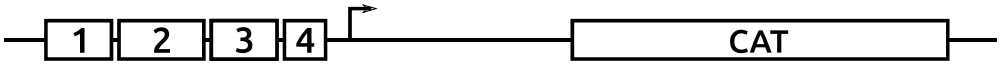
IBO 2013 Theoretical Exam 2

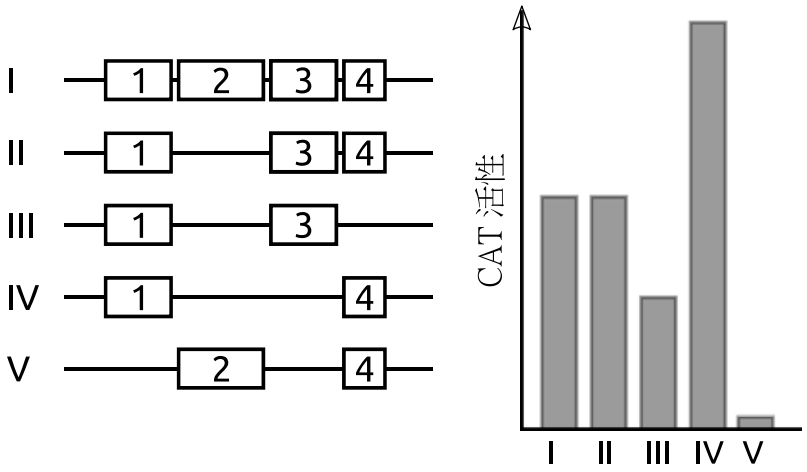
1

Cell-, molecular- and microbiology

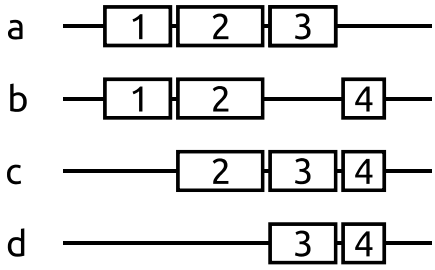
用氯黴素乙醯基轉移酶(CAT)作為報導基因(reporter gene)，並以報導基因分析研究一個新發現的基因啟動子。含有4個可能啟動子(編號1到4的白框)片段的線性雙股DNA被置於CAT報導基因的上游。



在轉殖各片段到細胞後，測得各CAT的活性如下。



下列的片段尚未被測試



指出下列敘述是對或錯。

A. 片段 a 作啟動子會比片段 I 更好

B. 片段 a 作啟動子會比片段 b 更好

C. 片段 c 作啟動子會比片段 b 更好

D. 片段 c 作啟動子會比片段 d 更好

A. False **B.** False **C.** False **D.** False

Original commentary
Notes

I = II -> 2 plays no role,
I > III -> deletion of 4 reduces the promoter strength -> 4 enhances promoter activity,
I < IV -> removal of 3 increases promoter strength -> 3 reduces promoter activity,
V shows almost no activity -> 1 provides basal promoter activity

Correct answers
A *false*
4 enhances promoter activity, removal of it in a decreases the activity of a.
B *false*
This case is similar to III versus IV, since 2 does not affect promoter strength.
C *false*
Without 1, c will show almost no activity, further decreased by the presence of 3.
D *false*
2 does not play a role, c and d have the same promoter strength.

Own commentary

在基因工程中，常希望提高分泌性蛋白質的產量。

指出下列各策略是否能增加其在哺乳動物細胞中的產量。

A. 大量表達在內質網中的伴護蛋白(協助其他蛋白質折疊的蛋白)。

B. 刪除編碼作 內質網中的糖化酶 之基因。

C. 大量表達 能促進分泌囊泡與細胞膜融合 的蛋白質。

D. 複製該目標蛋白質的基因。

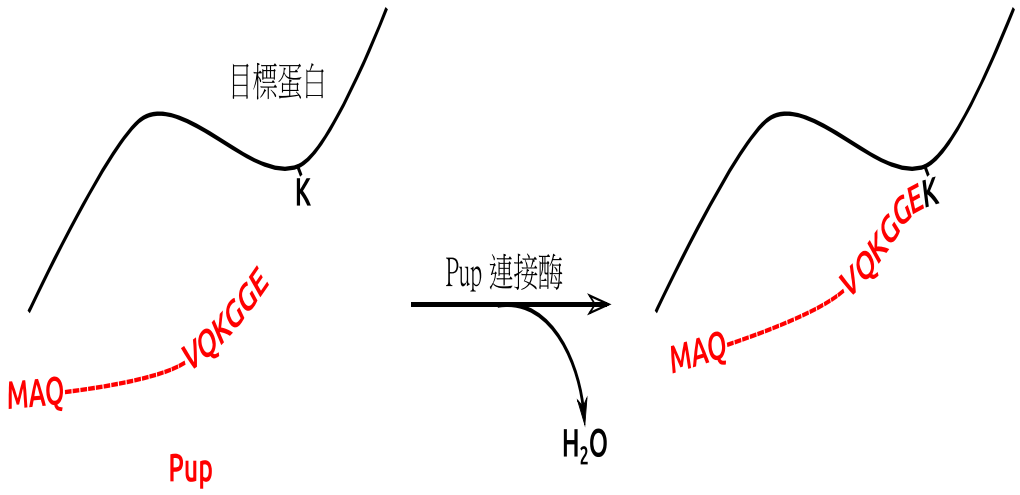
A. True **B.** False **C.** True **D.** True

Original commentary
Correct answers
A *true*
secretory proteins are folded in the ER, chaperones assist them in their folding and can increase the yield
B *false*
most secretory proteins are glycosylated, without glycosylation they are not recognised and are not trafficked further, and without glycosylating enzymes, the cell's membrane proteins cannot be glycosylated, the cells are not so healthy, this will also reduce the yield.
C *true*
secretory proteins are transported from the Golgi to the plasma membrane by vesicles
D *true*
Since each of the gene copies can be transcribed independently, genes with multiple copies are generally expressed more.

