis pattern of reaction A signifies that the gene of interest has three exons. 在反應 A 的電泳結果出現三個條帶，顯示目標基因具有三個外顯子。	○	○
The result of reaction A allows prediction of number and size of bands to be seen after electrophoresis in reaction B. 反應 A 的結果可協助預測反應B電泳後可見的條帶數量和大小。	○	○
The result of reaction B allows estimation of size of gene of interest. 光靠反應B的結果就可以估計目標基因的大小。	○	○
The combined results of reactions A and B allow prediction of the size of the introns of the gene. 光靠反應 A 和 B 的綜合結果就可以預測基因內含子的大小。	○	○
The combined results of the three reactions A, B, and C will allow prediction of length of ORF (open reading frame) of gene of interest 光靠 A、B 和 C 三反應的綜合結果就可以預測目標基因的 ORF（開放閱讀區）的長度。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 3 mRNA Splicing
mRNA剪接

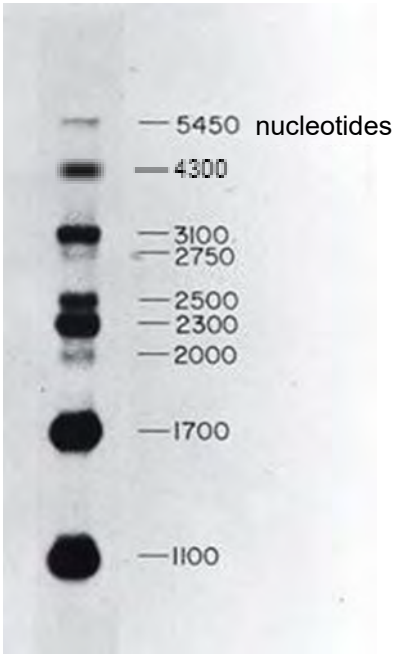
One of the questions that long ago arose with respect to splicing was whether the temporal order of removal of introns in transcripts of genes with multiple introns is the same as the physical order of the introns.

有一個有關基因剪接的長期課題是”在具有多個內含子的基因中去除內含子的時間順序是否與內含子的實質物理順序相同”。

To address this question with respect to the ovomucoid encoding gene (5.6 Kbp) that has seven introns (A-G), Northern blotting was performed on RNA isolated from nuclei of ovomucoid expressing cells. The probe used in the Northern blotting was labelled DNA of the ovomucoid encoding gene. An image of the Northern blot is presented below. RNA was extracted from each major band seen in gel, and the presence or absence of specific introns in RNA molecules of various band was assessed using intron-specific probes. Finally, the RNA molecules were grouped on the basis of number of introns removed by splicing and calculations that revealed identity of introns lost in various processed RNA molecules were made. The results of these calculations are also presented below.

為了解決關於具有7個內含子（A-G）的卵粘蛋白編碼基因（5.6Kbp）的問題，對從卵粘蛋白表現細胞的細胞核分離的RNA進行北方氏轉印雜合反應(Northern blotting)。Northern blotting 使用的探針為有標記的卵粘蛋白編碼基因的DNA。 Northern印跡的圖像如下所示。從凝膠中看到的每個主要條帶為提取RNA，並使用內含子特異性探針評估各種條帶的RNA分子中特定內含子的存在或不存在。最後，基於透過剪接去除的內含子的數量對RNA分子進行分組，並且計算顯示在各種已轉錄後修飾(加工)的RNA分子中丟失的內含子的身份。這些計算的結果如下:

Nuclear RNA



Northern blot

Intron removal from ovomucoid nuclear RNA
從卵粘蛋白核**RNA**中去除內含子

Frequency (%) of loss of individual introns

Group No.	**Number of introns spliced out** 被剪去的內含子數目	A	B	C	D	E	F	G
1	2	5	0	0	0	30	60	5
2	2	25	25	0	5	60	60	25
3	3	5	5	5	30	100	95	60
4	4	10	25	35	95	90	90	55
5	5	40	75	65	85	100	75	60
6	6	50	100	75	90	100	100	75

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 image of the Northern blot suggests that order of removal of introns from ovomucoid primary transcripts is not random. Northern印跡的圖像顯示從卵粘蛋白去除內含子是隨機的。	○	○
The data in the table show that intron E is usually but not always removed from primary transcripts before intron G is removed. 表中的數據顯示，在移除內含子G之前，內含子E通常但不總是從初級轉錄物中除去。	○	○
The data in the table indicate that introns A, B, and C are usually removed from primary transcripts before introns D and G. 表中的數據顯示內含子A，B和C通常在內含子D和G之前從初級轉錄物中除去。	○	○
The data presented suggest that at the time of analysis, there is generally a progressive increase in concentrations of more highly processed transcripts. 所呈現的數據顯示，在分析時，更高度修飾加工處理的轉錄物的濃度通常逐漸增加。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 4 Inflammatory Caspases
發炎反應之細胞凋亡酶

Inflammatory caspases such as caspase 1 are activated in response to microbial infection and stress signals. When activated, they cleave human gasdermin D (GSDMD) after Asp275, to generate an N-terminal cleavage product (GSDMD-NT) and a C-terminal fragment (GSDMD-CT). GSDMD-NT kills bacteria and induces a form of programmed cell death called pyroptosis in human cells. The details of the mechanism by which GSDMD-NT causes cell death are unknown. Mutation of two evolutionarily conserved positively charged residues to alanine produces a mutant form of the protein known as GSDMD-NT 2A, and mutation of four conserved positively charged residues to alanine produces GSDMD-NT 4A. Fig. 1 shows result of non-reducing gel electrophoresis of equal amounts of N-terminal cleavage product of the wild type and mutated forms of GSDMD.
當細胞被微生物感染或遇到壓力狀態時，會活化發炎反應細胞凋亡酶，例如凋亡酶 1 (caspase 1)。凋亡酶活化後，會從 Asp275 後分解 human gasdermin D (GSDMD)，產生N端GSDMD (N-terminal cleavage product (GSDMD-NT) 及C端GSDMD (C-terminal cleavage product (GSDMD-CT) 。GSDMD-NT會殺死細菌並誘導人類細胞細胞凋亡，稱為pyroptosis。 但GSDMD-NT導致細胞死亡的機制的細節尚不清楚。此外，亦會評估GSDMD-NT 2A(將兩鹼性殘基改變為alanine)及GSDMD-NT 4A 兩突變產物之效果。圖1顯示利用非還原凝膠電泳分析三種等量GSDMD的N-末端切割產物(GSDMD-NT; GSDMD-NT 2A及GSDMD-NT 4A)的結果。

In an experiment, *E. coli* and *Staphylococcus aureus* bacteria were exposed to nanomolar concentrations of recombinant forms of GSDMD, GSDMD-NT, GSDMD-CT, GSDMD-NT 4A and granulysin (a known cytotoxic lymphocyte pore-forming protein) and the antibacterial effect of these molecules was assessed by measuring reduction of colony formation (Colony Forming Unit (CFU))(Fig. 2). Other experiments showed the same relative effects of the wild type and mutant forms on pyroptosis in human cells.
實驗中， 分別投予大腸桿菌和金黃色葡萄球菌 nM 的GSDMD，GSDMD-NT，GSDMD-CT，GSDMD-NT 4A和顆粒溶素（一種已知的細胞毒性淋巴細胞穿孔蛋白）。此外，藉由量測細菌菌落之形成多寡 (菌落形成單位（CFU）)，評估此四種產物之抗菌作用（圖2）。其他實驗顯示對人類細胞中的細胞凋亡(pyroptosis) 有相同的影響。

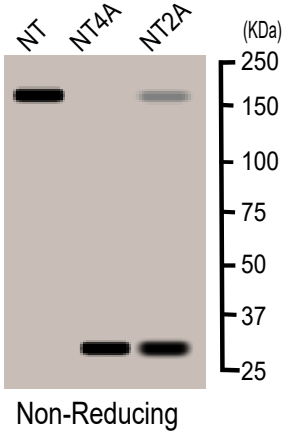


Figure 1

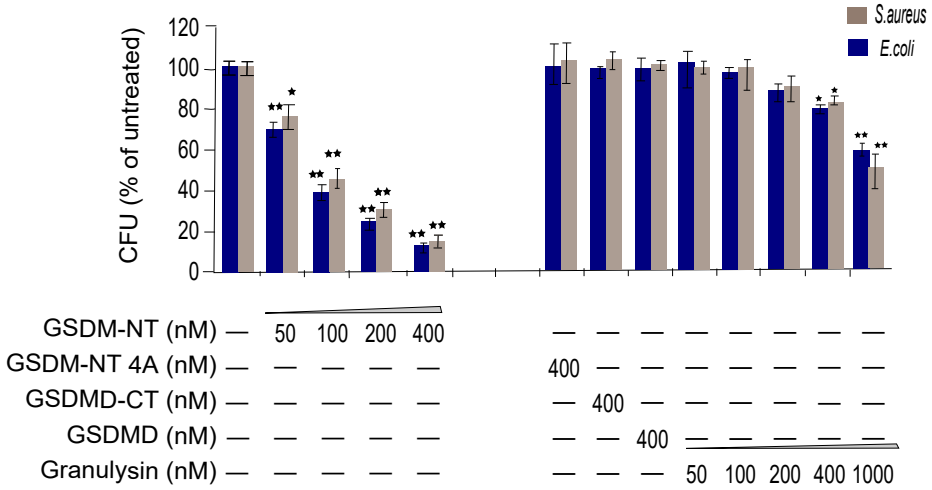


Figure 2

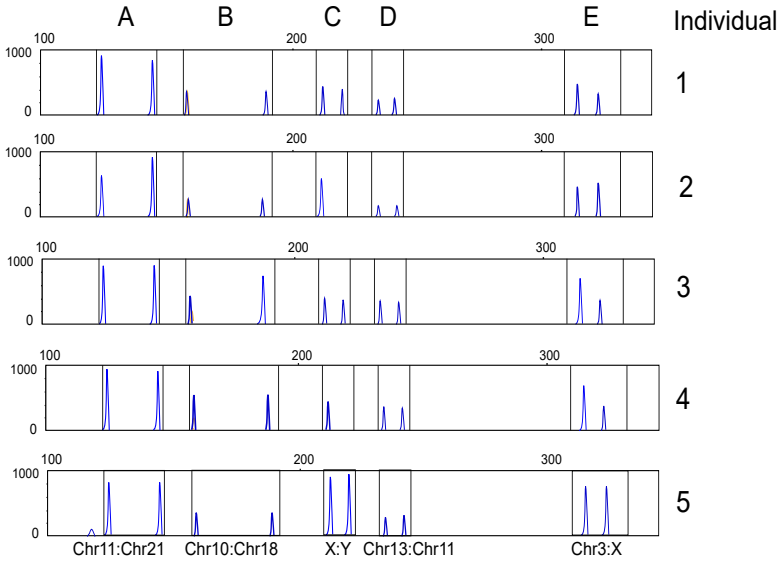
Based on these results indicate if each of the following statements is true or false.
根據這些結果，指出下列敘述是對或錯。

	TRUE 對	FALSE 錯
The data shows that GSDMD-NT oligomerization is involved in pyroptosis. 數據顯示 GSDMD-NT 寡聚化參與了細胞凋亡。	○	○
GSDMD-NT is a more effective anti-bacterial agent than Granulysin. GSDMD-NT是比 Granulysin更有效的抗菌劑。	○	○
By mutation of evolutionarily conserved basic residues to Ala, the number of disulfide bonds between monomers of GSDMD does not change. 透過將兩個鹼性殘基突變為Ala，GSDMD單體之間的雙硫鍵數目不會改變。	○	○
GSDMD-NT 2A mutant is likely less effective than GSDMD-NT for induction of pyroptosis. GSDMD-NT 2A突變體可能不如GSDMD-NT有效誘導細胞凋亡。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 5 Aneuploidy
非整倍體

Electrophoresis patterns of PCR products of several chromosome pairs (pairs shown on bottom) in five different individual (1-5) in figure below allow evaluation of presence or absence of chromosome number abnormality. Monosomy of autosomal chromosomes is known to be lethal. Relative height of the peaks in each box reflects the copy number ratio of the two chromosomes in that box. The horizontal axis shows migration, and the vertical axis shows fluorescence intensity.
下圖中五個不同個體（1-5）中幾對染色體（對數顯示於底部）PCR產物的電泳模式, 可用來評估染色體數目是否異常。已知體染色體的單體缺失是致命的。每個框中峰(peak)的相對高度反映了該框中兩條染色體的拷貝數比例。橫軸表示遷移，縱軸表示螢光強度。



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
Three individuals show trisomy . 三個人表現出三染色體性。	○	○
Two individuals show abnormal monosomy. 兩個人表現出不正常的單體性。	○	○
Two individuals have normal karyotypes. 兩個人的核型正常。	○	○
PCR products related to different chromosomes should have different sizes to allow copy number evaluation . 與不同染色體相關的PCR產物，應具有不同的大小，可用來評估拷貝數。	○	○

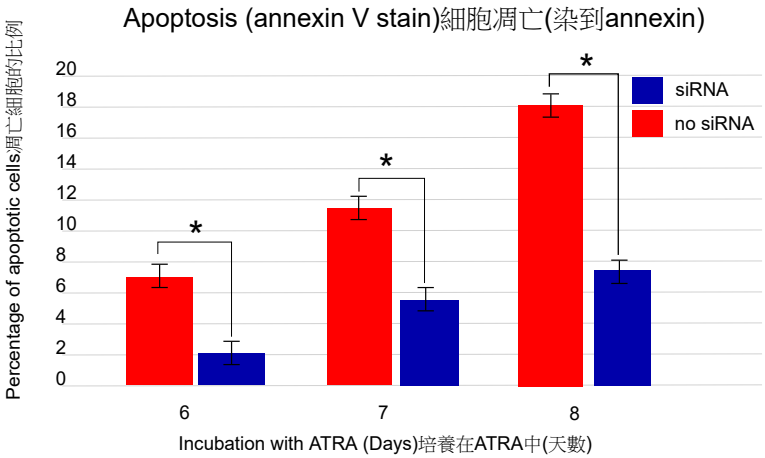
COMMENTS MAXIMUM POINTS STUDENT POINTS

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

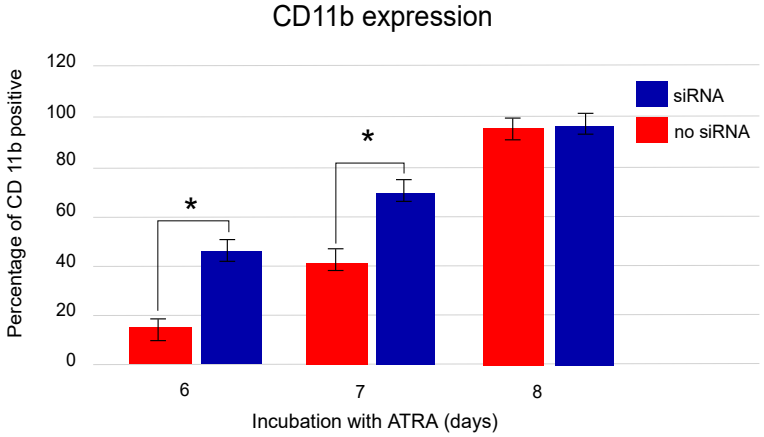
Q. 6 Differentiation of Neutrophils
嗜中性白血球的分化

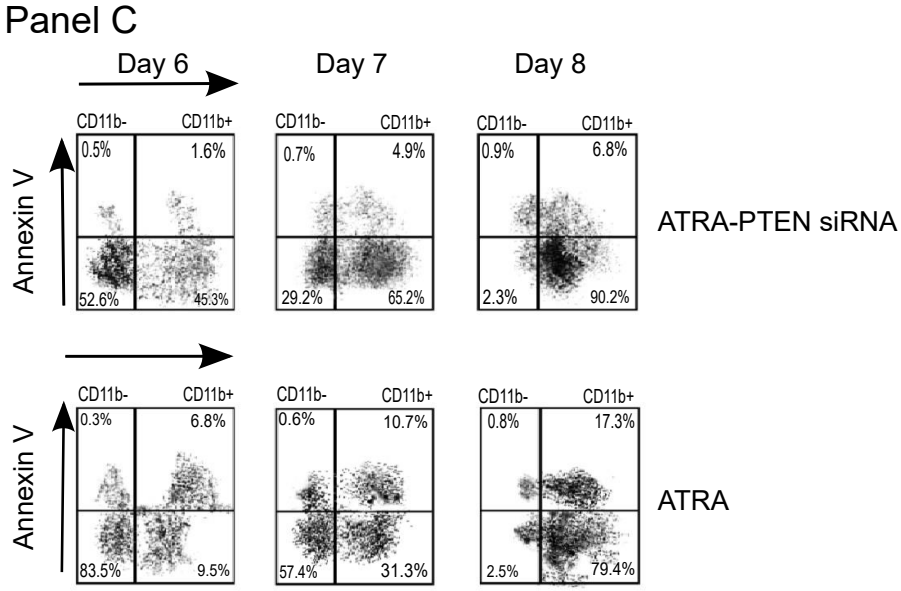
HL-60 cells differentiate to neutrophils after eight days of incubation in the presence of All Trans retinoic acid (ATRA). siRNAs are synthetic molecules used to suppress expression of genes. In the experiment whose results are presented below, an siRNA against the *PTEN* gene was used. Annexin V is a marker used to show apoptosis, and CD11b is a neutrophil surface marker. Percentage of apoptotic and differentiated cells as well as combination of both are shown in panels A, B and C. In panels A and B, stars indicate statistical significant.
當ATRA(All Trans retinoic acid)存在時，HL-60細胞在8天後會分化為嗜中性白血球。siRNAs這分子會抑制基因的表現。在本實驗(結果如下所示)，siRNA被用來抑制*PTEN* 這個基因。Annexin V染劑被用來標示細胞是否凋亡(apoptosis)。當細胞凋亡時，會顯現Annexin V；CD11b這個嗜中性白血球表面的蛋白質是否表現，被用來標示嗜中性白血球是否存在，當嗜中性白血球存在時，可以檢測到CD11b的表現。下面A、B、C三個圖分別呈現：細胞凋亡(apoptosis)的比例、分化成嗜中性白血球的比例，以及以上兩者(凋亡和分化)的總和；其中A和B圖中，若標註星號，代表兩個操作得到的結果有顯著差異。

Panel A



Panel B





Horizontal line within each box reflects threshold value for apoptosis. Vertical line within each box reflects threshold value for neutrophil differentiation.

每個小圖中之水平線顯示細胞凋亡之閾值，而垂直線則表示嗜中性白血球之分化閾值

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 level of differentiation to neutrophils in the presence of *PTEN* siRNA is less than in the absence of *PTEN* siRNA at a statistically significant level. 在有 *PTEN* siRNA下，嗜中性白血球細胞的分化數量顯著低於沒有 *PTEN* siRNA的處理時的量。	○	○
Panels a and b show that reduction of apoptosis causes an increase in the number of live neutrophil cells at all time points. 圖a和b 顯示細胞凋亡數的減少，會導致在所有時間點，活的嗜中性白血球細胞數量增加。	○	○
Panel c shows an inverse correlation between apoptosis and the number of differentiated neutrophil cells at at least two time points. 圖 c 顯示至少有兩個時間點，細胞凋亡的程度與已分化的嗜中性白血球細胞數量之間呈現負相關。	○	○
PTEN siRNA applications causes larger reduction of apoptosis in differentiated cells as compared to undifferentiated cells after 7 days of incubation with ATRA. ATRA培養7天後，與未分化細胞相比，PTEN siRNA的添加，會更大幅度的減少已分化細胞之凋亡程度。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 7 Blood Types
血型

Among 1290 individuals of a population under study, the numbers of individuals with blood group types M, MN, and N are, respectively, 340, 880, and 70.
1290個受測者中，血型分別為M, MN, N的各有 340, 880, 和 70個。

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, the frequencies of M and N alleles in the population are, respectively, 0.7 and 0.3. 根據結果，M和N等位基因的比例分別為0.7和0.3。	○	○
The population describe above is in Hardy Weinberg equilibrium with respect to alleles of the MN blood group. 上面所提MN血型族群的等位基因符合哈溫平衡(Hardy Weinberg equilibrium)。	○	○
If there is random mating in a population in which frequency of M alleles is 0.6 and frequency of N alleles is 0.4, the frequency of offspring with the NN genotype will be 0.16. 假設族群內的個體隨機交配，而M等位基因出現的頻度為0.6，N為0.4，則 子代為NN基因型的比例將為0.16。	○	○
In a start generation with frequency of M= 0.6 and frequency of N=0.4, after three generations of random mating the frequency of MM individuals in the population of the fourth generation who are offspring of MN*MN matings will be <10%. 假設第一代族群M等位基因出現的頻度為0.6，N為0.4，在經過三個世代的個體隨機交配後，MN*MN親代交配後的第四個世代(親代為第一個世代)，出現MM基因型的機會將低於10%。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

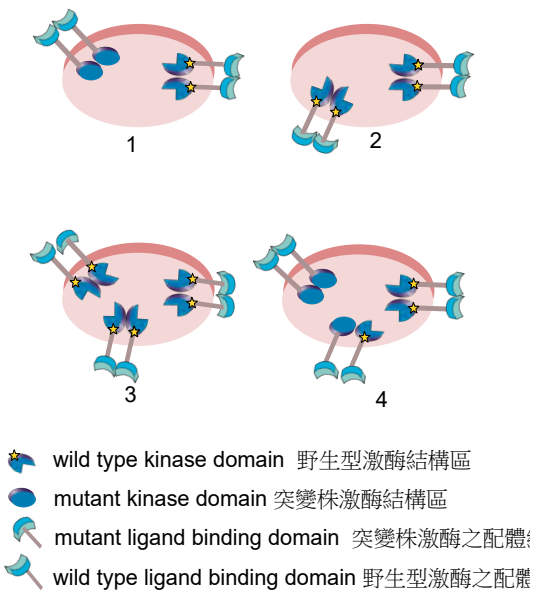
Q. 8 Receptor Tyrosine Kinases
酪胺酸激酶受器

Two different mutant forms of a gene that encodes a cell surface receptor tyrosine kinase (RTK) are separately inserted into vectors. One mutant encodes a protein with a non-functional kinase domain, and the other lacks a functional ligand binding domain. Each vector is separately introduced into normal cells that can express wild type RTK from their endogenous genes.