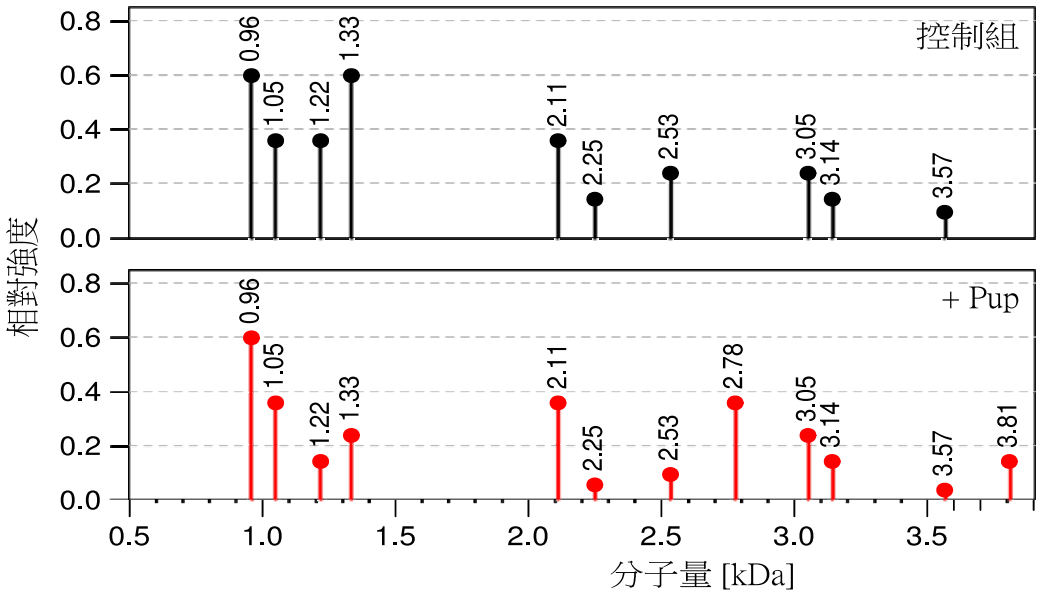
References
Peng et al, Biotechnology and Bioengineering (2009)
Tigges et al, Metabolic engineering (2006)

Own commentary

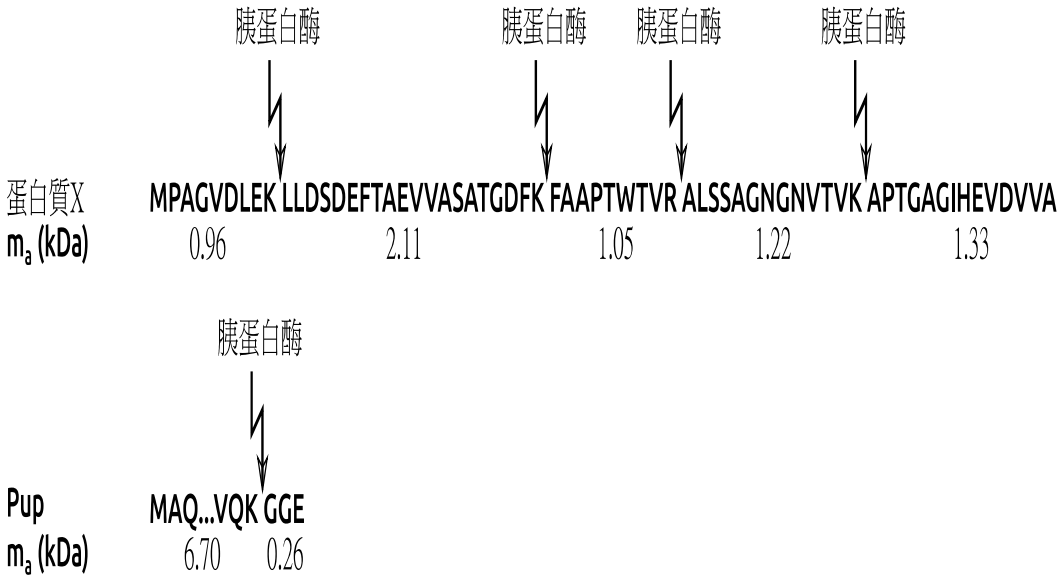
蛋白質的Pup化 是指在某些放線菌中發現的一種轉譯後蛋白質修飾，亦即以 Pup連接酶將短蛋白質Pup 結合到目標蛋白的離胺酸側鏈上。



為確定一蛋白質X是否 Pup化，將純化的蛋白質X與Pup及Pup連接酶共同孵育過夜後，加入胰蛋白酶將蛋白質水解（胰蛋白酶能在離胺酸(K)和精胺酸(R)處，藉加入分子量0.018 kDa的水而將蛋白質水解），然後以質譜儀測定胜肽的分子量(圖中紅色);同樣處理但不添加Pup的作為控制組(圖中黑色)。重量進位到小數點後第二位。注意：Pup片段超出檢測的範圍。



以下是蛋白質X和Pup的序列及多肽的分子量(m_a)。



指出下列敘述是對或錯。

A. 胰蛋白酶效率是指有些胜肽仍有部份未切。

B. 胰蛋白酶的水解是在 Pup化的離胺酸旁被抑制。

C. 在這些條件下，Pup化是對單一個離胺酸有專一性。

D. 約90%的目標蛋白被Pup化。

A. True **B.** True **C.** True **D.** False

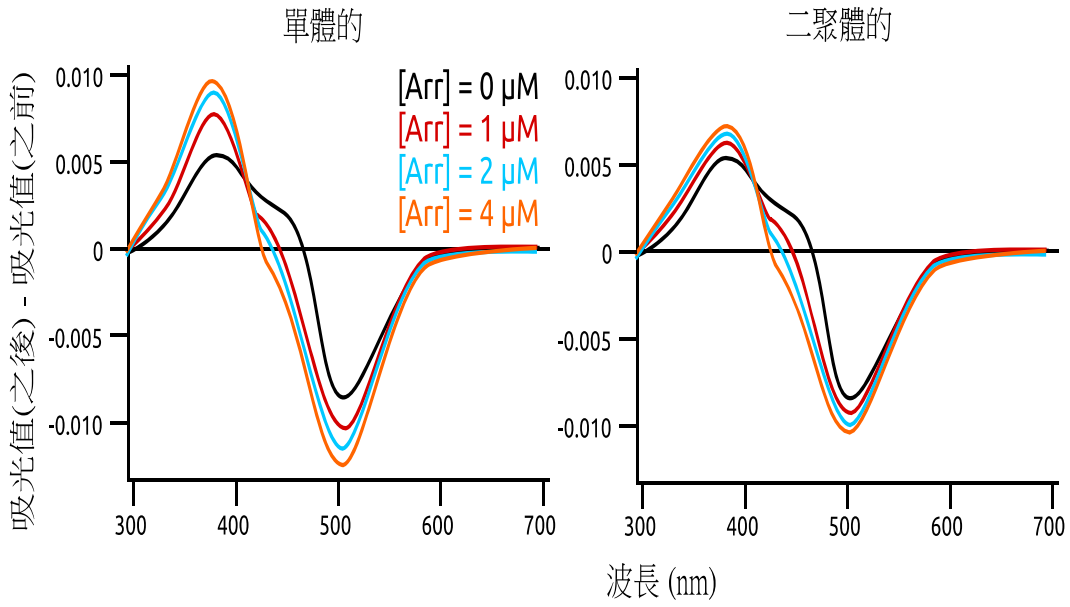
Original commentary

Note
The masses given in the second figure correspond to tryptic monopeptides. During trypsin hydrolysis, water (m_a 18.02 Da) is added, therefore, when calculating the mass of a dipeptide, the mass of water needs to be substracted.

Correct answers
A *true*
Masses corresponding to dipeptides can be observed in the black sepctra, e.g. the mass 3.05 kDa corresponds to a dipeptide formed by the two first tryptic peptides.
B *true*
The peak of the pupylated peptide at 2.78 kDa corresponds to a pupylated dipeptide and no pupylated monopeptide can be observed (the peak would be at 1.46 kDa for this lysine).
C *true*
Only two peaks (2.78 and 3.81 kDa) are present in the red spectra (with Pup) but not in the black one. The peak at 2.78 kDa corresponds to a pupylated dipeptide formed by the last two peptides of the protein, the peak at 3.81 corresponds to a pupylated tripeptide formed by the last three peptides of the protein.
D *false*
Two peaks (1.22 and 1.33 kDa) are reduced after ligation with Pup. The peak at 1.33kDa goes from 0.6 to about 0.25 relative intensity. Therefore, the protein is pupylated to about 1-(0.25/0.6) = 58%, not 90%. Furthermore, the peak corresponding to a pupylated peptide (2.78 kDa), has a relative intensity of only 0.4, added to the peak corresponding to the pupylated tripeptide (3.81 kDa) with a relative intensity of about 0.15, the pupylation level would be only about 55%.

Own commentary

在光照的活化之下，視紫紅質會進入多個中間型(Meta-states)，其中Meta-I 及 Meta-II處於動態平衡。當arrestin (Arr)存在時，這情況會趨向Meta-II，因為有些Meta-II會與arrestin連接。為研究視紫紅質的最小功能單位，實驗設計在不同arrestin濃度下，測量單體及二聚體的視紫紅質之吸光值差異值(照光活化後的吸光值減去照光活化前的吸光值)，結果如下圖所示。Meta-II在波長380 nm之下的吸光值較Meta-I 為強。