將兩種不同酪胺酸激酶受器的突變基因分別插入載體中。其中一個突變株會產生不具激酶功能的蛋白質，另一個突變株則會產生無法與配體(ligand)結合的蛋白質。將每種載體分別送入可表達野生型RTK的正常細胞中。

It is known that the cells used have a high capacity for RTK receptors on their surface, that ligands bind to monomeric forms of receptor proteins and that heterodimeric receptors are inactive in signaling. The diagrams below depict four cell types identified. Each diagram shows the only receptor forms observed on the respective cell types in the ratio that they were observed.
The experiments were performed under non-saturating concentrations of ligand.

已知此細胞表面上的RTK具有高潛力(capacity)：配體可與單體(monomoeric) RTK結合，並且異型聚合體受體在訊號傳導過程中無活性。下圖顯示所得到之四種細胞類型。每個圖分別顯示了在相對應細胞類型上觀察到的受體及其比例。
本實驗之配體濃度為非飽和濃度。



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
In type 1 cells, the mutant receptor with the non-functional kinase domain will interfere with signaling by the cells' normal RTK. 第1型細胞含有缺乏功能性激酶結構區的突變株會干擾來自細胞的正常RTK信號。	○	○
In type 2 cells, the mutant RTK lacking functional ligand binding domain will be inactive for signaling, but will not interfere with normal signaling mediated by the cells' own receptor tyrosine kinases. 在第2型細胞中，缺乏功能性配體結合結構區的RTK突變體無法進行訊息傳遞，但不會干擾細胞自身RTK媒介的正常訊息傳遞過程。	○	○
Equal levels of signaling will be achieved by type 3 and type 4 cells. 第3型和第4型細胞訊息傳遞能力相同。	○	○
The effects of mutant RTKs of cell type 2 and cell type 3 on levels of signaling by the cells' own normal RTKs will be the same. 第2細胞類型和第3類細胞的RTK突變株對細胞自身正常RTK的訊息傳導的影響相同。	○	○

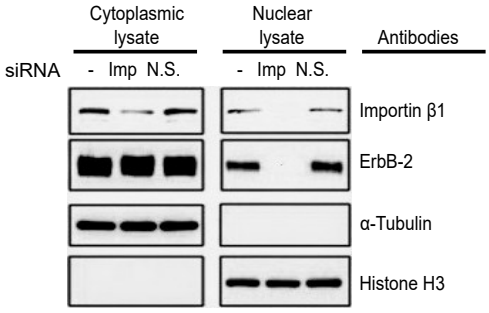
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 9 ErbB-2運輸

ErbB-2 is a receptor found on the plasma membrane of mammalian cells which can move from the plasma membrane to the nucleus. Because most proteins that shuttle between the cytoplasm and the nucleus are soluble and not integral membrane bound proteins, the mechanism by which ErbB-2 undergoes transport to the nucleus is of particular interest. Three experiments described below were done to shed light on the underlying mechanisms.
ErbB-2是在哺乳動物細胞膜上發現的受體，可以從細胞膜移動到細胞核。因為在細胞質和細胞核之間穿梭的大多數蛋白質是水溶的而不是嵌入式的膜結合蛋白，所以ErbB-2如何自膜轉運到細胞核的機制令人特別感興趣。下面三個實驗用以闡明其機制。

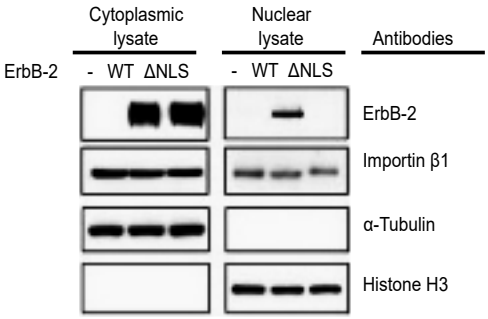
Experiment 1: siRNA knock down of importin β1 expression in target cells
The cells were transfected with importin β1 siRNA (Imp), nonfunctional siRNA control (N.S.), or buffer only (-). Proteins from the cytoplasmic and nuclear fraction of cell lysates were analyzed by Western blotting using importinβ1, and ErbB-2, α tubulin and histone H3 antibodies as indicated.

實驗1：利用siRNA降低標的細胞中輸入蛋白β1的表現
用輸入蛋白β1之siRNA（Imp），非功能性siRNA對照組（NS）或僅含緩衝液（ - ）來轉染細胞。之後利用西方墨漬法(Western blot)來分析這些轉染細胞中細胞質及細胞核中importinβ1，ErbB-2，α微管蛋白和組蛋白H3抗體的表現。



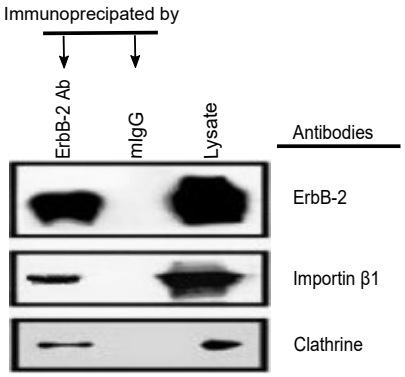
a)

Experiment 2: Mutant cells lacking ErbB-2 gene were transfected with wild-type ErbB-2 (WT), ErbB-2 mutant containing a deficient nuclear localization signal (ΔNLS), or vector control (-). Proteins from the cytoplasmic fraction, nuclear fraction were then analyzed by Western blotting with ErbB-2, importinβ1, α tubulin and histone H3 antibodies as indicated.
實驗2：分別將野生型ErbB-2（WT）基因；含有無法定位細胞核信號（ΔNLS）的ErbB-2突變體及對照用載體（ - ）轉染至缺乏ErbB-2基因的突變細胞。之後利用西方墨漬法(Western blot)來分析這些轉染細胞中細胞質及細胞核中importinβ1，ErbB-2，α微管蛋白和組蛋白H3抗體的表現。



b)

Experiment 3: Cell lysates from the cells were immune-precipitated with anti-ErbB-2 or mouse IgG (mIgG). The precipitated immune-complexes and the cell lysates were then analyzed by Western blotting with, clathrin, importinβ1, and ErbB-2 antibodies.
實驗3：本實驗利用免疫沉澱法進行分析。將細胞處理後，用ErbB-2抗體或小鼠IgG（mIgG）進行免疫沉澱。之後利用西方墨漬法(Western blot)來分析這些轉染細胞中細胞質及細胞核中clathrin, importin β1及ErbB-2的表現。



c)

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 data in Figure (a) suggest that ErbB-2 requires importin β1 in order to enter the nucleus. 圖（a）中的數據表明 ErbB-2需要輸入蛋白β1才能進入細胞核。	○	○
It is predicted that the antibody against importin β1does not precipitate the ErbB-2(ΔNLS). 預計輸入蛋白β1的抗體不會與含有無法定位細胞核信號（ΔNLS）的ErbB-2突變體進行免疫沉澱。	○	○
The data presented suggest that localization of histones to the nucleus is mediated by a mechanism distinct from that used to shuttle ErbB-2. 實驗數據顯示，組蛋白進入細胞核的機制與ErbB-2的機制不同。	○	○
As true for other membrane bound receptors, ErbB2 enters the cytoplasm by endocytosis. 與其他細胞膜上受體類似，ErbB2透過胞吞作用進入細胞質。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 10 Yeast Secretion Trap 酵母菌分泌陷阱

Phytopathogens use their secreted proteins "secretomes" to attack plant hosts. The yeast secretion trap (YST) functional screen is a method used for isolation and identification of these secreted proteins. This method involves generating a vector library that includes cDNAs (containing 5ˈ non-coding sequences) synthesized using phytopathogen RNAs fused to a mutated form of the Saccharomyces cerevisiae suc2 reporter gene.
植物病原體利用其分泌的蛋白質 (分泌蛋白) 來攻擊植物宿主。酵母菌分泌陷阱(YST) 功能性篩選 是用以分離和鑑定這些分泌蛋白質的方法。該方法涉及產生載體庫，該載體庫包括cDNA (含有5個非編碼序列)，此cDNA是利用和釀酒酵母(*Saccharomyces cerevisiae*) suc2報告基因的突變型 融合的植物病原體RNA所合成的。

Suc2 encodes invertase which is the only protein used by yeast for sucrose degradation. Degradation occurs in the extra-cellular medium. The mutated form of the gene suc2-SP encodes an invertase that lacks the signal peptide for secretion at the amino terminal. The fusion library is used to transfect an invertase-deficient yeast strain, and the cells are subsequently plated on a sucrose selection medium. Each rescued cell is expected to contain a recombinant vector whose cDNA that encodes a signal peptide for the chimeric protein. Vectors are isolated and their cDNAs are sequenced to identify the secreted proteins.

Suc2編碼轉化酶，是酵母菌用於蔗糖降解的唯一蛋白質，而它會在胞外培養基中發生降解。suc2-SP這個基因的突變形式可以編碼”氨基末端缺乏分泌用的訊息肽”轉化酶。

”基因融合庫”是用來轉染具有”轉化酶缺陷型”的酵母菌株，隨後細胞會被接種在蔗糖選擇培養基上。每個被拯救的細胞含有重組載體，其cDNA能編碼一個可產生嵌合蛋白的信號肽。該載體會被分離，其cDNA會被測序以鑑定分泌的蛋白質。

Figure 1 is a schematic presentation of the vector, and Figure 2 summarizes the protocol described above.
圖1是載體的示意圖，圖2總結了上述操作。

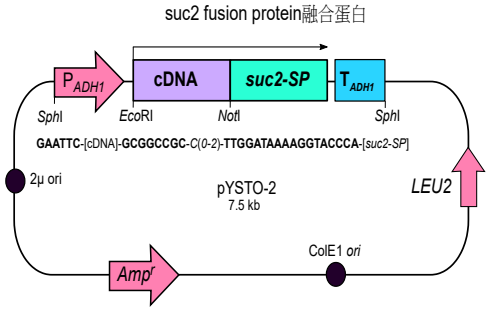


Figure 1
GAATTC: EcoR1 recognition site; GCGCCCGC: Not1 recognition site
GAATTC: EcoR1的辨識序列
GCGGCCGC: Not1 的辨識序列

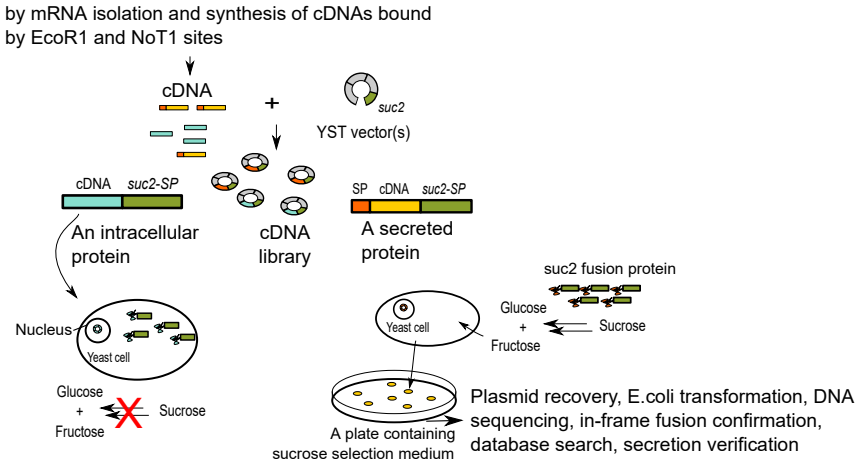


Figure 2

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
For the purpose of this screen, oligo-dT primers can be used for synthesis of cDNAs 基於篩選的目的，oligo-dT引子可用於合成cDNA	○	○
Variable number of Cytidine nucleotide(s) after the Not1 site in the vector ensures achieving a correct reading frame. 載體中，Not1位點後方有不同數目的胞苷核苷酸 (Cytidine nucleotide(s))，可確保獲得正確的閱讀區。	○	○
Presence of signal peptide in the fusion protein will not necessarily ensure the growth of yeast on the selection medium. 融合蛋白中的信息肽不一定能確保酵母菌在選擇培養基上的生長。	○	○
For introduction of EcoRI and NotI sites to ends of cDNA molecules, linkers (which are short double stranded oligonucleotides; example shown below) are better than adapters (which have single stranded ends; example shown below). Example of EcoRI linker ; -GAATTC- - CTTAAG- Example of EcoRI adapters; -G- and -AATTC- -CTTAA- -G- 為了將EcoRI和NotI位點引入cDNA分子的末端，連接子（linkers，其為短雙鏈之寡核苷酸；如下例所示）優於銜接子（adapters，其具有單鏈末端；如例下所示）。 EcoRI連接子的例子; -GAATTC- - CTTAAG- EcoRI銜接子的例子; -G- 和 -AATTC- -CTTAA- -G-	○	○

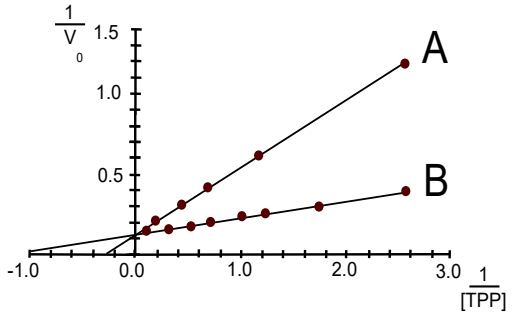
COMMENTS	MAXIMUM POINTS	STUDENT POINTS

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 11 Enzyme - Coenzyme Interaction
酶 - 輔酶的交互作用

Many disease causing mutations in enzyme coding genes affect parameters related to interactions of the enzymes with their coenzyme, which in turn lowers the rate of the reaction. The cofactor of a group of enzymes called TPP- or thiamine-dependent enzymes such as transketolase is thiamine pyrophosphate (TPP).
許多疾病肇因於酵素遺傳密碼突變，這些突變不僅會影響酵素與輔酶之作用，更進而降低其反應速率。其中一組輔酶 稱為thiamine pyrophosphate (TPP)或thiamine-dependent enzyme (硫胺素-依賴 酶)，例如轉酮酶 (transketolase) 即是thiamine pyrophosphate (TPP)。

The kinetic properties of a TPP-dependent enzyme isolated from a patient's tissue and a normal individual's tissue were compared under condition of substrate saturation. The TPP-free forms of the enzyme was prepared and used for enzyme kinetic measurements. The Lineweaver-Burk like plots are shown below.
自患者組織和正常個體組織分離出TPP-依賴酶並在受質飽和的條件下，並另外製備不含TPP的TPP-依賴酶進行酵素動力學之比較，下圖顯示 Lineweaver-Burk的結果圖。



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
A is related to the patient's enzyme A與患者的酶有關。	○	○
Maximum velocity of B is higher than the maximum velocity of A. B的最大速度高於A的最大速度。	○	○
It can be concluded that the enzyme in A has a lower affinity for its substrate(s). 從圖中可得結論: A所代表的酶對受質親和力較低。	○	○
Administration of thiamine to patients is expected to restore enzymatic activity. 對患者投與硫胺素應可恢復酶的活性。	○	○

COMMENTS MAXIMUM POINTS STUDENT POINTS

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 12 Förster Resonance Energy Transfer
Förster 螢光共振能量轉移

Förster resonance energy transfer (FRET) is a distance-dependent process whereby energy from an excited fluorescent molecule (donor) is transferred to a second, non-excited molecule (acceptor) in its vicinity. The FRET efficiency depends on the spectral overlap of the donor emission spectrum and the acceptor absorption spectrum. Acceptors in various forms of FRET may or may not emit fluorescence after receipt of energy from donor.
Förster 螢光共振能量轉移（FRET）是一種依賴於距離的過程，來自激發的螢光分子（提供體）的能量會被轉移到其附近的第二個非激發的分子（接受體）。 FRET的效率取決於提供體發射光譜和接受體吸收光譜間之光譜重疊度。從提供體接收能量之後，各種形式的FRET的受體可能會或可能不會發出螢光。

Quantum dots (QDs) are fluorescent nanoparticles that can act as FRET donors and can be used in biosensor systems. The binding of some molecules to QDs enhances the emission properties of the QDs. In this study, 560 nm emitting QDs (QD-560) were used. Maltose Binding Protein (MBP)-bounded QD-560 has higher emission than unbound QD-560.
量子點（QD）是具螢光的奈米粒子，可以作為FRET提供體，且可用於生物感應系統。一些分子與 QD 的結合會增強 QD 的發射特性。
在該研究中，使用能在 560 nm 發射的 QD (QD-560)。麥芽糖結合蛋白(MBP) －QD-560結合體比未結合的QD-560具有更高的發射強度。

The effect of native MBP or penta-histidine tagged MBP (MBP-5His) binding to QD-560 on fluorescence intensity was tested over a range of protein-to-QD ratios (Figure 1). Histidine residues can bind zinc ions present on the surface of the QD particles.
在一系列蛋白質對QD比率下，測試了原生的MBP 或是 5-組氨酸標記的MBP (MBP-5His)與QD-560 結合對螢光強度的影響（圖1）。組氨酸殘基可在QD顆粒表面上與鋅離子結合。

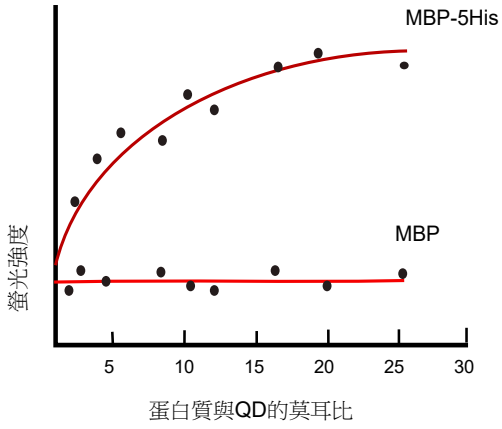


Figure 1: Fluorimetric measurements of QDs bound to MBPs or to MBP-5His at 560 nm.
圖1：與MBP結合的QD 或 在560 nm下 與MBP-5Hs 結合的QD 之螢光測量。

For construction of a Maltose detecting biosensor, the saccharide binding pocket of each QD-coordinated MBP-5His was preloaded with a maltose analog named β-cyclodextrin bound to QSY9 (β-CD-QSY9); the QSY9 component absorbs light. Figure 2 shows the biosensor.
為了建構麥芽糖檢測生物感應器，在每個QD配對的MBP-5His 上的糖結合槽中，預先裝有與QSY9（β-CD-QSY9）結合的 β-cyclodextrin (與麥芽糖結構相似)；QSY9會吸收光線，此生物感應器顯示如圖二。