根據這些結果，判斷下列各敘述正確或錯誤。

A. 在照光活化前，視紫紅質吸收波長500 nm 的光。

B. Meta-II型視紫紅質的比例隨arrestin的濃度呈線性增加。

C. 以視紫紅質與arrestin的接合而言，二聚體視紫紅質比單體更緊密。

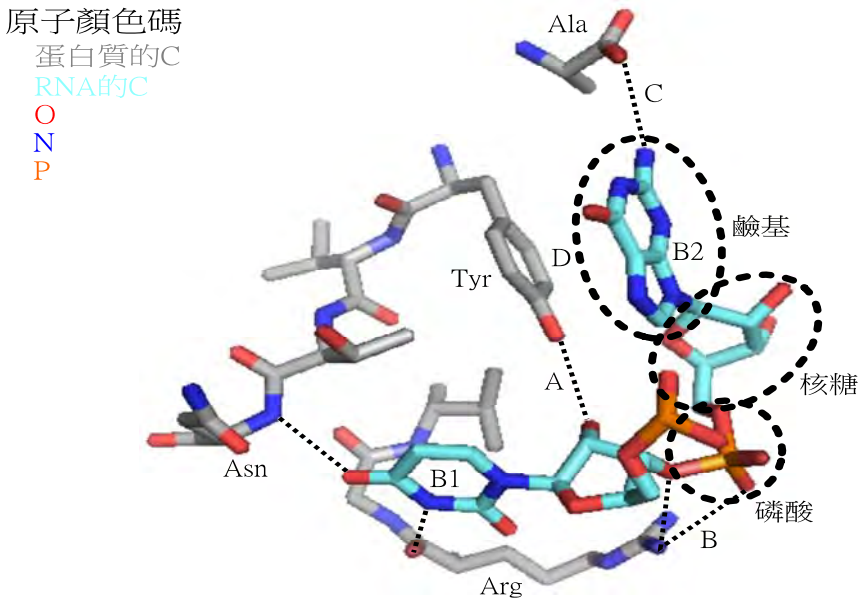
D. 單體的視紫紅質是最小的功能單位。

A. True **B.** False **C.** False **D.** True

Original commentary
Correct answers
A *true*
the negative difference absorption at 500 nm shows that dark-state rhodopsin absorbs light at 500 nm.
B *false*
as can be seen from the graph, the difference in absorption between 2 and 4 μM is smaller than the one between 1 and 2 μM. If Meta-II would increase linearly with the arrestin, it should be equal to the double. Furthermore, one can think, that as more arrestin is added, less free rhodopsin is present, therefore, less increase in absorption is observed.
C *false*
with monomeric rhodopsin, the increase of absorption at 380 nm is bigger than with oligomeric rhodopsin
D *true*
monomeric rhodopsin is enough for arrestin-binding, it is the minimal functional unit

Own commentary

下圖顯示某一蛋白質與2個RNA鹼基(B1和B2)結合位的一部分，此蛋白質對RNA的專一性超過對DNA。



指出下列反應對RNA的專一性是否超過對DNA。

A. 氫鍵接在A 與 Tyr間

B. 氫鍵接在B 與 Arg間

C. 氫鍵接在C 與 Ala間

D. Tyr 與 B2間的疏水堆疊D

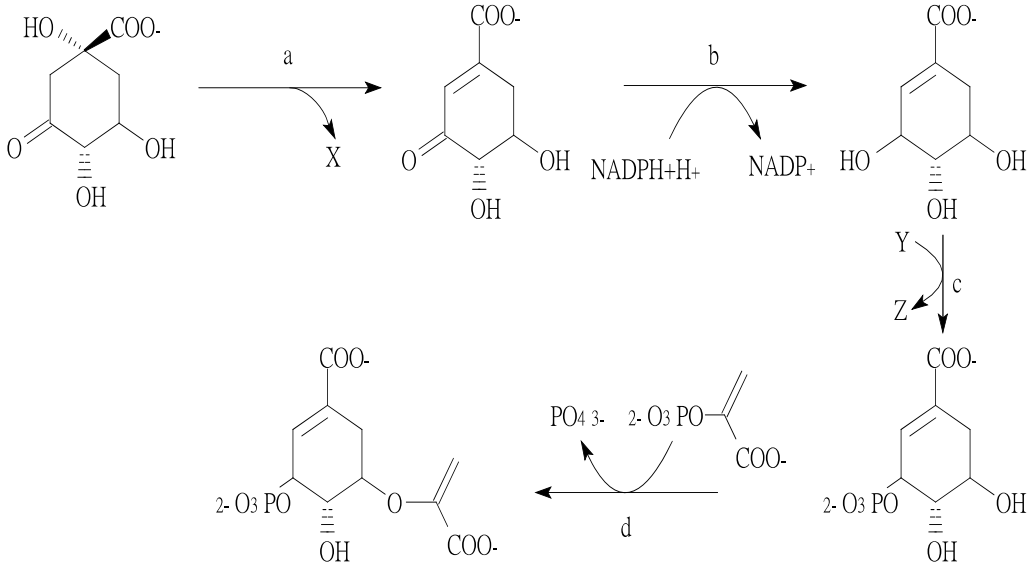
A. True **B.** False **C.** False **D.** False

Original commentary
Correct answers
A *true*
Only RNA, not DNA, has a hydroxyl group at the 2' position in the sugar.
B *false*
Both RNA and DNA have phosphate groups in the backbone.
C *false*
This hydrogen bond is specific for B2, but B2 is a guanine present both in RNA and DNA (the only difference in term of bases between RNA and DNA is uracil vs. thymine, both are pyrimidines, small bases with only 1 ring).
D *false*
Hydrophobic stacking is a non specific interaction which is found in interactions both with DNA and RNA.

References
Handa et al, Nature (1999)

Own commentary

下圖顯示莽草酸路徑，它是細菌生產芳香族胺基酸生成路徑的一部分。



指出下列敘述是對或錯。

A. 反應a中的X代表H_2O

B. 反應b中的受質被減少

C. 反應c中的Y代表ADP或GDP.

D. 反應d是受質的磷酸化

A. True **B.** True **C.** False **D.** False

Original commentary
Correct answers
A *true*
A is a dehydration, the -OH group as well as a hydrogen are removed and form water.
B *true*
NADPH+ H^+ is a reducing agent. The oxidation number of the carbon of the carboxyl in the substrate changes from + 2 to + 1 in the product of b: this is a reduction.
C *false*
GDP cannot phosphorylate substrates, Y represents here ATP.
D *false*
In d, a phosphate group is released as part of the condensation of the 2 substrates.

Own commentary

以洋菜糖凝膠分離DNA片段，製備1公升的10 x TAE緩衝液(包含Tris、醋酸、EDTA)。TAE及可用原液的所需濃度如下：

藥品	所需濃度	可用原液
Tris基	0.40 M	Powder (121 g/mol)
醋酸	1.14%	100 %溶液
EDTA	0.01M	0.50 M溶液
蒸餾水		

指出下列敘述是對或錯。

A. 需要4.84 g 的Tris 基

B. 需要11.4 ml的醋酸

C. 需要0.2 ml的 EDTA

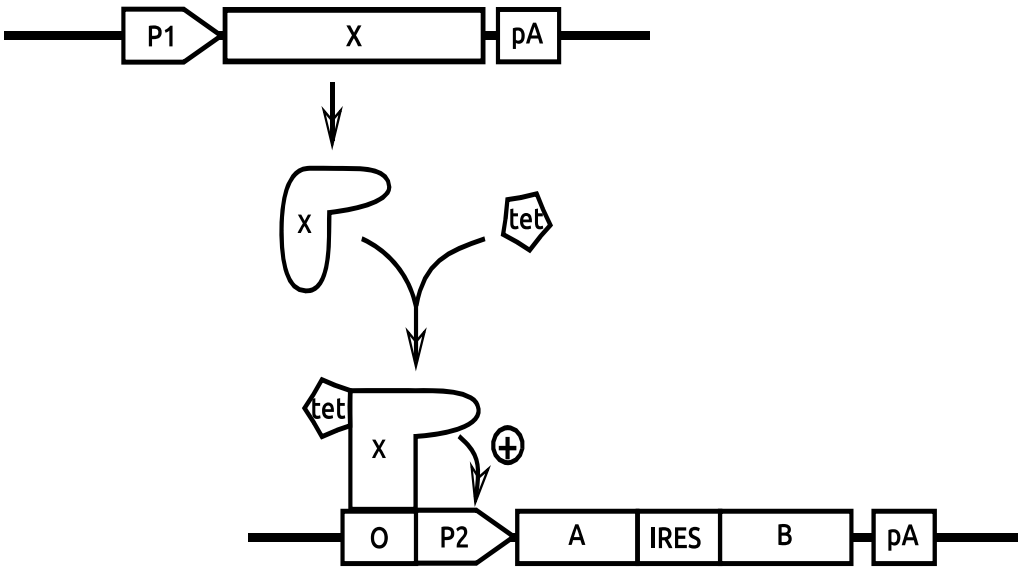
D. Tris 基、EDTA 及醋酸要加入 1 公升的蒸餾水

A. False **B.** True **C.** False **D.** False

Original commentary
Correct answers
A *false*
Tris base: 0.4 mol/l * 1 l * 121 g/mol =48.4 g
B *true*
acetic acid: dilution: V1 = c2*V2/c1 = 1.14% * 1l/100% = 11.4 ml
C *false*
EDTA: dilution: c1*V1 = c2*V2 <=> V1 = c2*V2/c1 = 0.01 mol/l * 1 l / 0.5 mol/l
D *false*
Tris, EDTA and acetic acid are first added to a smaller amount of water. When Tris is completely dissolved, the volume is adjusted to 1 l with water. If they were added to 1 l of water, the final volume would be greater than 1 l and the concentrations would be wrong.

Own commentary

包含A和B二條多肽的某一個蛋白質複體需要被大量表現，為確保能形成正確構形，此蛋白質須在真核宿主中表現。爲達成上述目的，有2個人工建構基因必須被一起轉殖入真核細胞中。在第一個建構基因中(圖上方)，轉錄因子X基因的表現由啟動子P1控制；在第二個建構基因中(圖下方)，A蛋白基因和B蛋白基因中間插入一段內部核糖體起始序列(IRES)，此建構基因由特定啟動子P2調控。加入四環黴素於細胞後，X會附著在操作子O，並活化啟動子P2，如圖所示(pA代表多腺核苷酸的位置)



判定下列各敘述是否正確

A. 如果P1是活化的，則唯有四環黴素存在時，基因A和基因B才會表現

B. 四環黴素存在時，如果核糖體附著mRNA的5'端強過附著於IRES，則基因B的表現量會高於基因A的表現

C. 如果X的DNA附著區被移除，即使沒有四環黴素，基因A和基因B也會表現

D. X mRNA上多腺核苷酸的長度會影響蛋白X的合成量

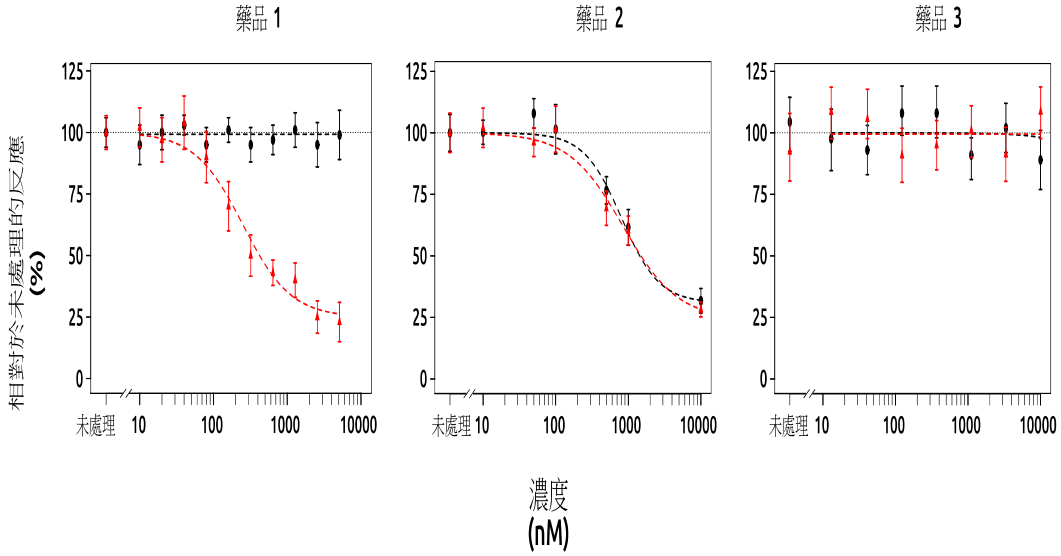
A. True **B.** False **C.** False **D.** False

Original commentary
Correct answers
A *true*
A and B can only be expressed if X is present in the cell, for this, P1 needs to be active.
B *wrong*
gene B would be more expressed than A if the ribosome would bind stronger to the IRES than the 5'-cap
C *false*
if the DNA-binding domain of X was removed, X could not bind the DNA and activate gene expression, so neither A nor B would be produced.
D *true*
an mRNA with a longer or shorter poly-A tail may survive longer in the cell and can be translated during a longer time, so more X-protein could be produced.