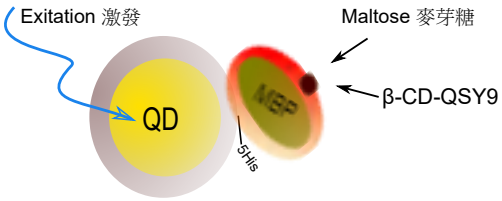


Figure 2: Schematic representation of maltose detecting biosensor.
麥芽糖偵測感應器的示意圖

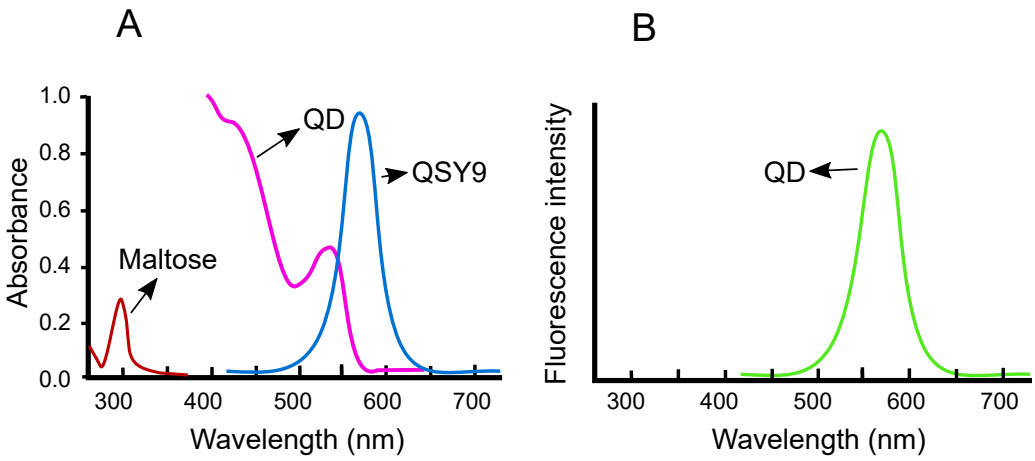


***Figure 3**: Absorption (A) and emission (B) spectra of various molecules.*

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
Displacement of β-CD-QSY9 by maltose on the biosensor will result in reduced fluorescence intensity. 在此生物感應器上若將β-CD-QSY9置換為麥芽糖將導致螢光強度降低。	○	○
In the absence of maltose, FRET cannot occur in the biosensor. 在沒有麥芽糖的情況下，生物感應器中不會發生FRET。	○	○

TRUE 對 FALSE 錯

It is expected that relative fluorescence intensity levels under conditions below are
C> B>A
A: QD with MBP-5His and ß-CD-QSY9 dye
B: QD with MBP-5His and free QSY9 dye
C: QD with MBP-5His

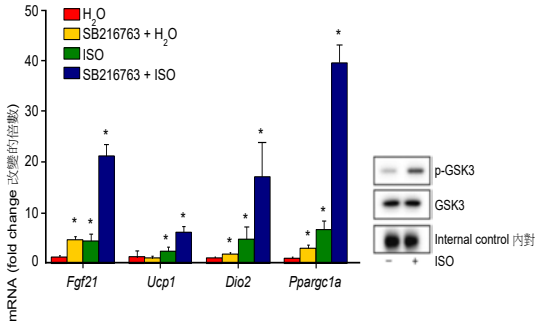
在以下條件下，相對螢光強度預計是
C> B> A.
A：具有 MBP-5His 和 ß-CD-QSY9染料的QD
B：具有 MBP-5His 和 游離QSY9染料的QD
C：具有 MBP-5His 的 QD

QD incubated with MBP that was preloaded with ß-CD-QSY9 will not show FRET.
QD 與事先裝載β-CD-QSY9的MBP作用將不會顯示FRET。

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 13 Expression of Thermogenic Genes
產熱基因的表現

Brown adipose tissue (BAT) activation through β-adrenergic signaling pathway is associated with expression of thermogenic genes and the process of thermogenesis. Glycogen synthase kinase-3 (GSK3) acts as a regulator of β-adrenergic signaling in brown adipocytes. ISO is also a chemical stimulator of BAT activation; its effect on GSK3 is shown by the Western blot below (p-GSK3 is phosphorylated form of GSK3). SB216763 is an inhibitor of GSK3. Effects of these two agents on the expression of thermogenic genes (*Fgf21, Ucp1, Dio2*, and *Ppargc1a*) are shown in the Figure below.
β-腎上腺素活化棕色脂肪組織（BAT）的訊息傳遞路徑與產熱基因的表現和產熱過程有關。肝醣合成酶激酶-3（GSK3）在棕色脂肪細胞中可調節β-腎上腺素之訊息傳導路徑。ISO為可活化BAT的化學促進劑。下面的西方墨漬法顯示ISO對GSK3的作用（p-GSK3是GSK3的磷酸化形式)。SB216763是GSK3的抑制劑。這兩種試劑對產熱基因（ *Fgf21，Ucp1，Dio2*和*Ppargc1a* ）表現的影響如下圖所示。



(*) shows significant difference as compared to control (H_2O)
(*)表示與對照組比較有顯著差異

Based on these results indicate if the following statement are true or false.
根據結果，指出下列敘述是對或錯

	TRUE 對	FALSE 錯
GSK3 acts as a negative regulator of β-adrenergic signaling in brown adipocytes. GSK3可以作為β-腎上腺素對棕色脂肪組織訊息傳導路徑的負調節物。	○	○
Phosphorylation of GSK3 causes decreased expression of *Fgf21*. GSK3的磷酸化導致*Fgf21*的表現降低。	○	○
SB216763 may prevent diet-induced obesity. SB216763可以預防飲食誘導的肥胖。	○	○
Use of SB216763 and ISO together cause much higher increase in the number of *Ppargc1a* mRNA transcripts as compared to *Fgf21* mRNA transcripts. 與*Fgf21* mRNA轉錄的數量相比，同時利用SB216763和ISO會大大增加*Ppargc1a* mRNA轉錄物數量	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 14 Antioxidant Defense in *Plasmodium* 瘧原蟲的抗氧化防護作用

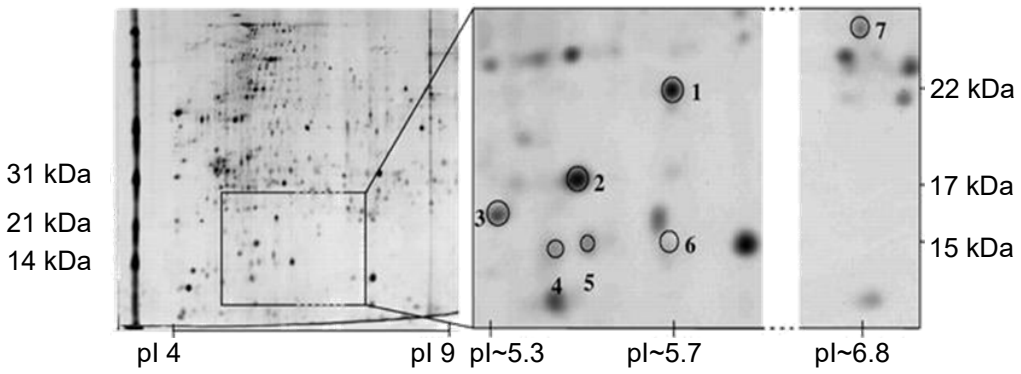
Plasmodium is a parasitic protozoan that is prevalent in tropical countries. Once the parasites invade host red blood cells, they multiply within 24 h. Fe^{2+} in red blood cell can react with free O_2 as well as H_2O_2, causing formation of free radicals that can damage parasite cells.
Unlike host cells, the parasites lack several enzymes of antioxidant defense systems. Scientists analyzed the proteins from the parasite cytosol using two dimensional gel electrophoresis (see image below).

瘧原蟲是一種寄生蟲，在熱帶國家很普遍。一旦寄生蟲侵入宿主紅血球細胞，它們會在24小時內增殖。

但是紅血球細胞中的Fe^{2+}可以與游離的O_2以及H_2O_2反應，形成可以破壞寄生蟲細胞的自由基。由於瘧原蟲缺乏幾種抗氧化防禦系統的酶，所以科學家使用二維凝膠電泳分析瘧原蟲細胞質中的蛋白質（見下圖）。

Then, using mass spectrometry and peptide mass fingerprinting, they identified 6 proteins (spots 1 to 6) corresponding to human peroxiredoxin, while one protein (spot 7) corresponding to *Plasmodium* peroxiredoxin.

接下來，科學家使用質譜和肽質量指紋識別，鑑定了對應於人過氧化物酶的6種蛋白質（點1至6），而一種蛋白質（點7）與瘧原蟲的過氧化還原酶有關。



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

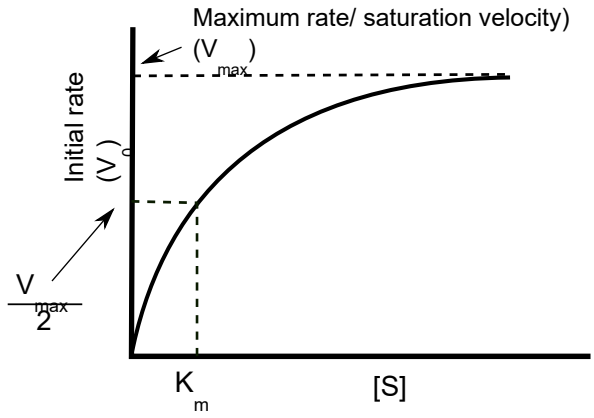
	TRUE 對	FALSE 錯
Based on the presented data, *Plasmodium* peroxiredoxin is a multimeric protein. 所以根據以上資訊，瘧原蟲的過氧化還原酶是一種多聚體蛋白	○	○
All human peroxiredoxin proteins have a positive net charge at physiological pH. 所有人類的過氧化還原酶在正常生理酸鹼環境下都帶正電	○	○

	TRUE 對	FALSE 錯
Gel filtration chromatography is suitable for separation and purification of the six human peroxiredoxin proteins. 光使用凝膠過濾法就可以分離與純化這六種人類的過氧化還原酶	○	○
Immunoaffinity chromatography can be used for separation of *Plasmodium* peroxiredoxin from other *Plasmodium* cytosolic proteins. 免疫親合層析法可以有效把瘧原蟲的過氧化還原酶與其它瘧原蟲細胞質內蛋白質分離	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 15 Enzyme Reaction Rate 酵素反應速率

The figure below depicts the relation between substrate concentration and enzyme reaction rate.
下圖顯示的是受質濃度與酵素反應速率之間的關係



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

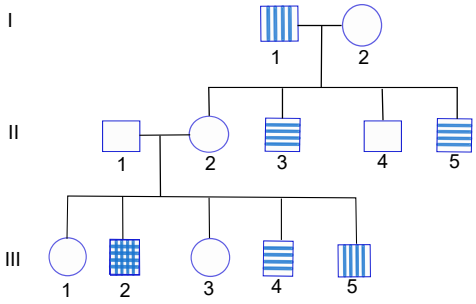
	TRUE 對	FALSE 錯
At saturating levels of substrate, the rate of an enzyme catalyzed reaction is proportional to the enzyme concentration. 在飽和量的受質中，酵素催化反應的速率與其濃度成正比。	○	○
If enough substrate is added, the Vmax of an enzyme catalyzed reaction in the presence of a noncompetitive inhibitor can be the same as Vmax of the reaction in absence of the inhibitor. 如果添加足夠的受質，則在非競爭性抑制劑存在下，酵素催化反應的Vmax會與沒有抑制劑時的反應的Vmax 相同。	○	○
The rate of an enzyme catalyzed reaction in the presence of a rate-limiting concentration of substrate decreases with time. 在受速率限制濃度的受質存在下，酵素催化反應的速率隨時間降低。	○	○
The sigmoidal shape of the V versus [S] curve obtained with allosteric enzymes indicates that the affinity of the enzyme for substrate decreases as the substrate concentration is increased. 用異構酶獲得的V對比[S]曲線的S形顯示，隨著受質濃度的增加，酵素對受質的親和力降低。	○	○
The affinity of an allosteric enzyme for substrate varies with enzyme concentration. 異構酶對受質的親和力隨酵素濃度而變。	○	○

COMMENTS MAXIMUM POINTS STUDENT POINTS

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 16 Pedigree Analysis
譜系分析

The inheritance pattern of two **rare** traits, represented as vertical and horizontal lines, is shown in the pedigree below.
兩個稀有性狀的遺傳模式，分別以垂直和水平線表示，顯示在下面的譜系中。



Indicate if the statements are false or true.
指出敘下列述是對或錯。

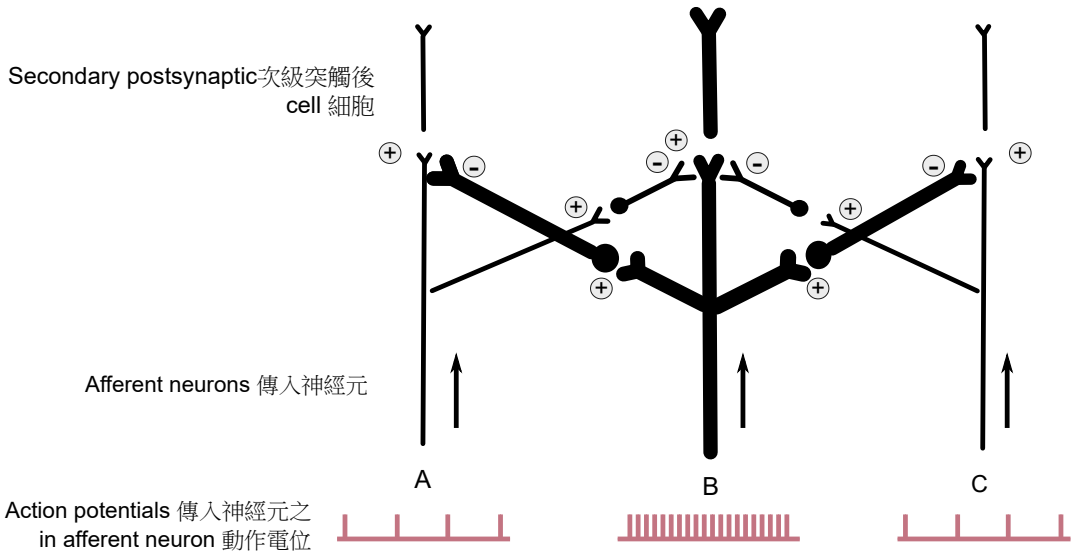
	TRUE 對	FALSE 錯
Inheritance of one of the traits is Y-linked. 其中一個性狀特徵的遺傳模式是Y連鎖的遺傳。	○	○
The data presented is consistent with autosomal recessive inheritance for both traits. 所呈現的數據與兩種性狀的體染色體隱性遺傳一致。	○	○
The phenotype of III-2 may be due to non-dis junction in II-2. III-2的表型可能是因為 II-2 中染色體不分離的結果。	○	○
The phenotype of III-2 may be due to cross over in II-2. III-2 的表型可能是因為 II-2中 發生互換的結果。	○	○
The probability of the phenotype of III-2 being due to a mutation that occurred in an egg cell of II-2 before fertilization is twice the probability of the phenotype of III-4 being due to a mutation that occurred in an egg cell of II-2 before fertilization. 由於在受精前， II-2 的卵細胞發生突變，導致 III-2 表型的機率會是 III-4 的兩倍。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

動物生理學和解剖學

Q. 17 Secondary Neurons
次級神經元

As it is shown in the figure, the sensory neurons can modify the function of adjacent sensory pathway. This inhibitory effect is conducted via intermediate neurons at their synapse with second-order neurons. The width of neurons is correlated with their activity.
如圖所示，感覺神經元可以調節相鄰感覺神經徑路。其抑制作用主要是藉由與二級神經元形成突觸之中間神經元(intermediate neuron)(此種功能主要是透過抑制性中間神經元)，而神經元的寬度與它們的活動密切相關。



According to this phenomenon:
根據這種現象：

	TRUE 對	FALSE 錯
The firing rate of all second-order neurons is higher than to first-order neurons. 與初級神經元相比，所有二級神經元激發率更高(更易激發)。	○	○
The highest relative changes between second and first-order neurons will happen in Path B. 次級和初級神經元之間的最高相對強度變化將發生在路徑B中。	○	○
The difference between the firing rate of second order neurons in A and B pathways will be higher than the difference between firing rate of the first order neuron in these pathways. A和B路徑中次級神經元的激發率的差異將高於這三個路徑中初級神經元的激發速率的差異。	○	○
This mechanism may help to localize the sensory stimulus more accurately 以上機制可能有助於更精準定位感覺刺激。	○	○

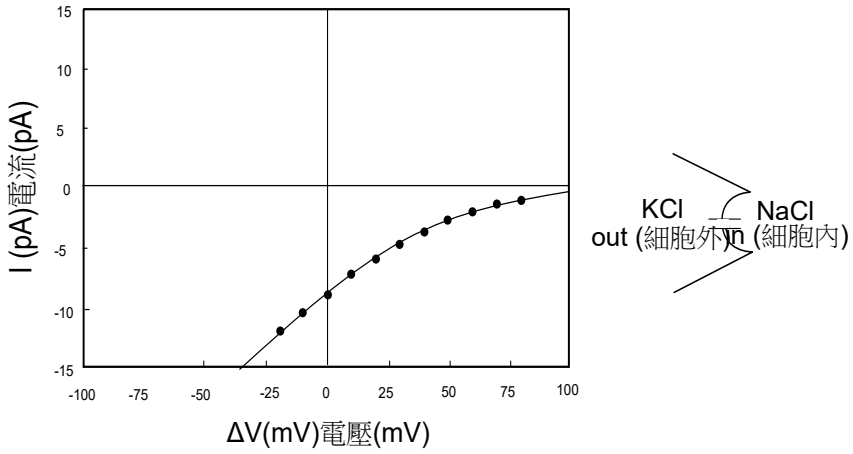
COMMENTS MAXIMUM POINTS STUDENT POINTS

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 18 Patch Clamp
膜片鉗技術

A researcher used a patch clamp technique to record the current of only a cation channel (single channel recording). The pipette contains 150 mM of KCl surrounded by a bath solution containing 150 mM of NaCl, and measures the channel current by clamping the voltage in different values. Current-Voltage curve (I-V curve) is shown in the following figure
.ΔV=Vinterior - Vexterior .
研究人員使用膜片鉗技術(patch clamp)記錄一個陽離子通道所產生之電流(單一離子通道紀錄)。微滴管內含有150mM的KCl，滴管外含有150mM NaCl的溶液，實驗者可固定膜電壓於不同數值，並記錄不同電壓時離子通道之電流。實驗所得之電流 - 電壓曲線（IV曲線）如下圖所示。
ΔV=Vinterior - Vexterior .