References
Fussenegger et al, Biotechnol. Prog. (2001)

Own commentary

藉計算神經脊細胞的存活數(下圖中黑圓點)及遷移細胞數(下圖中紅三角)來進行體外測試3種不同藥品1到3的毒性。下圖為相對於未處理的培養基，在不同濃度多次重複所測得的平均數及標準差。



請指出下列各敘述正確或錯誤。

A. 結果支持藥品1 影響接受遷移訊息的受體 。

B. 結果 支持藥品2 只影響細胞的存活率。

C. 濃度100到500 nM的藥品3，可能有利於神經脊細胞的存活。

D. 藉由測量神經脊細胞存活率，足以確認這些藥物可被允許的最高濃度。

A. True **B.** True **C.** False **D.** False

Original commentary

Correct answers

A *true*

Chemical 1 affects only migration, not viability of neural crest cells. This could be explained e.g. by chemical 1 inhibiting receptors involved in migration.

B *true*

Even if the migration is reduced with increasing concentrations of chemical 2, it is so with the same amplitude as the viability is reduced. The reduction in viability is enough to explain the reduction in migration (since dead cells do not migrate).

C *false*

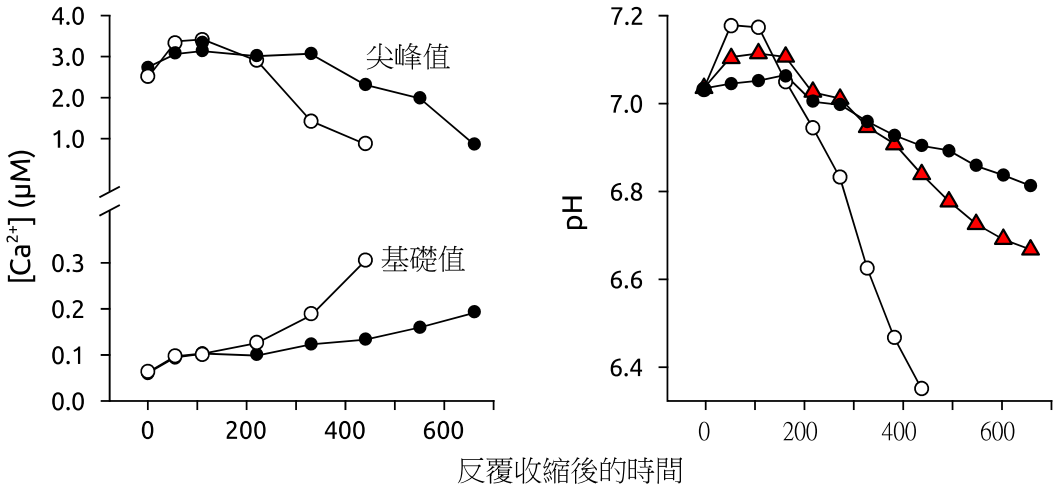
Even if the viability in the presence of 100 to 500nM of chemical 3 is higher than the viability of untreated neural crest cells, this is due to the large standard deviation in the measurements, not to a beneficial effect of chemical 3.

D *false*

As for chemical 1, the response in cell viability and migration is not always similar. Since during embryonic development, neural crest cells need to migrate to create different tissues, it is important to take cell migration into account when establishing maximum permissible concentrations.

Own commentary

肌纖維收縮主要是透過電位刺激，使鈣離子自肌漿網(sarcoplasmic reticulum)釋放到細胞質液中。肌纖維收縮後，鈣離子會透過肌漿網上的鈣離子幫浦(Ca^{2+} ATPases; SERCA)將細胞質液內的鈣離子打回肌漿網中。為深入了解肌纖維收縮與鈣離子幫浦運作時的能量消耗情形，科學家以非洲爪蟾(*Xenopus laevis*)腿部的骨骼肌纖維為實驗材料，並投予BTS及氰化物兩種藥劑。BTS會抑制肌凝蛋白與肌動蛋白形成架橋(cross-bridging)，而氰化物會抑制細胞色素C氧化酶的作用。下圖除顯示細胞質液中鈣離子的基礎濃度及最高濃度外，亦顯示單一肌纖維在不同處理重複收縮時的pH值（控制組：空心圓圈。BTS處理組:實心圓圈。同時投予氰化物及BTS處理組：紅色三角形),



下列各項敘述何者為正確或錯誤

A. 肌凝蛋白及SERCA處的ATP水解是肌纖維疲乏的主因。

B. 當這些肌纖維重複收縮約200秒後，有氧呼吸產生的ATP幾乎成為ATP的唯一來源。

C. ADP受到肌酸磷酸酶的磷酸化過程中會釋放氫離子。

D. 僅在氰化物存在時，肌纖維的細胞質液隨時間而酸化，但其程度應介於肌纖維在自然狀態及肌纖維同時添加BTS及氰化物兩組之間。

A. True **B.** False **C.** False **D.** False

Original commentary
Correct answers
A *true*
This can be seen easily from the right figure where the pH decreases over time (due to anaerobic glycolysis) is substantial even when no ATP is hydrolyzed at actin heads (in the presence of BTS).
B *false*
The decrease in pH over time is due to anaerobic glycolysis. Since the pH decreases well beyond 200 seconds, aerobic respiration may be contributing substantially to the production ATP, but is far from being the only important source. In the first 60 seconds, substantial sources of ATP are the stock of ATP and the phosphorylation of ADP from creatine phosphate.
C *false*
It actually absorbs H^+ ions (ADP + PCr + H^+ = ATP + Cr). This can easily be seen in the right figure since the pH is increasing at first.
D *false*
In the absence of aerobic respiration, the drop in pH is expected to be even quicker than for the natural conditions.

References
Nogeira et al, AJPRICP (2013)
Walsh et al, Experimental Physiology (2008)

Own commentary

重症肌無力是一種自體免疫疾病，其原因是個體會產生抗體，且以競爭性的方式結合並阻斷骨骼肌的神經肌肉接合處之突觸後神經元上的尼古丁乙醯膽鹼受器。

下列各項敘述何者為正確或錯誤

A. 小腸蠕動能力降低亦可能為本疾病的症狀之一。

B. 肌肉連續收縮(肌肉強直收縮)亦可能為本疾病的症狀之一

C. 降低突觸間隙處乙醯膽鹼的分解之藥物亦可能會緩解此疾病的症狀。

D. 抑制胞毒T細胞增生的藥物可緩解此疾病的症狀。

A. False **B.** False **C.** True **D.** False

Original commentary

Correct answers
A *false*
The guts contain no skeletal but smooth muscles. The latter are usually not affected by Myastenia gravis due to the absence of neuromuscular junctions.
B *false*
The antibodies block the access of acetylcholine to the post-synaptic receptor (as mentioned in the stem), which cause a paralyzation or a reduced postsynaptic neuronal stimulation.
C *true*
Slowing down the degradation of Acetylcholin (for instance by inhibiting the Acetylcholinesterase) allows it to act longer on the post synaptic receptors, which leads to a stronger signal since antibodies bind reversible on the ACh Receptors (they are in competition).
D *false*
B-Lymphozytes not T-Lymphozytes produce antibodies.

Own commentary

微血管內的液體移進或移出微血管的量，取決於微血管內、外液體兩者間的靜水壓及膠體滲透壓之差距。(膠體滲透壓是指由蛋白質所產生的滲透壓)。

- 以下為計算J_v的公式
- $J_v = K_f \times [(P_c - P_i) - \sigma(\pi_c - \pi_i)]$
- 其中
- Pc：微血管內靜水壓
- Pi：組織液靜水壓
- πc：微血管內的膠體滲透壓
- πi：組織液膠體滲透壓
- Kf：過濾係數
- σ：反射係數

指出下列狀態是否會增加個體水腫的風險

A. 烈日下的網球賽導致身體脫水

B. 穿防止血栓形成的襪子

C. 發炎導致血管通透性增加

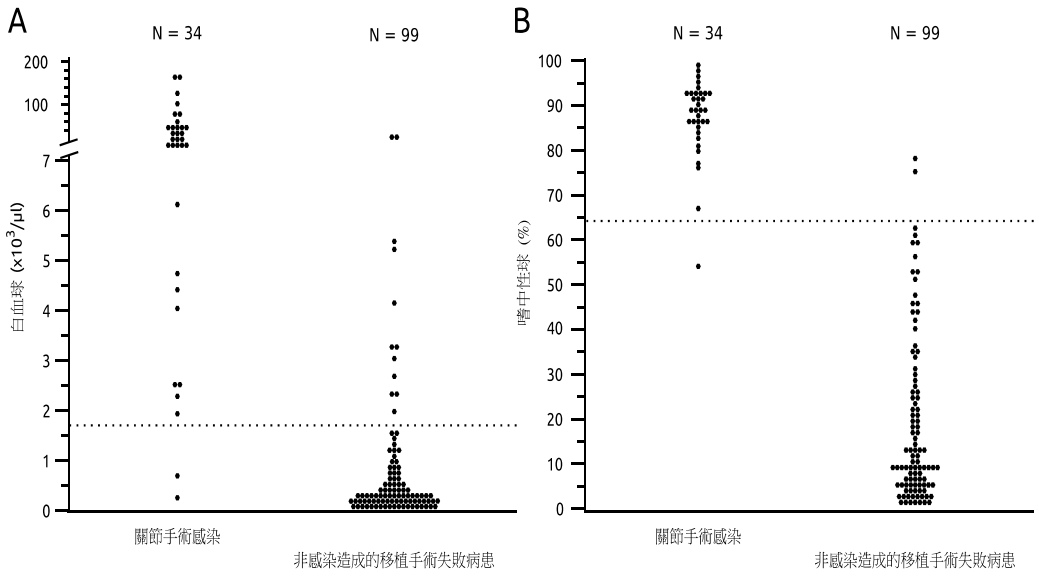
D. 蛋白尿(腎臟排出過多蛋白質)

A. False **B.** False **C.** True **D.** True

Original commentary
Correct answers
A *false*
Excessive sweating causes a reduction of intravasal fluid which lowers the hydrostatic pressure in the capillaries.
B *false*
Anti thrombotic stockings increase the interstitial hydrostatic pressure and peripheral edema are decreased consecutively.
C *true*
Increased blood vessel permeability/leak -> plasma proteins move to the interstitium increasing the interstitial oncotic pressure -> more water movement to the interstitial space.
D *true*
Proteinuria reduces the concentration of proteins in the blood resulting in a reduced capillary oncotic pressure.