A negative current value (i.e., inward current) can reflect either the movement of positive ions (cations) into the cell or negative ions (anions) out of the cell.
A positive current value (i.e., outward current) can reflect either the movement of positive ions (cations) out of the cell or negative ions (anions) into the cell.
負電流值（即電流流向細胞內）可以反映正離子（陽離子）進入細胞或負離子（陰離子）離開細胞。
正電流值（即電流流出細胞外）可以反映正離子（陽離子）離開細胞或負離子（陰離子）進入細胞。



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

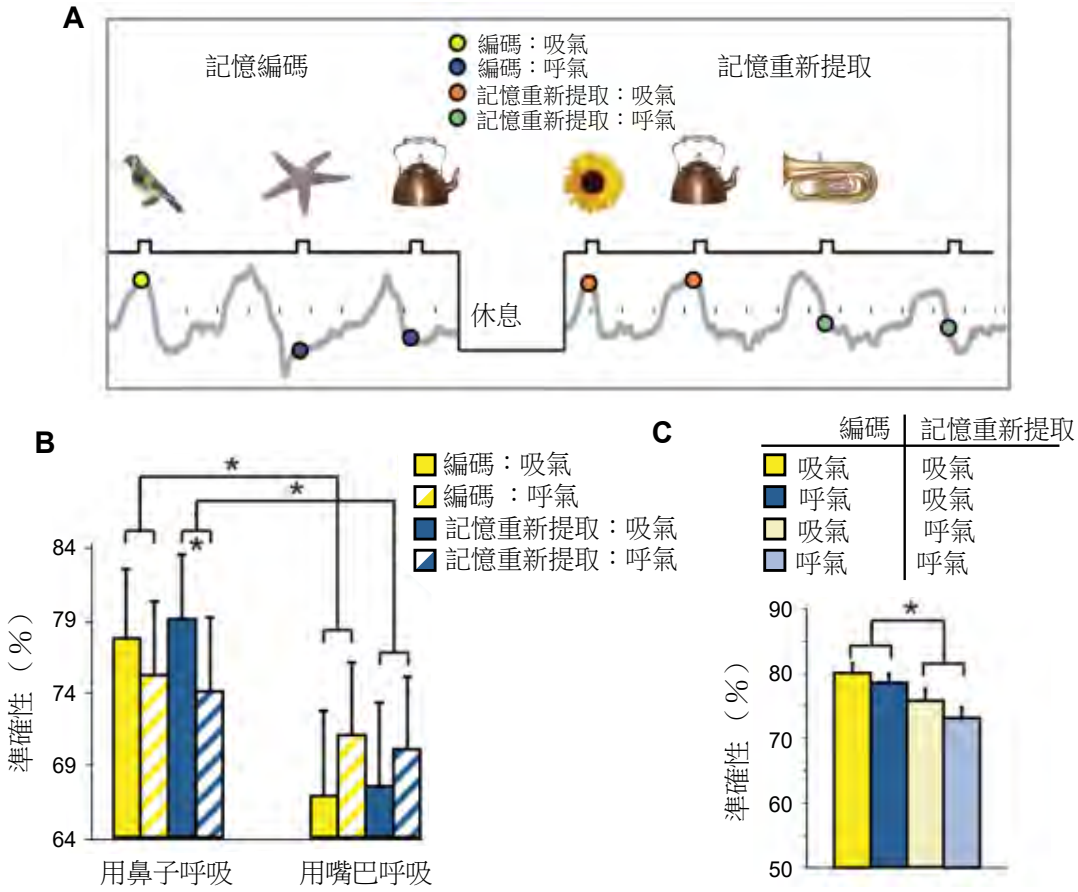
	TRUE 對	FALSE 錯
This channel is not selective, and both K^+ and Na^+ ions pass through this channel. 該離子通道並非專一性離子通道，可讓K^+和Na^+離子通過。	○	○
The Na^+ current decreases with increasing voltage. Na^+電流隨著電壓的增加而降低。	○	○

	TRUE 對	FALSE 錯
The K^+ current increases with increasing voltage. K^+電流隨著電壓的增加而增加。	○	○
The resistance of the channel to negative voltages is less than positive voltages. 此離子通道在負電壓的電阻小於正電壓。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 19 Memory Performance
記憶表現

In a recognition memory task, subjects (human being) viewed a series of different visual objects that occurred at different times within the breathing cycle. The interval between displaying images was 3-6 seconds. After a 20 min break, subjects were presented with the old pictures from the encoding session plus an equal number of new pictures; and the subjects pressed the “Yes” button if they had previously viewed the object's image, and pressed the “No” button if the image was new. Subjects' memory performance was examined in the episodes of inspiration and expiration, and in mouth breathing and nasal breathing (In figures “*” means $p < 0.05$ which indicates significant difference between groups).
在識別記憶任務中，受試者觀察在呼吸循環內不同時間的一系列視覺影像。兩個影像顯示的間隔為3-6秒。休息20分鐘後，向受試者同時呈現已編碼之舊圖片以及相同數量的新圖片，並要求如果是之前的舊圖片，就按下"是"的按鈕；若為新圖片，則按下“否”按鈕。受試者接下來分別在呼吸周期中吸氣和呼氣，以及口呼吸和鼻呼吸等過程中，檢測受試者的記憶表現（“*”表示$p < 0.05$，表示組間有顯著差異）。



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

	TRUE 對	FALSE 錯

	TRUE 對	FALSE 錯
The inspiration and expiration phase does not affect memory performance during oral breathing. 受試者若利用嘴巴呼吸，則吸氣和呼氣階段不影響受試者的記憶表現。	○	○
Memory function during nasal breathing is significantly more than during oral breathing. 用鼻呼吸期間的記憶功能明顯高於用嘴巴呼吸期間的記憶功能。	○	○
Regardless of whether the object's image is displayed during the encoding in the inspiration or expiration phase, if the object's images are depicted in the inspiration phase during the retrieval, memory performance is significantly greater. 若在記憶之編碼時期，無論在呼吸過程任一階段的對受試者顯示圖像，而在吸氣時進行記憶重新提取要求描繪圖像，則受試者之記憶效能將顯著提高。	○	○
In breathing through the nose, unlike encoding, the accuracy of retrieval in the inspiration phase is significantly higher than in the expiration phase. 若受試者用鼻子呼吸，則與編碼不同，在吸氣階段的記憶重新提取準確性顯著高於呼氣階段。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 20 Magnetic Resonance Imaging
核磁共振影像

The principle of magnetic resonance imaging (MRI) is based on the fact that the nuclei of certain elements align with the magnetic force when placed in a strong magnetic field. At the field strengths currently used in medical imaging, hydrogen nuclei (protons) in water molecules and lipids are responsible for producing anatomical images.
磁共振成像（MRI）的基本原理主要是將某些元素置於強大磁場時，所產生之磁力會改變元素原子核的旋轉排列方向，使之共振。在生物醫學領域方面，由於水分在人體內占大部分，而細胞膜之主要成分為脂肪，故主要利用氫原子之共振產生人體解剖影像。

If a radiofrequency pulse at the resonant frequency of hydrogen is applied, a proportion of the protons change alignment, flipping through a present angle, and rotate in phase with one another. Following this radiofrequency pulse, the protons realign (relax), they induce a signal which, although very weak, can be detected and localized by copper coils placed around the patient. An image representing the distribution of the hydrogen protons can be built up.
如果在強烈磁場中對氫施加特定頻率之電磁波，則會使質子改變旋轉方向及角度，產生共振，如此一來，質子共振會產生特殊訊號，雖然微弱，但受試者周圍之層層銅圈仍可測得訊號，如此一來即可建立氫質子分佈的影像。

The strength of the signal depends not only on proton density but also on two relaxation times, T1 and T2; T1 depends on the time the protons take to return to the axis of magnetic field, and T2 depends on the time the protons take to dephase. A T1-weighted image is one in which the contrast between tissues is due mainly to their T1 relaxation properties, while in a T2-weighted image the contrast is due to the T2 relaxation properties.
信號強度不僅取決於質子密度，還取決於兩個回覆時間T1和T2; T1取決於質子返回磁場軸所需的時間，T2取決於質子進入dephase的時間。 主要有T1和T2兩種加權圖像以更精確判讀。

T1-weighted image: Fat signal intensity > Water signal intensity
T2-weighted image: Fat signal intensity < water signal intensity
T1加權圖像：脂肪信號強度>水信號強度
T2加權圖像：脂肪信號強度<水信號強度

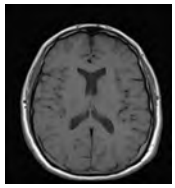


Figure 1:
axial image
of brain

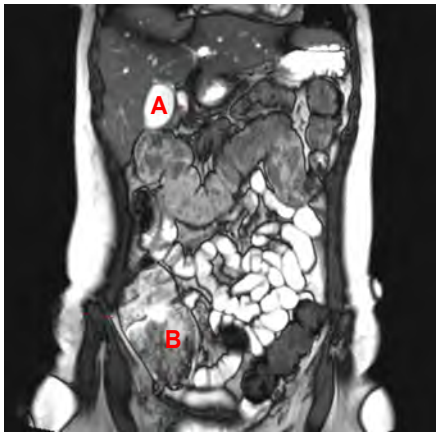


Figure 2:
Coronal T2-weighted
image of abdomen

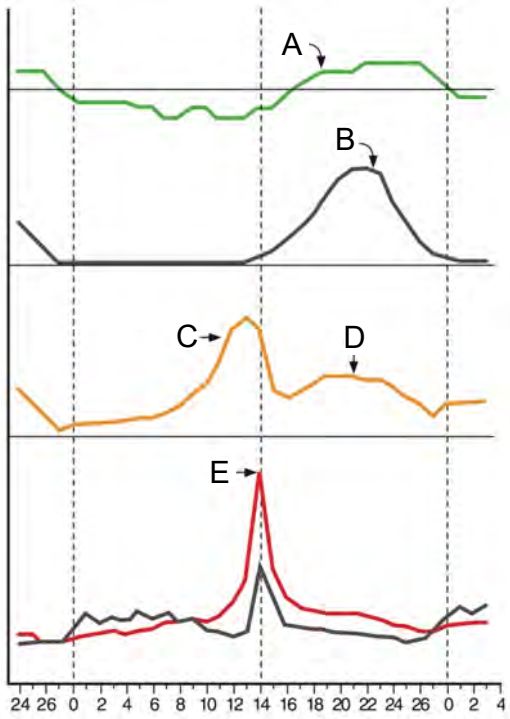
Based on your anatomical and physiological knowledge indicate whether the below statements are true or false.
根據您的解剖學和生理學知識，指出下列敘述是對或錯。

	TRUE 對	FALSE 錯
The figure 1 must be T1-weighted image due to higher signal intensity of white matter than gray matter. 圖1必為T1加權圖像，因為白質的信號強度高於灰質。	○	○
If there is inflammation in a tissue the inflamed area would be of higher intensity in T2-weighted due to the resulting edema. 如果組織發炎，因為發炎會導致水腫，發炎區域在T2加權圖像中訊號會更強烈。	○	○
the major secretions of the organ in figure 2 which is marked as **A**, are amylase and lipase. 圖2A器官的主要分泌物是澱粉酶和脂肪酶。	○	○
In figure 2 the part **B** is shorter in herbivores than carnivore mammals. 在圖2中，草食動物中的**B**部分比食肉動物及哺乳動物短。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 21 Menstrual Cycle
月經週期

The menstrual cycle is the regular natural change that occurs in the female reproductive system. In the ovary, where oogenesis take place, each cycle can be divided into three phases consisting of the follicular phase, ovulation and luteal phase. The menstrual cycle is controlled by hormones of hypothalamus-pituitary-ovary axis. The figure shows alternations in body temperature and hormonal changes during the menstrual cycle.
月經週期是女性生殖系統中發生的規律自然變化。月經週期主要發生在卵巢中，每個週期可分為三個階段，包括濾泡期，排卵期和黃體期。月經週期由下視丘-腦垂體 - 卵巢軸所分泌的激素控制。下圖顯示了月經週期中體溫和各激素的關係



月經週期之天數

Use the figure to answer questions 1 to 5.
使用該圖來回答問題**1**到**5**。

	TRUE 對	FALSE 錯
The increase shown at point A is caused by the effect of estrogen on the anterior pituitary. A點的上升是由雌激素對腦垂體前葉的影響所引起。	○	○
Curve B shows changes in progesterone level during menstrual cycle. 曲線B顯示月經週期期間黃體素濃度的變化。	○	○
The source of the increase in concentrations indicated at point C and D are granulosa cells and corpus luteum, respectively. 在C點和D點的濃度增加分別是來自顆粒細胞和黃體。	○	○

	TRUE 對	FALSE 錯
Substance E is secreted by follicular cells. 物質E由濾泡細胞所分泌。	○	○
The cause of the sudden increase shown at point E is positive feedback of estrogen on the anterior pituitary and absence of progesterone. E點突然急遽上升是因為雌激素對腦垂體前葉的正回饋作用和黃體素的缺乏。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 22 Coombs Test

There are two clinical tests to detect some antibodies against erythrocytes (RBCs), direct coombs test and indirect coombs test.
直接Coombs試驗和間接Coombs試驗為兩種臨床上用以偵測紅血球抗體之檢測方式。

During the direct coombs test a blood sample is taken from a person. RBCs are washed (removing the patient's own plasma) and then incubated with anti-human globulin, which attaches to all IgG antibodies. Coombs test is positive if agglutination reaction occurs.
直接Coombs檢測：自受試者取血液樣本後，首先洗滌RBC（以去除患者自身的血漿），然後與人體球蛋白抗體一起培養，因人體球蛋白抗體可附著所有IgG抗體。如果發生凝集反應則此Coombs試驗呈現陽性反應。

n the indirect coombs test, serum is extracted from the blood sample taken from the person. Then, the serum gets incubated with RBCs of known antigenicity and is washed. Finally, anti-human globulin is added. If agglutination occurs, the indirect coombs test is positive.
在間接coombs測試中，首先從人的血液樣本中萃取血清。然後，將血清與已知抗原性的RBC一起培養及洗滌。最後，添加人體球蛋白抗體。如果發生凝集，則此間接Coombs試驗呈現陽性反應。

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

	TRUE 對	FALSE 錯
Direct coombs test will be positive only if autoantibodies are present. 只有在自體抗體存在時，直接Coombs測試才會呈現陽性。	○	○
If the result of indirect coombs test using serum of patient 1 and RBCs of patient 2 is positive, so we can use the patient 2 as a blood donor for patient 1. 如果將患者1的血清和患者2的RBC進行間接Coombs測試，其結果都是陽性，那麼患者2可捐血給患者1。	○	○
Anti-human globulin specifically binds to the variable part of human anti-bodies. 人體球蛋白抗體可特異性結合人體抗體的可變部分。	○	○
In a positive indirect coombs test, antigen-antibody reaction happens *in vivo.* 若間接Coombs試驗結果呈現陽性，則此抗原 - 抗體之反應可*在體內*發生。	○	○

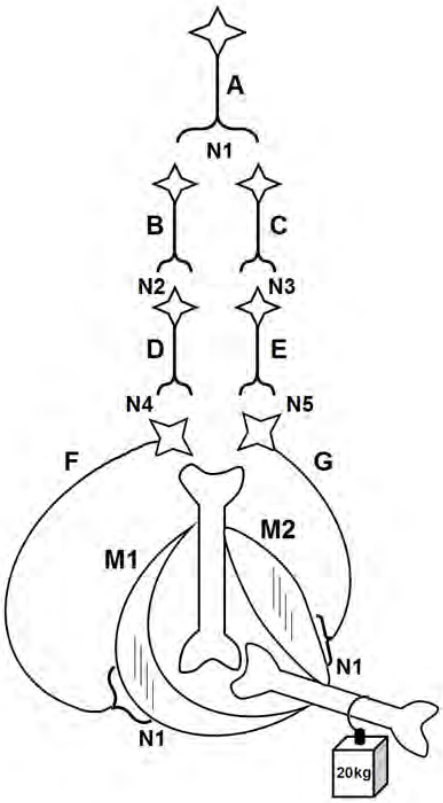
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 23 Neural Network
神經網絡

The diagram below illustrates a neural pathway and the features of the associated neurotransmitters are described in the table.
下圖顯示神經傳導徑路而其所分泌之神經傳導物質（N1-N5）及其屬性列於下表。

Ions concentrations inside and outside of the cells are same as their physiological normal values in body and inhibition of an inhibitory neuron results in the stimulation of postsynaptic neuron.
"+" Symbol in table indicate the activation of the ion channels which increases the ion permeability across the membrane.
細胞內外的離子濃度與體內的生理正常值相同，而抑制性神經元的抑制反而會導致突觸後神經元的興奮。
表中的"+"符號表示離子通道的激活，增加了細胞膜對離子的通透性。

Neurotransmitter 神經傳導物質	Cl^- 通透性	Na^+ 通透性	K^+ 通透性
N1		+	
N2	+		
N3			+
N4	+		
N5		+	



Indicate if each of the following statements is true or false.
假設**A**神經元受到刺激，請指出下列敘述是對或錯。

	TRUE 對	FALSE 錯
The function of N1 neurotransmitter is same as acetylcholine. N1此種神經傳導物質的功能與乙醯膽鹼相同。	○	○
Neuron G is not depolarized and neuron F is stimulated so muscle M1 contracts. 神經元G沒有去極化且神經元F被刺激的狀態下，肌肉M1收縮。	○	○
Neuron G gets depolarized as a result of Na ions influx. 由於Na離子流入，神經元G去極化。	○	○
Neuron F gets depolarized as a result of Cl ions efflux. 由於Cl離子流出，神經元F去極化。	○	○

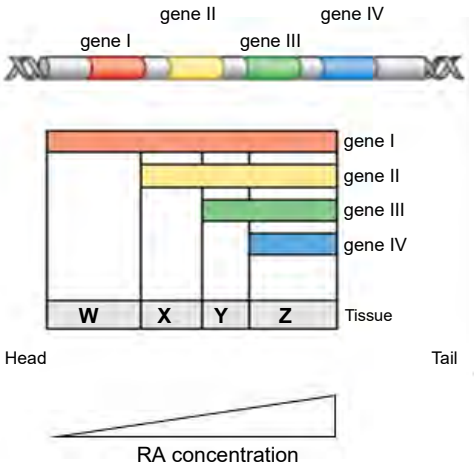
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 24 HOX Genes 同源異型基因

Neural tube in the vertebrate embryos,lies the anterior-posterior (AP) axis and creates a variety of structures. There is a large body of evidence showing that AP patterning of the vertebrate embryos is controlled by HOX genes. Spatial and temporal expression patterns of HOX genes are controlled by factors usually present as gradients in the AP axis of embryos. One of these gradients is generated by retinoic acid (RA), a derivative of vitamin A, with maximum concentration in the posterior region of the embryos (Figure below).

脊椎動物胚胎中的神經管位於前 - 後（AP）軸並發育出多種結構。有大量證據顯示脊椎動物胚胎的AP模式受HOX基因控制。 HOX基因的時空表達模式由一個通常作為胚胎AP軸的梯度存在的因子控制。

其中一個梯度由視黃酸（RA）(Vitamin A的衍生物)產生，在胚胎的後半部區域具有最大濃度（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
Overuse of vitamin A by pregnant women may cause abnormalities in the embryos. 孕婦過量使用維生素A可能會導致胚胎異常。	○	○
In an embryo that has been affected by excessive amounts of RA in the early stages of embryogenesis, the forebrain may not form. 在胚胎髮育早期受到過量RA影響的胚胎中，前腦可能不會形成。	○	○
Loss of function of a HOX gene in the embryo may have the same effect as an excessive amount of RA. 胚胎中HOX基因的功能喪失可能與過量的RA具有相同的效果。	○	○
In an embryo whose expression of RA nuclear receptors has been downregulated, the midbrain may develop similar to the forebrain. 在RA核受體表現下調的胚胎中，中腦可能發育類似於前腦。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 25 Shell Coiling 蝸牛殼的旋性

In snail, the direction of cleavage, and therefore the snail shell coiling, is controlled by a single gene, in which the right-coiling allele, D, is dominant to the left-coiling allele, d. Below table shows the results of a set of mating experiment.

在蝸牛這類生物中，卵裂的方向，還有殼的旋性，是由單一基因所控制。右旋殼(right-coiling)的等位基因D，較左旋殼(left-coiling)的等位基因d優勢。下表顯示了一組交配實驗的結果。

		Genotype	Phenotype
DD♀ x dd♂	→	Dd	All right-coiling
DD♂ x dd♀	→	Dd	All left-coiling
Dd x Dd	→	1DD:2Dd:1dd	All right-coiling

Based on the results of mating experiment, indicate if each of the following statements is true or false.
根據交配實驗的結果，指出下列敘述是對或錯

	TRUE 對	FALSE 錯
The direction of cleavage is determined by the genotype of the developing snail. 蝸牛卵裂的方向是由正在發育中的蝸牛的基因型所控制。	○	○
If the egg cytoplasm of a recessive homozygous right-coiling mother is injected into the eggs of the “dd” mother, the resulting embryos coil to the left. 若將來自隱性(recessive)同型合子(homozygous)的右旋蝸牛母親的卵細胞質，注射到“dd”母親的卵中，產下的胚胎會是左旋。	○	○
Injection of the egg cytoplasm from a heterozygous left-coiling mother into the eggs of the right coiling heterozygous mother, does not affect the right-coiling in the embryos.若將來自異型合子(heterozygous)的左旋蝸牛母親的卵細胞質，注射到右旋且具異型合子母親的卵中，產下的胚胎還是右旋。	○	○
“DD” or “Dd” mothers place a coiling determinant factor inside the egg cytoplasm. “DD” 或 “Dd”的母蝸牛，會將決定螺殼是左旋或右旋的物質，置入在蛋細胞質中。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 26 *Dendrogramma* 澳洲神奇海香菇

Dendrogramma is a new animal species which has been collected at 400 and 1000 metres on the Australian continental slope off eastern Bass Strait and Tasmania during a cruise in 1986 and described as a new taxon in 2016. The new taxon is multicellular (metazoan), non-bilateralian, apparently diploblastic with a dense mesoglea between an outer epidermis and an inner gastrodermis.

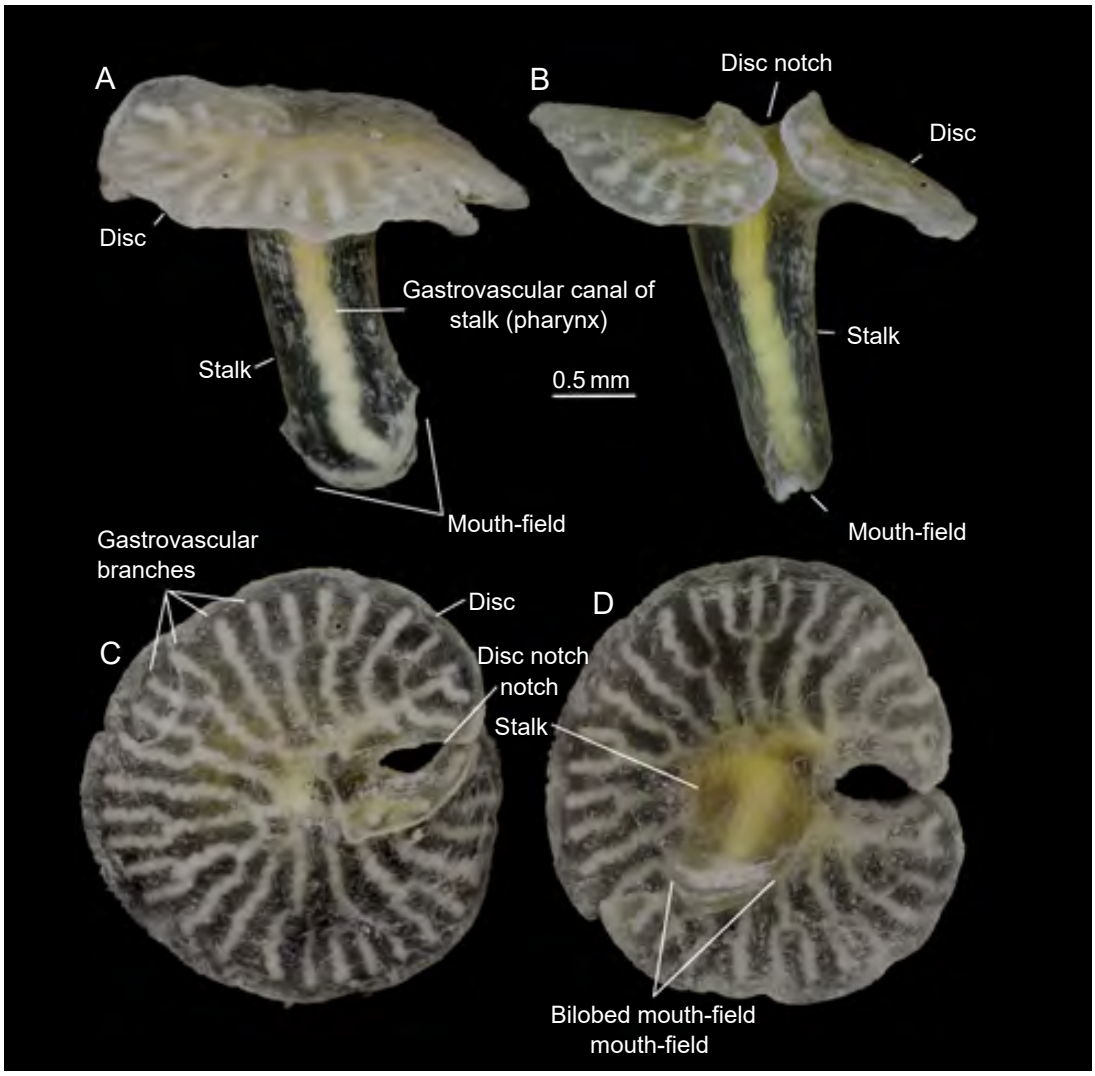
*Dendrogramma*是一群在1986年於澳洲巴斯海峽和塔斯馬尼亞島的深海中所發現的動物，並在2016年被描述為新的分類群。這個香菇狀的玩意兒是多細胞，非兩側對稱，有兩胚層，在外表皮和內腸間有豐富的中膠層啊。

This animal is composed of a body divided into a stalk with a mouth opening terminally, and a flattened disc. The mouth is set in a specialized, lobed epidermis field, leading into a gastrodermis-lined gastrovascular canal (pharynx) in the stalk which aborally branches dichotomously into numerous radiating canals in the disc. We can state with considerable certainty that the organisms lack cnidocytes, tentacles, marginal pore openings for the radiating canals, ring canal, sense organs in the form of statocysts or the rhopalia, or colloblasts, ctenes, or an apical organ.

這種動物有一個莖體和一個圓盤組成。口腔位於在葉狀表皮區，通向莖體中的消化腔，在盤狀部又有許多放射狀管道。牠們缺乏刺絲胞，觸手，放射管的邊緣開口，環狀管，靜脈竇、囊狀體或頂端器官。

No cilia have been located. They have simple mouth opening with specialized lobes secreting mucus.

牠們沒有纖毛，有簡單的口狀結構而且會分泌黏液。



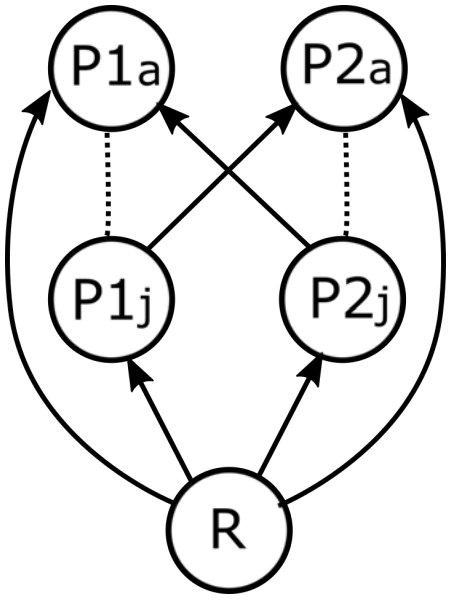
Indicate if each of the following statements is true or false.
指出下列敘述是對或錯

	TRUE 對	FALSE 錯
According to the characteristics of *Dendrogramma* it could be placed in Cnidaria. 神奇香菇一定是刺絲胞動物	○	○
It seems likely that *Dendrogramma* feed on micro-organisms. 大香菇可以吃微生物	○	○
Lack of statocysts and rhopalia shows that this taxon does not have nervous system. 因為缺乏一般水母的平衡囊與平衡棒，所以大香菇沒有神經系統	○	○
Most likely *Dendrogramma* could have Dinoflagellate symbionts such as *Symbiodinium.* 大香菇很可能具有雙鞭藻之類的共生生物	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 27 Intraguild Predation
相同食性階層內捕食

Intraguild predation is the killing and sometimes eating of potential competitors. Reciprocal intraguild predation with size structure, is one type of intraguild predation where both consumers feed on each other's juveniles. In this case, P1 has piercing-sucking type mouthparts, and P2 has chewing type mouthparts. In the figure below "R" represents resource, "P" represents (reciprocal) intraguild predator, "j"represents juveniles and "a" represents adults.
相同食性階層內捕食，指的是殺害，甚至食用同一食性階層內的競爭者，其中包括一種稱作reciprocal intraguild predation with size structure的相同食性階層內捕食，這種專指會互相捕食對方的幼體(juveniles)。假設P1這物種具有刺吸式口器，P2具有咀嚼式口器，在下圖，"R"代表資源，"P"代表捕食者(會捕食彼此)，"j"代表幼體，"a"代表成體。



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

	TRUE 對	FALSE 錯
If P1j population increases, then P2a will produce more eggs. 如果P1j數量增加，P2a將會生更多的卵。	○	○
If P2j population decreases, then P2a population will increase in next generation. 如果P2j數量減少，P2a的數量在下一個世代將會增加。	○	○
If R increases, then P2a doesn't feed on P1j. 如果R增加，P2a不會捕食P1j。	○	○
If R decreases, then P2a population will increase in next generation. 如果R減少，P2a的數量在下一個世代將會增加。	○	○

COMMENTS MAXIMUM POINTS STUDENT POINTS

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

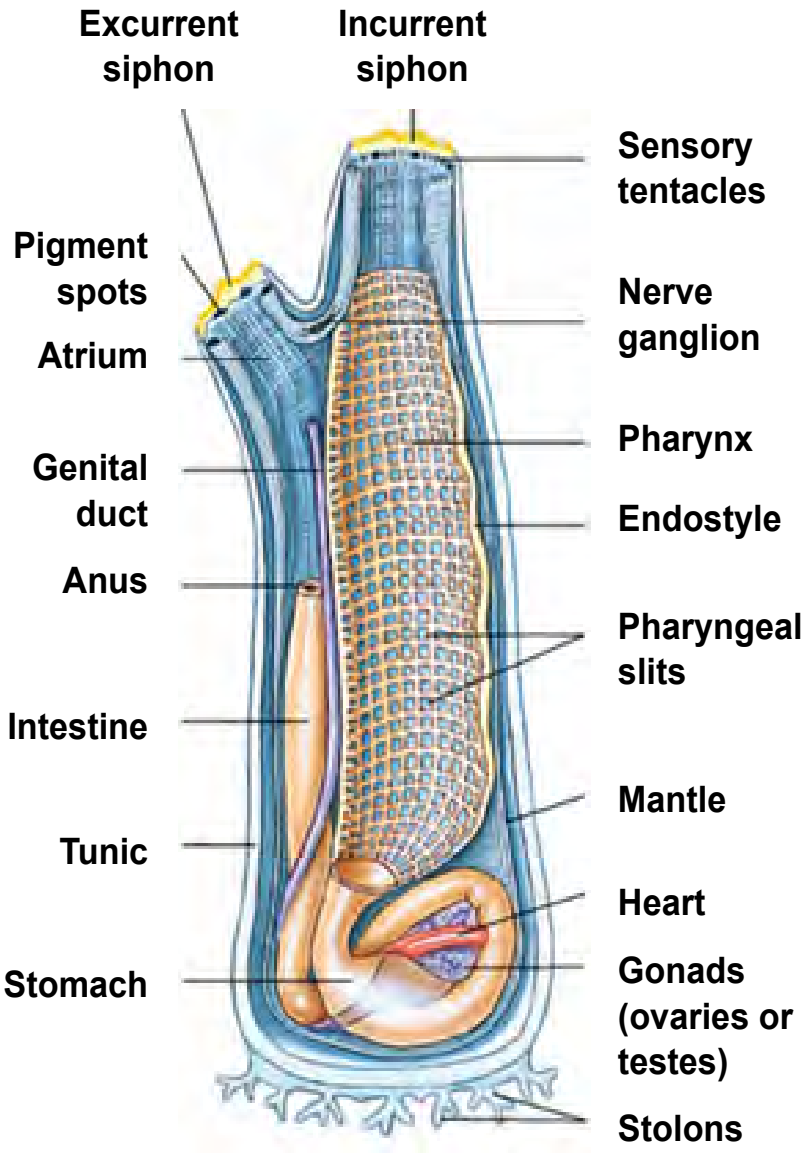
Q. 28 Tunicate Morphology 海鞘的形態

Five distinctive characteristics that, taken together, set chordates apart from all other phyla are notochord, dorsal tubular nerve cord, pharyngeal pouches or slits, an iodine secreting organ (endostyle), and post-anal tail. These characteristics are always found at some embryonic stage, although they may be altered or may disappear in later stages of the life cycle. Tunicates belong to Deuterostomia group of Metazoa and are found in all seas from near shoreline to great depths. Most are sessile as adults, although some are free-living. The name "tunicate" refers to the usually tough and nonliving tunic that surrounds the animal and contains cellulose-like components. As adults, tunicates are highly specialized chordates, for in most species only the larval form, which resembles a microscopic tadpole, bears all the chordate hallmarks. Tadpole undergoes metamorphosis and changes its morphology and anatomy.

脊索動物的共衍徵有五個：脊索，背管狀神經索，具有咽囊或狹縫，碘分泌器官（內胚層）和具有肛門後方的尾部。

這些特徵可以在胚胎階段發現，儘管它們可能會在某個生活史階段中發生變化或消失。

海鞘是後口類動物，雖然少數物種為自由漂浮，大多數成體是固著性的，而且在其外殼含有纖維素。海鞘的幼體看起來像蝌蚪，具有脊索，但在成長後脊索消失。



Structure of a common tunicate, Ciona sp.

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

	TRUE 對	FALSE 錯
Adult of tunicates shows two shared derived characters, which are present in all chordates. 海鞘成體仍然具備所有脊索動物共有衍徵中的兩個。	○	○

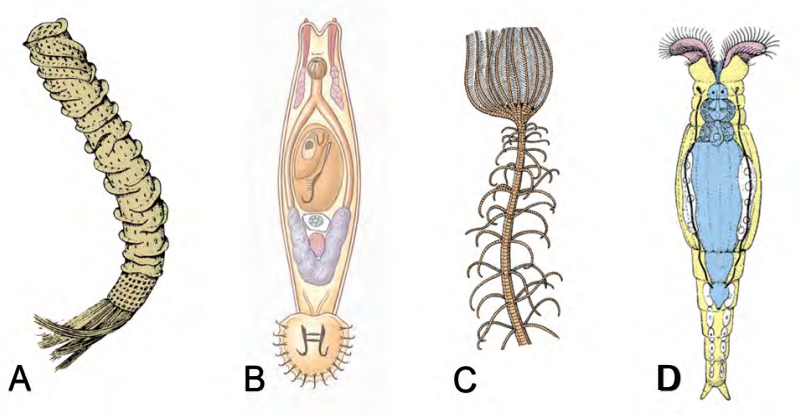
	TRUE 對	FALSE 錯
Main pathway for seawater is: incurrent siphon, gut, anus, atrium and excurrent siphon. 海鞘從海水濾食的途徑是：incurrent siphon, gut, anus, atrium和excurrent siphon。	○	○
In *Ciona*, notochoard is homologous to backbone of vertebrates. 海鞘的背柱與脊椎動物的脊椎骨同源。	○	○
Ciona belongs to the coelomate vertebrate group and coelom forms from fusion of enterocoelous pouches. 海鞘是真體腔"脊椎"動物，體腔是由腸體腔囊癒合而成。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 29 Metazoa Taxonomy 後生動物的分類

You are given four figures referring to typical representatives of four major phyla of animals.

在下面你會看到四張代表動物主要類群的圖片



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
Organism **A** belongs to a taxon characterized by unique aquiferous system, radial or no symmetry and lack of tissue and organ systems. A具有獨特的水溝系統、輻射對稱或沒有對稱性，不具備組織或器官。	○	○
Organism **B** belongs to a taxon characterized by bilateral symmetry, lack of coelom, protonephridia and ladder-like nervous system. B兩側對稱、沒有體腔、沒有原腎管，也沒有梯狀神經系統	○	○
Organism **C** belongs to a taxon characterized by entrocoelic development, pentaradial symmetry and metamorphosis. C有腸體腔、五放射對稱，生活史中有變態。	○	○
Organism **D** belongs to a taxon characterized by radial symmetry, hydrostatic skeleton and schizocoelic development. D輻射對稱、有水壓靜力骨和裂體腔發育。	○	○

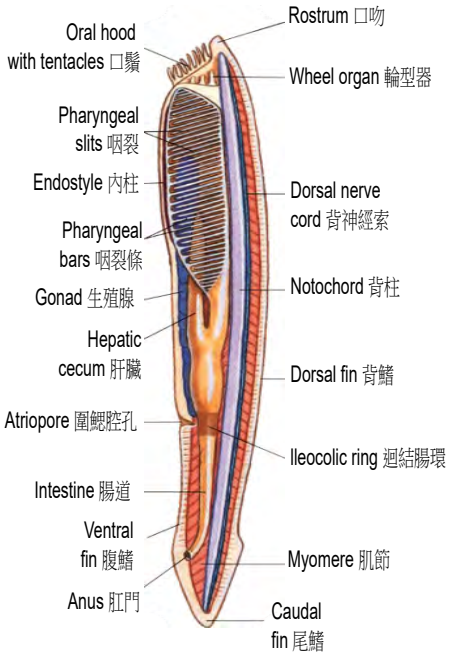
COMMENTS MAXIMUM POINTS STUDENT POINTS

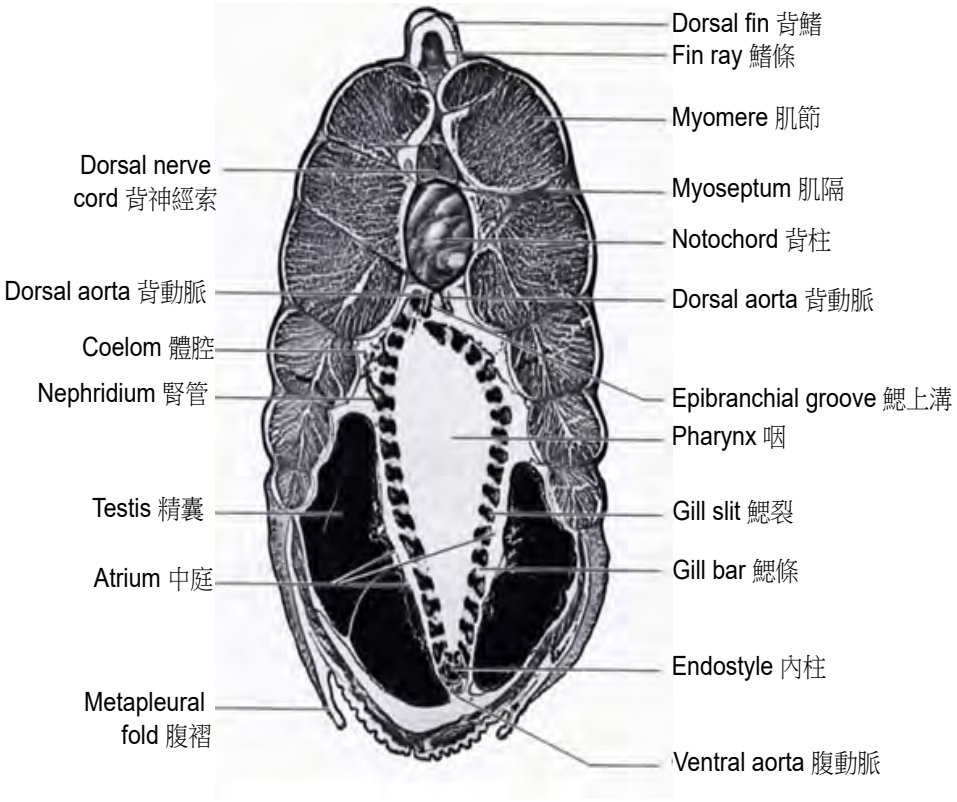
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 30 Amphioxus Morphology 文昌魚的形態

Amphioxus (lancelet) is a marine slender, laterally compressed and translucent filter-feeder deutrostome that inhabits the sandy bottoms of coastal waters around the world. Sexes are separate, gonads are located in the atrial cavity and there are no ducts. The closed circulatory system of this fish, like animals, is complex for such a simple chordate. The flow pattern is remarkably similar to that of primitive vertebrates. The colorless blood is pumped forward in the ventral aorta by peristaltic-like contractions of the vessel wall only, then passes upward through branchial arteries (aortic arches) in the pharyngeal bars to paired dorsal aortas which join to become a single dorsal aorta. From here the blood is distributed to the body tissues by microcirculation and then is collected in veins, which return it to the ventral aorta.

文昌魚(頭索動物)是一種小型濾食性脊索動物、兩性生殖、生殖腺位於心房腔內，沒有生殖管線、閉鎖式循環、血液循環接近原始脊椎動物。無色血液僅通過血管壁收縮在腹主動脈中向前泵送，然後向上穿過咽部的鰓動脈（主動脈弓）到成對的背主動脈，這些主動脈連接成為單個背主動脈。從這裡，血液通過微循環分派到身體組織，然後集中於靜脈中，靜脈將血液返回到腹主動脈。





Based on these data and Figure, indicate if each of the following statements is true or false.

根據圖片，請指出下列敘述是對或錯

	TRUE 對	FALSE 錯
The blood is circulated from anterior to posterior dorsally and from posterior to anterior ventrally. 血液是從背部開始，由頭流到後方，然後再從後面沿著腹方流回前面。	○	○
The heart consists of a sinuous venosus, a cardiac atrium, and a ventricle located ventrally and carries low oxygen blood. 心臟只由靜脈，心房和心室組成，腹側並攜帶低氧血。	○	○
It differs from vertebrates in having numerous pharyngeal slits that are not open outside directly but acts as a trapping structure to collect small-suspended particles. 牠的鰓裂是拿來'收集水中懸浮物的。	○	○
Sperms are released into the atrial cavity, and then pass out via genital pore and atriopore to the outside where fertilization occurs. 精子被釋放到心房腔內，然後通過生殖器的孔和圍鰓腔孔傳遞到外面。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 31 Electrocardiography 心電圖

Electrocardiography is a method to study the electrical activity of the heart (ECG). In addition to P, QRS and T waves, there are segments and intervals which are defined to show a specific period of time in a cardiac cycle. A variety of different factors like concentration of electrolytes, drugs and temperature could have an effect on waves and intervals of ECG. A group of researchers have studied the effect of body temperature on QT and RR interval in electrocardiogram of beagle dogs. The result of their study is demonstrated in figures 1 and 2.

心電圖是一種研究心臟電活動（ECG）的方法。除了P，QRS和T波之外，還有許多波與波之間的間隔可用以顯示心動週期中的特定活動。有各種不同的因素都會影響心電圖的波形和間隔，如電解質濃度，藥物和溫度等。研究人員研究體溫對比特犬心電圖中QT和RR間期的影響，他們的研究結果如圖1和圖2所示。

Note that RR interval is the time between two consecutive R waves and QT interval is the exact time before start of Q wave till the end of the next T wave.

注意，**RR**間隔是兩個連續**R**波之間的時間，**QT**間隔是**Q**波開始到下一個**T**波結束之前的確切時間。

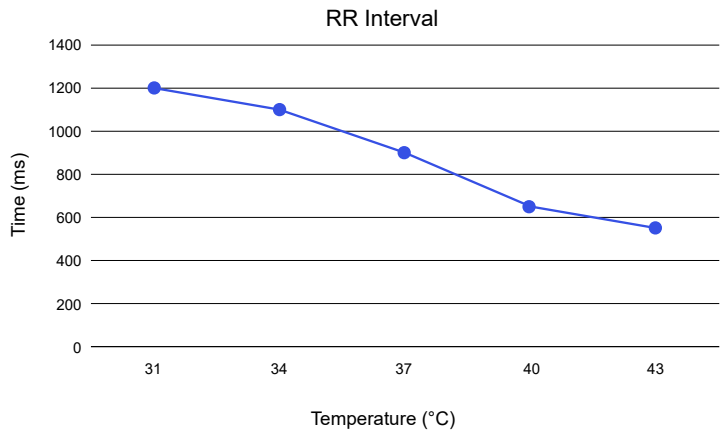


Figure 1. *Relation between RR Interval and body temperature RR間隔和體溫的關聯*

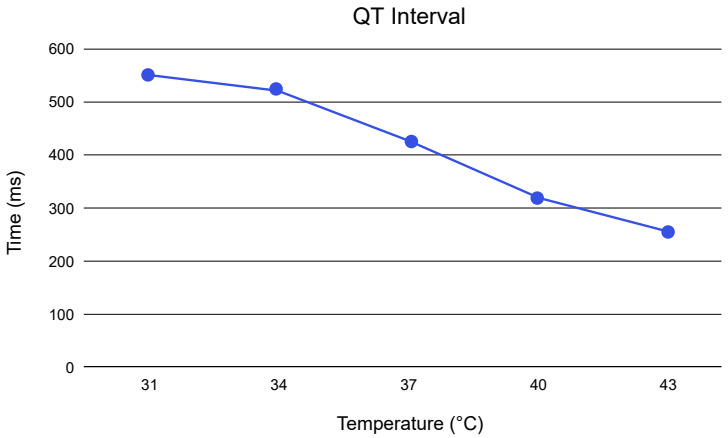


Figure 2. *Relation between QT Interval and body temperature*
*圖**2.**QT間隔和體溫兩者之間的關係*

Given that QT interval gets shorten by the shortening of the RR interval, a formula (given below) has been approved to calculate a corrected QT interval (QTc) to allow the comparison of QT interval over time at different heart rates.
-Hodges formula: QTC = QT + 1.75 (heart rate – 60)

已知縮短RR間期亦會縮短QT間期，下列公式可用以計算校正後的QT間期（QTc）以允許在不同心跳速率下比較QT間隔隨時間的變化。
-Hodges公式：QTC = QT + 1.75（心跳- 60）

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

	TRUE 對	FALSE 錯
Body temperature does not have any effect on heart rate. 體溫對心跳沒有任何影響。	○	○
Independent of changes of heart rate, QT interval is shortened by rise of body temperature. QT間期因體溫升高而縮短的現象與心跳變化無關。	○	○
Hypocalcemia will shorten the QTc interval. 低鈣血症會縮短QTc間期。	○	○
In higher body temperature, end diastolic volume of ventricles is increased. 在較高的體溫時，心室舒張末期容積會隨之增加。	○	○

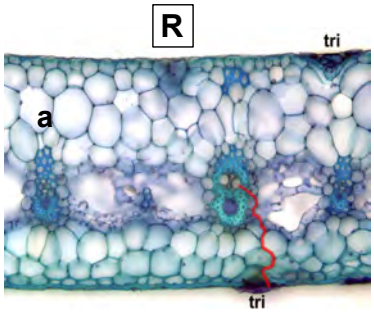
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

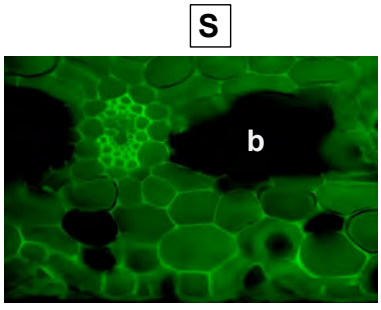
PLANT PHYSIOLOGY 植物生理

Q. 32 Bromeliad Morphology 鳳梨科植物的形態學

Some plants in the Bromeliaceae essentially lack stems and absorptive roots. They take up water from reservoirs known as “tanks” that are formed by overlaps of bases of different leaves (Fig. P-Q). All Bromeliads have profuse trichome coatings on both sides of their leaves. The coatings consist of tiny sliver white cells that are able to take up moisture and nutrients and transfer these into the plant.
鳳梨科的一些植物基本上缺乏莖和吸收根。他們從被稱為“水缸 (tanks) ”的儲水缸中吸取水分，這些水缸是由不同葉子的基部重疊而成的（圖A-B）。所有鳳梨科植物葉子的兩側表面都有豐富的毛狀體覆蓋，其由微小的銀白色細胞所組成，能夠吸收水分和養分，並進一步轉移到植物體中。

Morphology and anatomy of leaf of a bromeliad is shown. The leaf was cut at the base of the tank region, sealed, and immersed in aqueous solution of a fluorescent dye, for 2 h. Cross-sections were made from the blade (Fig. R) and tank (Fig. S) before and after staining, respectively. Red line indicates pathway for water between vein and trichome (tri).
圖中顯示了鳳梨葉片的形態和解剖。將葉子從"水缸"區域的底部切下，密封切下的葉片，並浸入含螢光染料的水溶液中2小時。在染色之前和之後分別從葉片(blade)區（Fig.C）和"水缸"區（Fig.D）製備橫切切片。紅線表示葉脈和毛狀體之間的水流動路徑 (tri)。





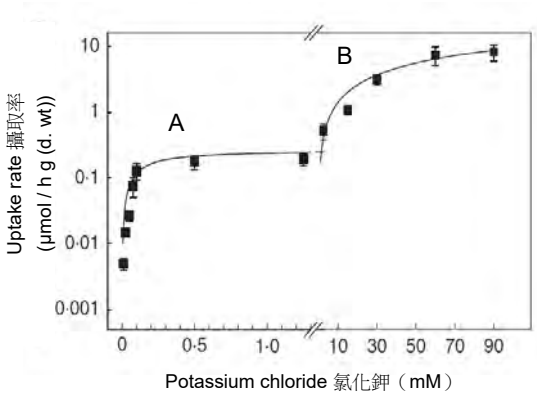
Indicate if each of the following statement is true or false.
指出`下列每個敘述是對或錯。

	TRUE 對	FALSE 錯
“a” in Figure R denotes aerenchyma 圖1C中的“a”是通氣組織	○	○
“b” in Figure S denotes hydrenchyma (aquatic parenchymal cells) 圖1D中的“b”是儲水組織（水生薄壁細胞）	○	○
The leaf anatomy suggests a C4/or CAM photosynthetic type 葉的解剖構造顯示其為 C4 / 或CAM 光合作用類型	○	○
Red line indicates pathway for water between vein and trichome on the upper side of leaf (adaxial) 紅線表示在葉子上表面的葉脈和毛狀體之間的水流動路徑（近軸面）	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 33 Potassium Acquisition 鉀的獲得

Physiological studies have been accomplished on the adaptations of bromeliad plants to nutrient acquisition and plant utilization of potassium. The Figure shows biphasic kinetics of potassium uptake by foliar trichomes of a tank bromeliad plant in the presence of 0.01–90 mM substrate. Uptake rates were calculated during the first 1–2 h of the experiment. The obtained results suggested that there were two transporter systems, and their Michaelis–Menten constants (Km) were calculated to be 41.3±8.7 μM and 56.5±13.7 mM.
有關鳳梨科植物對營養的獲取與鉀的利用之適應性的生理學研究，圖中顯示在0.01-90 mM受質存在之下，可儲水之鳳梨科植物的葉狀毛狀體攝取鉀的雙相動力學。在實驗的前1-2小時期間，計算攝取速率。結果顯示其有兩種運送系統，其Michaelis-Menten常數（K_m）計算為41.3±8.7 μM和56.5±13.7 mM。



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
The low affinity system accumulated K^+ slower than the high affinity system 低親和力系統累積K^+的速率比高親和力系統慢	○	○
K*m* of 56.5 mM belongs to B transporter system K*m* 為 56.5 mM 屬於B運送系統	○	○
Applying ATPase inhibitor compounds inhibits B transporters 應用ATPase的抑制劑可抑制B運送蛋白	○	○
B transporters are blocked more by potassium channel blockers, as compared to A transporters. 比起A運送蛋白來說，B運送蛋白更容易被鉀通道阻滯劑所阻斷	○	○

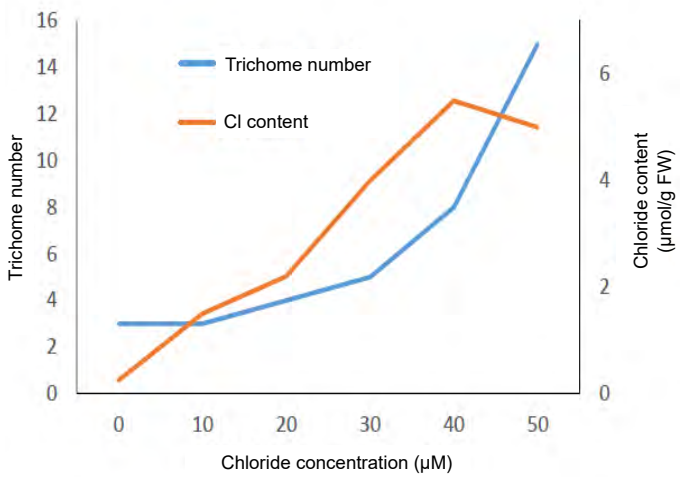
COMMENTS MAXIMUM POINTS STUDENT POINTS

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 34 Chlorine Uptake 氯的攝取

The relationship between trichome density on leaves and ion uptake was plotted from a bromeliad plants treated with different concentrations of chloride during 1 week.

取利用不同濃度的氯處理一周的鳳梨科植物，繪製其葉片上的毛狀體密度與離子吸收之間的關係。



The relationship between chloride supply, trichome number and chlorin uptake.

氯的添加、毛狀體數量和氯吸收之間的關係。

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

	TRUE 對	FALSE 錯
The results suggest that chloride is only absorbed by bromeliad trichoms. 結果顯示氯只會在鳳梨科植物的毛狀體被吸收	○	○
Induction of trichomes occurs at any increase in concentration of exogenously applied chloride. 額外添加氯濃度，皆會誘發毛狀體的形成	○	○
There is an exponential relationship between the chloride concentration and absorbed chloride by leaf trichomes. 氯的濃度和葉片毛狀體所吸收的氯量之間呈現指數形關係	○	○
Chloride is actively excluded or secreted above 40 µM concentration. 當濃度高於 40 µM，氯會被主動排出或分泌出	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 35 Plant Taxonomy 植物分類學

In a scientific excursion the students found four plant specimens that they had never seen before. They studied the plant organs carefully and made a few sections from them to look for the plants transport systems. The following table was completed based on their observation.

在一次科學參訪中，學生們找到了他們以前從未見過的四種植物。他們仔細研究植物的器官，並從中備製數個切片，以尋找植物的運輸系統。下表是他們的觀察結果。

plant number植物數量	Companion cell 伴細胞	Sieve cell 篩細胞	Sieve tube cell 篩管細胞	Tracheid 管胞	Vessel elements 導管細胞	Pollen 花粉
1	+	-	+	+	+	+
2	-	+	-	+	-	+
3	+	-	+	+	+	-
4	-	+	-	+	-	-

Supposing that these plants are representatives and all possible conductive elements were found, indicate if each of the following statement is true or false.

假設這些植物是主要植物類群的代表，而且具有所有的輸導組織元素，指出下列敘述是對或錯。

	TRUE 對	FALSE 錯
Plant 1 has with more than two cotyledons. 植物1具有兩個以上的子葉。	○	○
Plant 2 has winged pollen grain and double fertilization. 植物2 具有帶翅的花粉粒和行雙重受精。	○	○
Plants 3 and 1 have smaller female gametophyte as compared to plants 2 and 4. 與植物2和4相比，植物3和1具有較小的雌配子體。	○	○
Plant 3 does not belong to the flowering plants, because it does not have pollen grain. 植物3不是開花植物，因為它沒有花粉粒。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 36 Plant Phylogenetics 植物系統發生學

The plant genus Xcontains 6 species (*X. messa*, *X. obnoxia*, *X. beatifica*, *X. confusa*, *X. foetida, X. nerda*). All of them share many character states that distinguish this genus from all closely related genera. The species differ from each other, however, as described below. All species in the sister genus, Y, are vining plants with palmately compound, alternate leaves, sweet-smelling flowers with pink, free petals and 10 stamens, and drupes.
X屬植物有6種（*X. messa*，*X. obnoxia*，*X. beatifica*，*X. confusa* ，*X. foetida*，*X. nerda*）。他們有許多共同特徵，故能將這一屬與所有親緣相近的屬作區別。然而，其物種彼此不同，如下所述。其姊妹屬Y中的所有物種都是具有掌狀複葉、對生葉、粉紅色及具香甜味的花，花瓣分離且有10個雄蕊、以及具核果的蔓生植物。

X. messa： Plant upright, stems glabrous; leaves opposite, palmately compound; petals purple, free; stamens 5; flowers sweet-smelling; fruit a berry
X. messa： 植株直立，莖無毛；葉對生，掌狀複葉；花瓣紫色、分離；雄蕊5個；花香味濃郁；果實是漿果。

X. obnoxia： Plant vining, stems glabrous; leaves opposite, simple; petals red, free; stamens 10; flowers with a rotten meat smell; fruit a berry
X. obnoxia： 植物蔓生，莖無毛；葉對生、單葉；花瓣紅色、分離；雄蕊10個；花具腐臭味；果實是漿果。

X. beatifica ： Plant upright, stems glabrous; leaves opposite, palmately compound; petals pink, connate; stamens 5; flowers sweet-smelling; fruit a berry
X. beatifica ：植株直立，莖無毛；葉對生、掌狀複葉；花瓣粉紅色、合生；雄蕊5個；花香味濃郁；果實是漿果

X. confusa ：Plant upright, stems glabrous; leaves opposite, simple; petals purple, free; stamens 5; flowers sweet-smelling; fruit a berry
X. confusa ：植株直立，莖無毛；葉對生、單葉；花瓣紫色、分離；雄蕊5個；花香味濃郁；果實是漿果

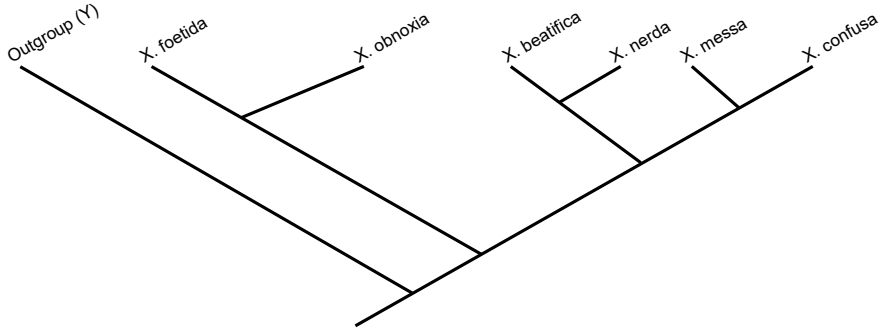
X. foetida ：Plant vining, stems hispid; leaves opposite, palmately compound; petals red, free; stamens 10; flowers with a rotten meat smell; fruit a berry
X. confusa ：植物蔓生，莖具硬毛；葉對生、掌狀複葉；花瓣紅色、分離；雄蕊10個；花具腐臭味；果實是漿果

X. nerda ：Plant upright, stems glabrous; leaves opposite, palmately compound; petals pink, connate; stamens 4; flowers sweet-smelling; fruit a berry
X. nerda ： 植株直立，莖無毛；葉對生、掌狀複葉；花瓣粉紅色、合生；雄蕊4個；花香味濃郁；果實是漿果

The data matrix, in which characters are coded according to whether character states are plesiomorphic (0) or apomorphic (1, 2) was presented in the following table. The most parsimonious cladogram was constructed from the data matrix.
在下表的數據矩陣中，其特徵是根據特徵狀態是祖徵（0）還是衍徵（1,2）來編碼。最簡約的分支圖是依據數據矩陣所建構的。

	Habit 習性	Stem hairs	Leaf position	Leaf structure	Petal Color	Petal fusion	Stamen number

		莖毛	葉序	葉構造	花瓣顏色	花瓣癒合	雄蕊數
X. messa	1	0	1	0	2	0	1
X. obnoxia	0	0	1	1	1	0	0
X. beatifica	1	0	1	0	0	1	1
X. confusa	1	0	1	1	2	0	1
X. foetida	0	1	1	0	1	0	0
X. nerda	1	0	1	0	0	1	2
Outgroup (Y)	0	0	0	0	0	0	0



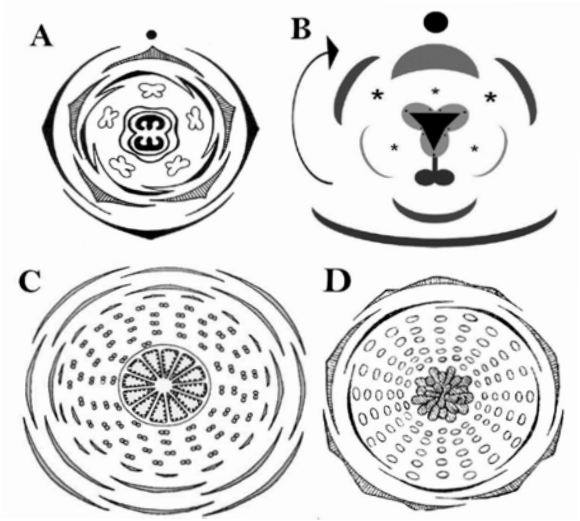
Indicate if each of the following statements is true or false.
指出下列每個敘述是對或錯。

	TRUE 對	FALSE 錯
Fruit as a berry and leaves opposite support the monophyly of the genus X. 果實為漿果與葉對生是支持X屬為單源系。	○	○
*X. obnoxia, X. beatifica*and *X. nerda* form a monophyletic group. *X. obnoxia*、*X. beatifica* 和 *X. nerda* 形成單系群。	○	○
Hispid stems and 4 stamens are autapomorphic (unique) for *X. foetida* and *X. nerda*, respectively. 硬毛莖和4個雄蕊分別是 *X. foetida* 和 *X. nerda* 的自衍徵（獨特的）。	○	○
Simple leaves in *X. obnoxia* and *X. confuse* appear to have evolved independently. *X.obnoxia* 和 *X. confuse* 中的單葉似乎是獨立演化的。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 37 Floral Diagrams 花式圖

The flowering plants show great diversity in their flower structure reflecting evolutionary changes in course of time. One method to illustrate the flower morphology is the usage of floral diagrams implementing various shapes and symbols to show the structure as exact as possible.
開花植物的花構造可顯示出很大的多樣性，此反映了隨時間的演化改變。一種說明花形態的方法是應用花式圖，配以各種形狀和符號，以盡可能精確地顯示其結構。



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
Diagram A can represent a basal herbaceous dicot. 圖 A可代表基礎的草本雙子葉植物。	○	○
Diagram B may represent a species from the the family Orchidaceae with 2 sterile stamens 圖 B可能代表具有退化兩枚雄蕊的蘭科植物	○	○
The most primitive flower among the illustrated diagrams in this task is C. 在本Task的花式圖中，最原始的花是C.	○	○
Diagram D belong to a same family as C. 圖 D與C屬於同一個科。	○	○
The perianth in diagram B is composed of 3 whorls. 圖 B中的花被是由3輪所組成。	○	○

COMMENTS MAXIMUM POINTS STUDENT POINTS

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

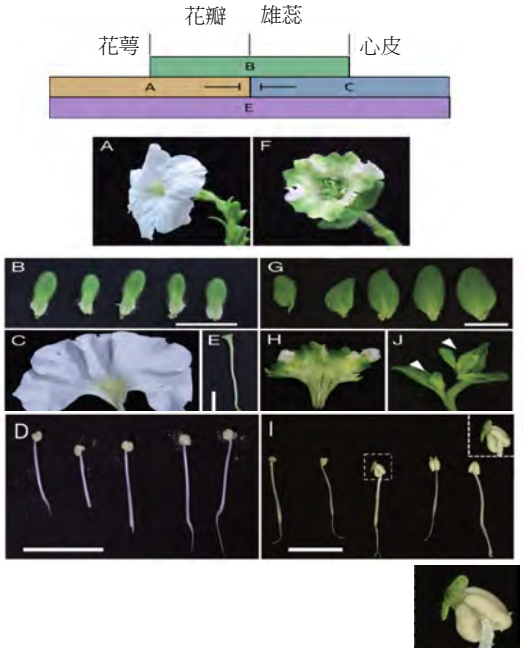
Q. 38 ABCE Model of Flower Development 花的發育之ABCE模式

The diagram below illustrates the ABCE model of flower development, in which the identity structure of floral organs of eudicots is regulated by floral homeotic genes divided into ABCE-classes, based on function: A- and E-class genes specify sepal identity; A-, B-, and E-class genes petal identity; B-, C-, and E-class genes stamen identity; and C- and E-class genes carpel identity.

下圖說明了花的發育之ABCE模式，其中真雙子葉植物的花器官的身份，是由分為ABCE類的花同源異型基因(homeotic genes)所調節，根據其功能：A-和E-類基因控制萼片類型; A-，B-和E-類基因的花瓣身份； B-，C-和E-類基因負責雄蕊的特性；C-和E-類基因負責心皮的特性。

ABCE-class MADS domain transcription factors (MTFs) are key regulators of floral organ development in eudicots. Aberrant expression of these genes can result in abnormal floral traits, such as phyllody. Certain plant pathogenic bacteria could trigger phyllody in particular species, such as *Petunia*, which is shown in the figures below.

ABCE類的MADS結構域之轉錄因子（MTF）是真雙子葉植物中花器官發育的關鍵調節因子。這些基因的異常表現會導致異常的花性狀，例如變葉症(phyllody)。某些植物病原菌可引發特定物種的變葉症，例如矮牽牛(*Petunia*) ，如下圖所示。



A-E are parts of a control flower and F-I are parts of a bacteria-treated flower. The same parts of the flowers are shown in B and G, C and H, D and I, and E; and J.

A-E 是對照組花的構造，而 F-I 則是細菌處理之花構造。B 和 G；C 和 H；D 和 I, ；E； 以及 J都是花的相同構造

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

TRUE 對 FALSE 錯

	TRUE 對	FALSE 錯
The bacteria caused perianth fusion of Petunia. 細菌造成矮牽牛的花被癒合。	○	○
The bacteria caused the expression of the protein coded by Gene E. 細菌引起基因E編碼的蛋白質之表現。	○	○
The bacteria decreased the frequency of moths landing on the flower. 細菌降低了飛蛾訪花的頻率。	○	○
The bacteria treatment proved that the flower reproductive parts are leaf modifications. 細菌處理證明花的生殖構造是來自葉片的變形。	○	○

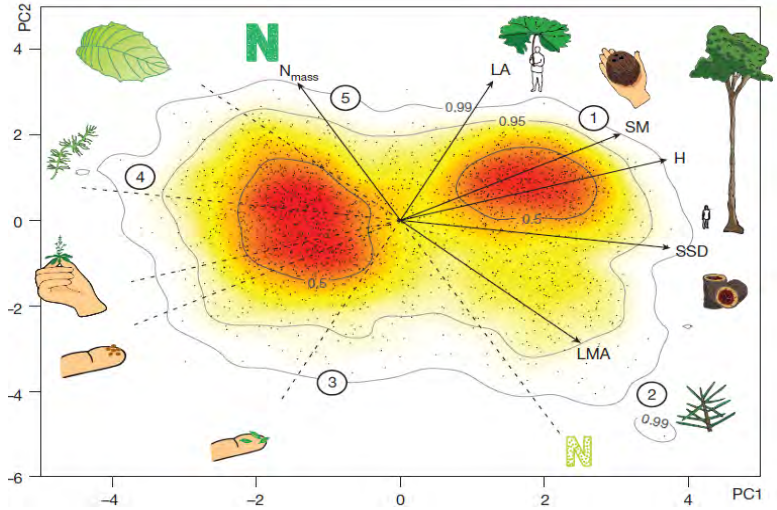
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 39 Trait Variation among Vascular Plants
維管束植物的特徵變異

During last 500 million years, a great amount of trait variation has been created in land plants in the course of evolution. However, there are some constraints over the possible combinations of traits which indicate evolutionary limitations and trade-offs. To investigate trait combinations in more than 46,000 extant vascular plants, a Principal component analysis was conducted (Díaz et al. 2016). Principal component analysis (PCA) is a statistical procedure converts a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. Figure 1-a shows distribution of investigated vascular plants (including angiosperms, gymnosperms and pteridophytes) in a space conducted by the PCA analysis. Each trait changes along its corresponding axis in this space. Areas with high density of points indicate functional hotspots. There are two major hotspots corresponding to woody and non-woody plants (LA: leaf area, SM: diaspore (fruit or spore) mass, H: plant height, SSD: stem specific density, LMA: leaf mass per area, N_{mass}: leaf nitrogen content per mass.)
在過去的5億年中，陸上的植物在演化過程中產生了大量的特徵變異。然而，對可能的特徵組合存在一些限制，這些特徵指出了演化的限制和權衡。

為了研究超過46,000個現生維管束植物的特徵組合，進行了主成分分析（Díaz等人，2016）。主成分分析（PCA）是一種統計過程，將可能相關變量的一組觀察值轉換為主成分的線性不相關變量的一組值。

圖1-a顯示了藉由PCA分析進行研究的維管束植物（包括被子植物、裸子植物和蕨類植物）的分佈。每個特徵沿著其相應軸改變。點密度高的區域表示功能熱點。對木本和非木本植物有兩個主要的熱點（LA：葉面積，SM：果實或孢子的重量，H：植物高度，SSD：莖特定密度，LMA：單位面積之葉重量，N_{mass}：單位葉片重量之氮含量。）



According to result of this study, indicate each of the following statements is true or false.
根據本研究的結果，指出下列敘述每個敘述是對或錯。

	TRUE 對	FALSE 錯
Woody plants tend to have higher N_{mass} than non-woody plants. 木本植物大多具有比非木本植物更高的 N_{mass} 。	○	○
Plants inhabiting temperate grasslands tend to place near points 4 and 5. 棲息在溫帶草原上的植物大多位於第4和第5點附近。	○	○
Dominant plants of boreal forests are mostly to locate near point 1. 北方森林的優勢植物大多位於第1點附近。	○	○
Plants inhabiting tropical forests tend to have higher LMA than plants inhabiting temperate forests. 居住在熱帶森林中的植物大多比居住在溫帶森林中的植物具有更高的 LMA。	○	○
N_{mass} correlates with leaf lifespan negatively. N_{mass} 與葉片壽命呈負相關。	○	○

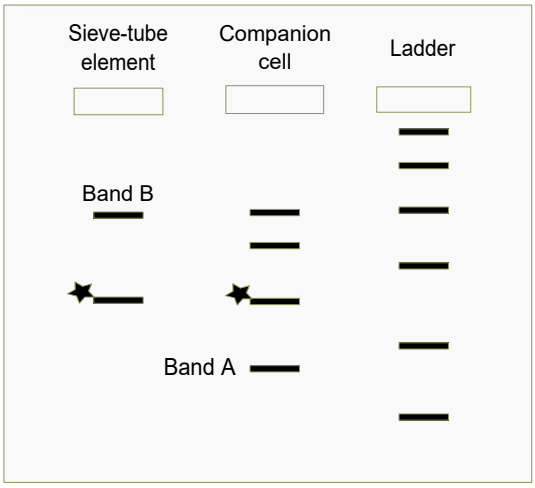
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 40 Sieve-Tubes 篩管

Plants conduct sugars and other substances throughout their body by means of phloem. Phloem is a compound tissue, including different cell types (e.g. sieve-tubes elements (in angiosperms), companion cells and parenchymal cells.). In a study, DNA genome samples prepared from sieve-tubes and companion cells of an angiosperm and investigated for DNA corresponding to X. Gene-specific primers were used to amplify gene X among whole genome of cells by PCR.

植物藉由韌皮部在其體內運送糖和其他物質。韌皮部是一種複合組織，包括不同的細胞類型（例如篩管細胞（被子植物中），伴細胞和薄壁細胞）。

在一項研究中，從被子植物的篩管和伴細胞製備基因組樣品，並研究對應於X的DNA。藉由PCR，以基因專一的引子在細胞的全基因組中擴增基因X.



Note: Each band represents a unique DNA molecule, asterisks denotes bands corresponding to functional genes.
注意：每個條帶代表一個獨特的DNA分子，星號表示與功能基因相對應的條帶。

Given the information above, indicate each of the following statements is true or false.
根據上述，指出下列敘述的對或錯。

	TRUE 對	FALSE 錯
Results of sieve-tube element genome analysis suggest that the plant is heterozygote in the gene X. 篩管細胞之基因組分析的結果顯示植物的基因X是源自異型合子。	○	○
The results obtained for the sieve-tube cells can be explained by gene X being present both in the mitochondrial and chloroplast DNA. 篩管細胞所得的結果可解釋為基因X存在於粒線體和葉綠體DNA中。	○	○
Band A most likely corresponds to an organelle-related DNA sequences in the nuclear genome. 條帶A很可能對應於細胞核基因組中的胞器相關之DNA序列。	○	○

	TRUE 對	FALSE 錯
Band B most likely corresponds to a pseudogene in nuclear genome. 條帶B很可能對應於細胞核基因組中的偽(假)基因。	○	○

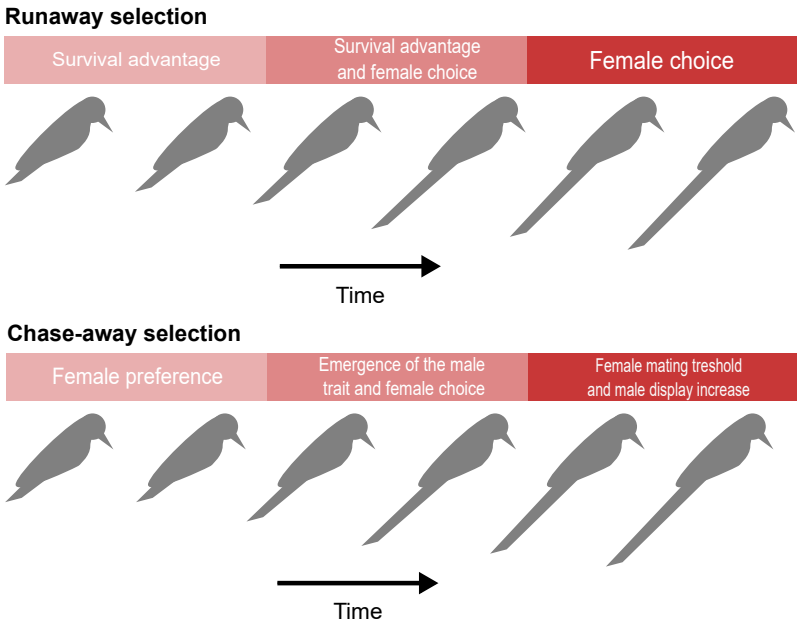
COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

ECOLOGY AND EVOLUTION 生態與演化

Q. 41 Evolution of Sexual Traits 兩性特質的演化

Evolution of sexual traits such as horn size, tail feathers and extreme coloration can be determined by sexual selection theory. According to the sexual selection theory male with such attributes gain an advantage over other males to acquire mate. Two processes have been proposed to account for exaggerated traits as the result of sexual selection (figure below).

根據性擇理論，具有誇張特徵的雄性在婚配上具有優勢，以下是誇張性狀演化途徑的兩個假說



Runaway selection: *Imagine some males with traits (such as tail length) with the higher survival rates than other males in same population. In this ancestral population, some females start to prefer these males. Their offspring will inherit both of these traits (higher tail length in males and females choice for such traits in males). This pattern generates a runaway process until the male trait becomes so exaggerated that it becomes selected against by natural selection.*

漸行漸遠假說：假設有些具有長尾羽的雄鳥適存度較好，在此祖先族群中有一些雌性開始喜愛這類雄性。其後代就同時遺傳雄性的長尾羽和雌性偏好，一直到該特徵變得超級誇張而遭到天擇汰選。

Chase-away selection: *A mutation in males provides them with a novel trait that becomes sexually attractive to the females, and changes female mate choice in favour of such novel trait. Males with this mutation can easily mate with the females, while they don't offer any material or genetic benefit to the females. When such choice becomes disadvantageous for the females, the females' threshold increases against such a trait. Males with more extreme forms trait will again attract the females and this process will continue until natural selection selects against this exaggerated trait.*

劣幣逐良幣假說(求偶循環假說)：有些雄性突變後忽然具有性吸引力，雌性的婚配選擇也因此被改變。雖然有突變比較容易把到妹，但是這樣的雄性既不顧小孩，也無法提供優質基因。由於這樣的特質無法提供真正的貢獻，反對她不利,所以雌性開始對此特性進行排斥, 雄性為此再將特性加碼以突破雌性的排斥,如此一再重覆攻防，最後到了某一種程度，天擇力量就會大到對此誇張性狀產生淘汰。

Based on the figure Indicate if each of the following statements is true or false.
根據上圖以下敘述是對或錯

	TRUE 對	FALSE 錯
In chase away selection, female choice correlates with male attributes that increase female fitness. 在劣幣逐良幣假說下，雌性對誇張雄性性狀的選擇會提高雌性的適存度。	○	○
Extreme traits will evolve in males according to the runaway selection and will decrease male life expectancy. 在漸行漸遠假說下，雄性的超誇張特徵反而會降低其壽命	○	○
Male attributes that become extreme because of chase-away selection will reduce male life expectancy. 雄性特徵之所以變誇張是因為劣幣逐良幣機制會降低雄性壽命	○	○
Sensory bias is the primary requirement for chase-away selection to be evolved, but is not necessary for runaway selection. 劣幣逐良幣假說成立的基礎是"感官上的偏見"，但是對漸行漸遠假說是不必要的	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

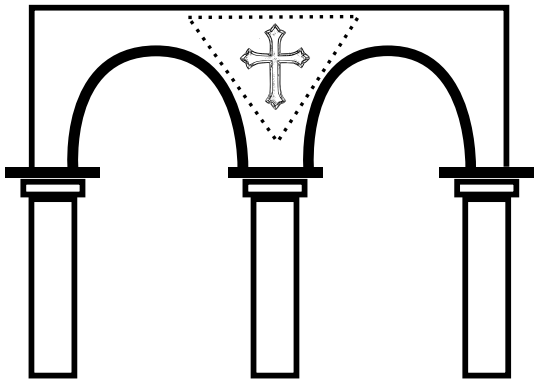
Q. 42 Adaptations 適應

Basilica of St Mark in Venice is an architectural marvel built in the 11th century CE. When examining the architecture, it is hard to avoid the spandrels in the corners of the ceiling, like the one in the figure (the triangular shape delineated by the dotted lines).

威尼斯聖馬可大教堂是建於公元11世紀的建築奇蹟。在檢查這棟建築時，我們很難避開天花板角落中的拱肩，如圖所示（由虛線描繪的三角形）。

Gould & Lewontin (1979) argue that these spandrels are the result of simple geometric constraints one encounters when trying to hold a dome with column and arches. If we were to use the tools of evolutionary biology we would at first consider the spandrels as “adaptations” for the purpose of having the decorations, but in fact they are non-adaptive features, and we can not count them as adaptations.

Gould & Lewontin（1979）認為這些拱肩是在試圖用柱子和拱門撐住圓頂時因受結構限制而產生的。如果我們使用演化生物學的概念來解釋，一開始可能會把這些拱肩視為“適應的結果”，目的就只是"裝飾"，但實際上它們並非” 適應性特徵” ，所以我們不能將之視為適應的產物。



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

	TRUE 對	FALSE 錯
If the feather characteristic of birds first evolved in dinosaurs for the purpose of thermal regulation, that feather is similar to spandrels. 如果羽毛(鳥類具有的特色)在恐龍演化出來的時候其功能是體溫調節，那羽毛的演化就很像這個拱肩。	○	○
When investigating the evolution of small regulatory RNAs (where the phenotype is closely tied to the genotype), biologists should not presume adaptation to avoid mistaking “spandrels” for true adaptations. 探討小RNAs (也就是表型與基因型產生很強關聯性的地方) 的演化時，生物學家不應該預設小RNAs的存在就是一種適應的結果，就好像拱肩的例子一樣	○	○

	TRUE 對	FALSE 錯
Biological “spandrels” are more common in species with historically high population size. 生物學上的"拱肩"在那些歷史上具有大族群的物種上比較常見 。	○	○
The evolution of big brain in humans would be a biological spandrel if its evolutionary trajectory is constrained by developmental process in primates. 如果靈長類大腦體積的發育在演化路徑上受到限制，那麼人類腦部變大的演化也可以被視為"生物學上的拱肩"	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

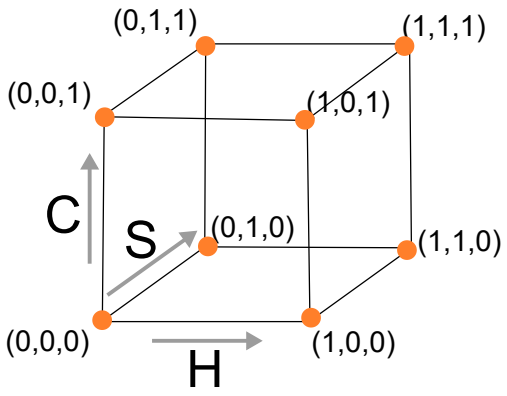
Q. 43 Godfrey-Smith Model 高佛瑞-史密斯族群演化模型

Peter Godfrey-Smith (2009) describes a parameter space in which a population can evolve using three parameters:

H: Fidelity of heredity
S: Dependence of reproductive differences on genetic differences
C: Continuity (when C is maximum, adding beneficial mutations to a genome results in the proportional betterment of the genotype. When C is zero, the effect of each mutation is entirely dependent on all the other loci)

We can imagine this space as cube (described by Peter Godfrey-Smith as A Darwinian space), as seen in the figure.

Peter Godfrey-Smith（2009）描述了一個參數空間，物種族群的演化可根據此三個參數：
H ：遺傳的忠誠度
S ：生殖差異對遺傳差異的依賴性
C ：連續性（當C最大時，在基因組中增加了有益突變導致基因型的改善比例。當C為零時，每個突變的作用完全取決於所有其他基因座）
我們可以將這個空間想像為立方體（由Peter Godfrey-Smith描述為達爾文方塊），如圖所示。



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
Accumulation of excessive mutations can result in the extinction of a population. (0,1,1) in the Darwinian space describes this situation. 積累過多的突變可能導致族群的滅絕。達爾文方塊（0,1,1）描述了這種情況。	○	○
In the absence of selection, a population of organisms resides at (1,0,0). 在沒有天擇的壓力下，生物族群存在於（1,0,0）。	○	○
If your attempts at optimizing a bacteria species to consume glucose almost always results in sub-optimized populations, you are exploring the space close to (1,0,1). 如果您嘗試優化某個菌種對葡萄糖的利用, 其結果幾乎總是獲得次優化群體，那麼您所探索的空間接近達爾文方塊中的（1,0,1）。	○	○

	TRUE 對	FALSE 錯
A somatic cell in the human body can reside at (0,1,1) (Here, heredity is defined for the human and not the cell.). 人體內的體細胞可以存在於（0,1,1）（此處，遺傳是以人為考量的單位而非細胞）。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 44 Mutation Rates
突變率

The lack of advanced molecular biology methods, such as DNA sequencing or site-directed mutagenesis, did not stop the pioneers of evolution from asking difficult questions concerning the fundamental aspects of biological systems. J. B. S. Haldane attempt to calculate the mutation rate in 1930s is an illuminating example.

即使缺乏如DNA測序或定點突變誘發的分子生物學技術，也並沒有阻止早期演化學者嘗試解讀生物學難題。

JBS Haldane嘗試計算1930年代人類的突變率就是一個例子。

With no direct genetic evidence, he focused on men living in London and hemophilia A, an X-linked recessive disorder. Assuming that men with this disorder do not reproduce, his calculations show that the mutation rate is three times the frequency of men with this disorder in London. His estimate of mutation per generation per locus is not that different from the more recent estimates for many genes.
由於沒有直接的遺傳證據，他專注於生活在倫敦的男性和A型血友病，一種和X性染色體聯結的隱性疾病。

假設男性患者不能繁殖，他的計算顯示，倫敦這種疾病的男性突變率是一般的三倍。他對每個基因座每代突變的估計與現代人最近對許多基因的估計沒有太大差別。

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 purported relationship between mutation rate and frequency of that mutation is only limited to populations that have mutation selection reached equilibrium. 突變率和該突變頻度之間的所謂關係僅限於已達突變天擇平衡的族群。	○	○
For a recessive autosomal disorder that results in sterility, one would expect mutation rate to be equal to six times the frequency of that disorder in a population. 對於隱性體染色體所引起的不孕性疾病，可以預期突變率等於族群中該疾病頻率的六倍。	○	○
The model assumes there is no drift. 該模型假設沒有基因漂移。	○	○
Linkage between a beneficial allele and hemophilia would have inflated Haldane's estimate of mutation rate for hemophilia. 有益的等位基因和血友病之間的關聯會誇大Haldane對血友病突變率的估計。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 45 Language Phylogeography
語言的親緣地理學

There are two hypotheses that try to explain the origin of the Indo-European language family.
有兩個假說用來解釋印歐語系的起源

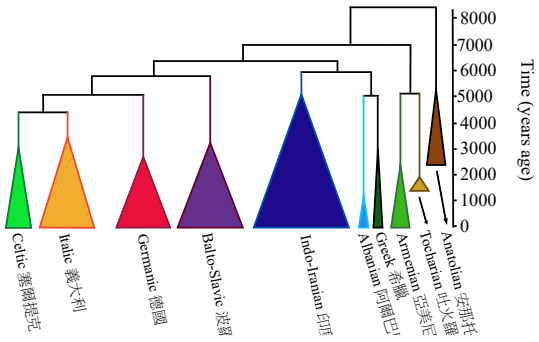
The Steppe hypothesis traces back the origin of Indo-European language to the Pontic steppes region north of the Caspian Sea. Archaeological records provide some clues regarding to expansion from this area about 6000 years ago, however the implied models of such expansion remain untested. Alternatively, it has been claimed that the languages spread from Anatolia with the development of agricultural activities about 8000 to 9500 years ago (the Anatolian hypothesis). The agricultural expansion reached the edge of Western Europe by 5000 years ago and had run its course about 4000 years ago.

大草原假說(Steppe hypothesis)認為印歐語系起源自裏海北邊的Pontic大草原區域，考古提供了一些大約6000年前，這些語言可能由這區域擴散出去的證據。但是這項假說尚未被檢測過。

相對地，安那托利亞假說(the Anatolian hypothesis)認為8000至9500年前，伴隨著農業活動的擴展，這些語言由安那托利亞這個地區往外擴散，在5000年前農業活動擴展到西歐的邊緣，然後在4000年前自然消失。

Bouckaert and his colleagues (2018) assessed the two hypotheses with Bayesian phylogeographic approaches using vocabulary information from the ancient and contemporary Indo-European languages.

Bouckaert等人利用貝葉氏法則與親緣地理學的方法，分析遠古和現今印歐系各種語言的字彙，來檢測較符合那一個假說。



Maximum clade credibility tree indicating the divergence of the major Indo-European subfamilies. The tree demonstrates the timing of the appearance of the major branches and their subsequent variation. The area of each triangle represents the relative number of languages in each subfamily.
這個樹型(Maximum clade credibility tree)顯示印歐洲語系中主要語種分化的狀況。這個樹描述這些語言支系出現的時間以及接下來的變化。

三角形面積越大，代表該支系包括的語言種類越多。

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 result does not favor an Anatolian origin over a steppe origin. 以上結果並不支持安那托利亞假說(the Anatolian hypothesis)	○	○
It is unlikely that the spread of agriculture serves as the sole driver of language expansion on the continent. 農業活動的擴散，不太可能是造成語言擴散至整個大陸的唯一驅動力。	○	○
Rate of language diversification in Balto-Slavic subfamily was higher than Germanic subfamily. "波羅的海-斯拉夫"支系分化的速率較"德語"支系分化的速率快。	○	○
Drawing such trees is based on the assumption that languages does not affect each other when they come in contact. 建立出這個分支樹，是建立在當不同語言有機會接觸時，彼此不會互相影響的假設上。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 46 Population Growth
族群成長

The following data were collected by a researcher over seven successive years from a population of a fish in a pond. He calculated population growth rate (*r*) for each year using this formula $r=\ln N_{t+1}-\ln N_t$.

Note: N= the population size, K= the carrying capacity.

下面的資料是一個池塘裡的魚的七年資料，研究者利用 $r=\ln N_{t+1}-\ln N_t$.這個公式計算每年族群成長率(*r*)。N代表族群數量，K為族群乘載量

Year	Number of Fish	Population growth rate (r)
2002	2	2.77
2003	32	1.02
2004	89	-0.75
2005	42	0.39
2006	62	0.15
2007	72	-0.15
2008	62	-

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 fish population grows exponentially as r is bigger than **1** in all years**.** 這個魚的族群在每年都是以指數方式成長，因為在所有年份中 r大都於1	○	○
When fecundity is less than mortality we can assume N < K, which means that the population is growing. 當生殖率小於死亡率時，我們可以假設N<K，代表族群數量在增加。	○	○
The fraction of the resources that were used by the fish in each year can be calculated by N/K. 每年資源被魚使用的比例，可以利用計算N/K來得知。	○	○
The pond carrying capacity (*K*) is between 62 and 72. 該池塘的族群乘載量介於62和72隻之間。	○	○

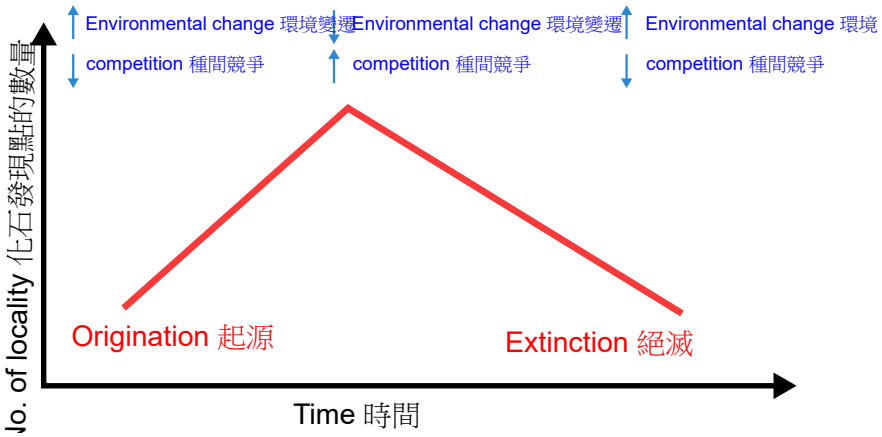
COMMENTS MAXIMUM POINTS STUDENT POINTS

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 47 Species Persistance
一個物種可以存在多久

Žliobaitė *et al.* (2017) point out that for a given taxon, the pattern below is usually observed in the fossil record (red line) defined as the number of localities where a taxon is found. They propose that this pattern is a reflection of the evolutionary process, as shown by blue arrows representing the effects of environment and competition.

Žliobaitė et al.（2017）指出，任何一個化石分類群常會展現如下圖的現象(紅線)，縱軸是化石被發現的地點數，橫軸是時間，可算是一種演化的歷程. 紅色代表某種類生物的起源、巔峰到絕滅的過程，藍箭頭表示環境因素與物種競爭。



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

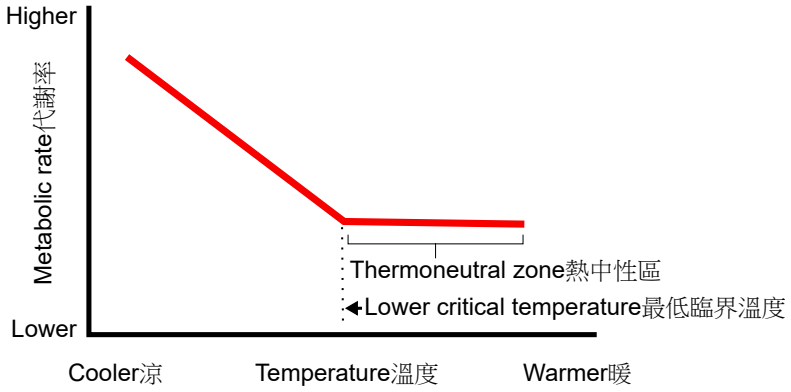
	TRUE 對	FALSE 錯
According to the model the peak of a taxon's history is only identifiable after its extinction. 根據這個模型，一個分類群"演化生命"中的高峰只有在其滅絕後才能被辨識。	○	○
It has been observed that when different species reach their maximum population size in an island, competition and species richness is also at their maximum. This is consistent with the effect of environment and competition as shown in figure. 當不同物種在同一個島上達到其最大族群規模時，種間的競爭和與物種豐度也應該達到最大值。這與圖中所顯示的環境和種間競爭對物種豐度的效應是一致的。	○	○
The extinction of a taxon should not depend on its age. 一個分類群的滅絕與其在演化歷史上所存在的時間長短無關。	○	○
When a taxon is rare, its extinction is more likely to be the result of abiotic factors 當一個分類群很稀有時，非生物因素比較可能造成其滅絕。	○	○

COMMENTS MAXIMUM POINTS STUDENT POINTS

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 48 Endothermy
內溫

Endotherm animals can only tolerate narrow range of body temperature (30 ºC- 45 ºC), but their ability to generate heat internally allowed them to expand their distributions. On the other hand, the cost to be endotherm is high because of their constant demand for food to support the energy needed for heat production.
內溫動物的體溫只能忍受很窄的溫度範圍(30ºC至45ºC)，不過牠們能藉由體內產生熱能的方式，來擴展牠們的分布範圍，但是需要付出高的代價, 因為內溫動物必須持續覓食，用以產熱來維持體溫。



According to the graph indicate if each of the following statements is true or false.
根據圖，下列敘述是對或錯。

	TRUE 對	FALSE 錯
In a drastically-changing environment optimal body temperature of an endotherm animal will be largely maintained with minor behavioral adjustments. 在一個變動相當大的環境中，一個內溫動物的最適體溫大多藉由微調其行為來維持。	○	○
When body temperature of endotherm animal starts dropping, it triggers the increase of metabolic heat generation, independent of animal habitat. 無論處在哪種棲地環境，當內溫動物的體溫開始下降時，會刺激體內增加代謝產生熱能。	○	○
Basal metabolic rate of an endotherm animal stays constant throughout a limited range of environmental temperatures. 內溫動物的基礎代謝率在一有限的溫差環境中呈現恒定狀態 .	○	○
One way that some endotherm animal species tolerate extreme cold conditions is to alter their lower critical temperature. 一些內溫動物忍受極度寒冷環境的方式，是改變最低臨界溫度。	○	○

COMMENTS MAXIMUM POINTS STUDENT POINTS

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 49 Dynamics of Infectious Diseases
傳染病動態

SIR model was developed by Kermack and McKendrick (1927) to explain dynamics of an infectious diseases. In this model, there are only three subgroups in the population including susceptible, infected, and recovered (S, I, and R respectively).
Kermack 和 McKendrick 這兩個人提出一個叫SIR的數學模型，用來解釋傳染性疾病的動態。在這個數學模型中，一個族群可以被分做三個亞群，包括一個亞群裡面的個體尚未被感染，因此有機會在未來受到感染(S, susceptible)；一個亞群裡的個體正被感染(I, infected)；以及一個亞群裡的個體以前被感染過，但現在已經復原(R, recovered)。

The model assumes that everyone is born susceptible and there is no passive immunity for the infants, everyone who recovers from the disease is immune, the probability of getting the infection is the same for every susceptible person, and people in each group die with their own per capita death rate (m_S, m_I, and m_R).
In this model, if a susceptible person contacts with an infected one, infection will be transmitted by probability of A and the rate of recovery is B.

這個數學模型假設，當每人出生後，都有機會被感染，而且假設嬰兒不會自母親那裏得到抗體，因此不會對該傳染病免疫。這個模型也假設，當被感染過的人復原後，就終身免疫，且每人得到該傳染病的機率相同。這三個亞群(susceptible, infected, recovered)的死亡率分別為m_S, m_I, 和 m_R。在這數學模型中，尚未被感染的人被已經感染的人傳染的機率為A，已經感染的人復原的機率為B。

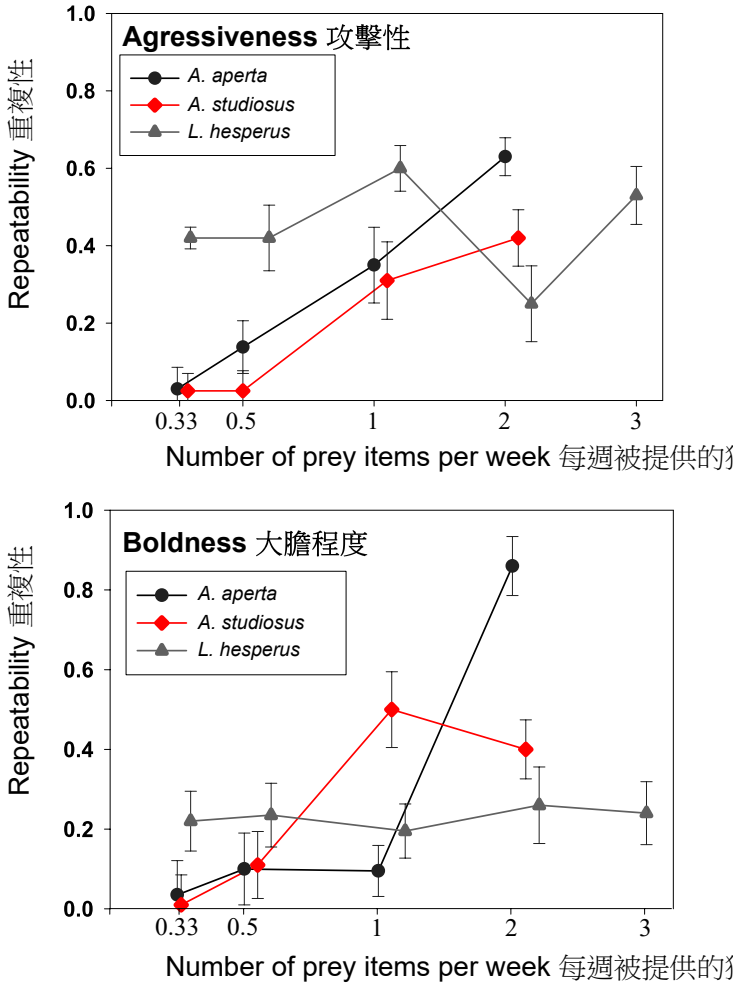
Based on the description above, indicate true and false statements.
根據上面描述，下列敘述是對或錯。

	TRUE 對	FALSE 錯
For the disease to remain in the population without adding any new source of infection, A should be at least equal to B. 某個傳染病若要持續在一個族群中存在(假設這個族群不會有新的被感染的人自族群外移入)，則A至少要和B相同。	○	○
The smaller the minimal infectious dose (the amount of pathogen required to cause an infection), the higher the A is. 當讓人生病所需要的病菌數量越少時，A就越高。	○	○
If the disease is very lethal, it is more likely for it to be self limited (the epidemic will finish all by itself). 某個傳染病越致命，該傳染病就越有可能消失。	○	○
If the infection period is longer, a higher proportion of population is infected. 當被感染後，生病的時間越長時，族群中就有越高比例的人是處於感染狀態的。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 50 Animal Personality
動物個性

Animal personality is defined as individual differences in behavior that are consistent across time and ecological context. One of the important drivers of personality difference is factors that alter the value of a decision. It was hypothesized that altering the feeding regimes of some spider species affect some aspects of their personality as you can see in graphs below.
動物個性被定義為不同個體有不同的行為，且同一個體所表現的行為，即使在不同時間或環境狀態下也不太會改變。但是根據下面提供的圖，蜘蛛個性是否會保持一致，推論可能會受到蜘蛛被提供多少食物所影響。



Estimates of repeatability of boldness and aggressiveness response of three spider species under different feeding regimes. Error bars represent 95% confidence intervals for our repeatability estimates (After Lichtenstein, et al. 2016).
估計不同飼養方式下，三種蜘蛛的大膽程度(當面對捕食者時)和攻擊性(當獵物存在時)反應的可重複性。誤差範圍代表重複估計的95%信賴區間（Lichtenstein 等， 2016）。

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
This study failed to demonstrate association between boldness and aggressiveness regardless of feeding regimes.不論如何餵食, 這個研究無法顯示大膽程度(boldness)和攻擊性(aggressiveness)是否有關。	○	○
Repeatability of aggressiveness response in *L. hesperus* is independent of feeding regimes. *L. hesperus*這種蜘蛛的攻擊(aggressiveness)的一致性(repeatability)，不會受到每周被餵食多少所影響。	○	○
Behavioral variation of each individual always decreases when spiders suffered prolonged food restrictions. 當蜘蛛長時間被餵食很少食物時，每個個體行為的變異程度都是會降低。	○	○
L. hesperus shows different repeatability in behavioral response than two other species regarding to different feeding regime, thus we can assume different species have different behavior over time and contexts.*L. hesperus*這種蜘蛛，當面對食物資源多寡改變時，行為反應的一致性的變化，和其他兩種蜘蛛面對食物資源多寡改變時，行為反應的一致性的變化不同，因此我們可以說不同的物種，當所處的時間或環境不同時，會有不同的行為反應。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Q. 51 Parasitic Life Strategies
寄生蟲生存策略

Sam is an imaginary single-celled organism. His body is covered with cilia which enable him to move. He has two nuclei: housekeeping genes are expressed in the macronucleus, while gene-expression tasks relevant to reproduction are undertaken by the micronucleus. Sam divides via a process called “schizogony”, whereby nuclei undergo multiple fission and then the cell itself divides. Sam can eat food particles and even bacteria through his mouth, a characteristic that helps him to live freely as a saprophyte. Sam has a monomorphic shape throughout its life cycle and experience enlargement and division, consecutively. Sam has decided to abandon his free-living lifestyle and transform into a merry parasite (with limited harm to the host).

Sam是一個虛擬的單細胞生物，身體上覆滿了用來幫助它移動的纖毛。Sam體內有兩個細胞核，大細胞核(macronucleus)和小細胞核(micronucleus)。大細胞核內的基因的產物，主要用以處理日常生活所需之用，例如代謝；與生殖遺傳有關的基因則是位於小細胞核中。Sam經由裂殖(schizogony)這個過程進行分裂，在這過程中，細胞核會進行多次的分裂，接著細胞進行分裂。它經由嘴巴取食物碎屑，甚至包括細菌，因此能夠行自由生活。Sam整個生活史只有一種外觀型態，在過程中會不斷變大，然後分裂。有一天Sam決定放棄自由生活，讓自己變成一隻快樂的寄生蟲(不會對宿主造成太大的傷害)。

Jack is also a parasite and is more aggressive (damages its host) than Sam and his single-celled body is covered by an armor made out of protein. This protective layer is jagged and gives Jack a rugged look. Jack also has two nuclei. He has two flagella that allows him to move, attack, and penetrate. He is able to secrete enzymes that can degrade many animal tissues. immature individuals of who belong to Jack species lack traits mentioned above; they are small and proliferate rapidly. In addition, Immature individuals of Jack needs to find host to grow and cannot live independently.

Jack也是寄生蟲，但是相較於Sam，Jack會對宿主造成較大的傷害。Jack是個有兩個細胞核的單細胞生物，外表披覆蛋白質組成的盔甲，外觀看起來較為粗糙。Jack有兩條用來幫助它移動、攻擊、和穿刺的鞭毛，也能分泌酵素來分解動物組織。不過Jack這種寄生蟲的未成熟個體，有一些和成熟個體不一樣的特徵：未成熟個體體型較小，且生長繁衍快速。此外，未成熟個體需要找到宿主寄生才能成長，無法行自由生活。

Indicate for each statement which strategy will be more suitable for Sam compared to Jack.
指出下列各種不同的策略(敘述), 相較於Jack，何者對Sam比較合適。

	TRUE 合適	FALSE 不合適
Utilizing antigen shuffling, even though it is a costly trait. 利用抗原重組(寄生蟲不斷重組表面抗原，以避免被宿主消滅)的方法，即使這種方法很耗能	○	○
Having a life cycle consisting of two hosts. 生活史包括兩個宿主	○	○
Choosing an r-selected host. 寄生在r選擇(r selection)的宿主身上	○	○

	TRUE 合適	FALSE 不合適
Secreting *Samilosporin* (an antibiotic which destroys many of bacterial species that are virulent for the host). 分泌一種抗生素(*Samilosporin*)，這種抗生素會摧毀對宿主造成嚴重傷害的其他種細菌。	○	○
Transmitting to the next generation by infecting the gametes. 透過感染配子的方式，傳遞至下一代。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

Assume that Sam and Jack chose a common host. Given the presence of these two parasites together, indicate which of the following statements are True or False.
假設Sam和Jack選一個普通的宿主，當Sam和Jack剛好寄生在同一個宿主身上時，指出下列敘述是對或錯。

	TRUE 對	FALSE 錯
Sam will probably win the competition against Jack. Sam可能會競爭贏過Jack	○	○
If a lethal bacterium spread through the population of the host, Sam's fitness will increase. 假如Sam和Jack的宿主被很致命的細菌感染，Sam的適存度會增加。	○	○
Sam's fitness is negatively correlated with Jack's abundance. Sam的適存度和Jack的數量呈現負相關的關係。	○	○
Sam's fitness is less affected by the life-history traits of the host than Jack's. 相較於Jack的適存度，Sam的適存度比較不會受到宿主有哪種生活史所影響。	○	○

COMMENTS	MAXIMUM POINTS	STUDENT POINTS
TOTAL		0

MAXIMUM POINTS	STUDENT POINTS
	0