Own commentary

人工關節植入手術後需要耗費許多精神及金錢於處理術後長期細菌感染的問題。很不幸，個體不易分辨感染源及植入物。為了發展新的診斷方法，科學家在34個罹患關節感染及99個非感染造成的關節移植失敗患者中，測量白血球絕對值(A)及嗜中性球在白血球中比例值(B)。每一個測試圖中，黑色橫線表示感染與否之判別分界線。



下列各項敘述正確或錯誤

A. 將白血球絕對值的分界線設定在7000/µl，可降低將未感染誤判為感染的機會

B. 將白血球絕對值的分界線設定在1500/µl，則遭感染的病患有超過90%的機會將得到正確診斷。

C. 降低嗜中性球比例的分界線至50%，可預防未來將關節手術有感染卻誤判為未感染的機會。

D. 本研究結果顯示嗜中性球與白血球的比例較白血球絕對值更具診斷價值。

A. True **B.** True **C.** False **D.** True

Original commentary
Correct answers
A *true*
By rising the cut off less patients without an infection would get the incorrect diagnosis (but less real infections would be detected).
B *true*
With the cut off of 1700 µ/l, 2/34 Pat with a real joint infections get missed, so 32/34 = 94% were correctly diagnosed.
C *false*
By lowering the cut off all patients with a true infection in the study would be detected. However, given that 2 out of 34 patients show low proportion of neutrophils, there is no guarantee that in a larger sample no individual with an even lower proportion was present. Given the distribution it seems even likely.
D *true*
Using the neutrophil count, more patient with a prosthetic joint infection were correctly diagnosed (33/34 vs. 32/34 for the leucocyte count) and less patients without an infection got false-positive results (2/99 vs. 12/99 for the neutrophil count).

References
Trampuz et al, AJM (2004)

Own commentary

絲球體過濾率 (GFR) 的大小主要由絲球體內的血壓決定，而非個體的系統血壓。GFR主要透過入球與出球小動脈本身來調控小動脈的舒張或收縮，而達到穩定狀態。許多藥物的副作用會干擾上述調節機制，例如：非類固醇的抗發炎藥物(NSAID)可降低入球小動脈的舒張能力，而血管收縮素轉換酶抑制劑(ACEI)(抑制血管收縮素II產生)則可降低出球小動脈的收縮能力。

下列各項敘述正確或錯誤

A. 服用NSAID會降低腎絲球血流量。

B. 服用ACEI會降低絲球體內的血壓。

C. 同時服用NSAID及ACEI則可相互抵消對絲球體過濾率的副作用。

D. 醛固酮長期分泌過量可用ACEIs治療，但投予醛固酮拮抗劑對絲球體自我調控作用的影響較少。

A. True **B.** True **C.** False **D.** True

Original commentary

Correct answers

A *true*

A side effect of NSAIDs is to inhibit dilation of the afferent arterioles. Hence the glomerulus is unable to increase blood flow through that mechanism.

B *true*

If the glomerular filtration pressure is not high enough, Renin is produced, which coverts the pre-hormone Angiotensinogen into Angiotensin I, which is then converted into Angiosin II by the Angiotensin-converting-enzyme. By inhibiting this enzyme, the ability to constrict the efferent arteriols is reduced (as mentioned in the stem). In addition, the production of Angiotensin II rises the blood pressure by rising the vascular pressure and rising the production of Aldosterone, which itself rises the renal reuptake of Natrium and water. Inhibiting this further decreases blood pressure system wide.

C *false*

While NSAID decrease the blood flow into the glomerulus, ACEI increase the outflow of blood. Hence both lead to a reduction on the glomerular pressure and lead to a reduction of the GFR.

D *true*

An Aldosteron overproduction can be treated by inhibiting the Angiotensin-converting-enzyme, as this leads to a lower level of Angiotensin II, which is a stimulant for the production of Aldosteron. However, due to the larger role of Angiotensin, a direct antagonist of Aldosteron implies a smaller effect, including the one described in this question.

References

Campell Biology

Own commentary

成年女性之呼吸商數(RQ)為0.7，且其呼出氣體中氧氣濃度為170 ml/l。所謂呼吸商數是指人體呼出 CO_2 的量對吸收 O_2 的量之比值。葡萄糖與棕櫚酸(palmitic acid)的代謝如下：

- 葡萄糖：$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$
- 棕櫚酸：$C_{16}H_{32}O_2 + 23\ O_2 \rightarrow 16\ CO_2 + 16\ H_2O$

下列各項敘述正確或錯誤

A. 這位婦女所呼出的氣體中，每公升氣體約含119毫升二氧化碳。

B. 如果這位婦女僅代謝葡萄糖，則其呼吸商數的值應比僅代謝棕櫚酸所產生的呼吸商數為高。

C. 如果這位婦女僅代謝棕櫚酸，則其呼吸商數的值應維持原來的數值。

D. 如果這位婦女被迫短跑幾分鐘，她的呼吸商數應會快速下降。

A. False **B.** True **C.** True **D.** False

Original commentary

Correct answers

A *false*

The adult woman is exhaling 170ml of O_2 per liter of air. Since the concentration of oxygen in the atmosphere is about 210 ml/l, the woman is absorbing around 40 ml of oxygen per liter of air. Given an RQ of 0.7, 28 ml of carbon dioxide (and not 119ml) must be eliminated per liter of exhaled air.

B *true*

An RQ of about 1 is expected when metabolizing glucose, but only 0.7 in the case of palimitc acid. Note that the students do not need to make the full calculations to answer this question, but just observe that there is an imbalance of O_2 absorbed and CO_2 eliminated when metabolizing palimitc acid, compared to a balance when metabolizing glucose.

C *true*

Metabolizing solely palmitic acid requires an absorption of 23 O_2 per 16 CO_2 eliminated (see equation 2). Hence the expected RQ is 16/23=0.69565, or 0.7 when rounded to the significant digits provided in the question.

D *false*

Short but heavy exercise leads to a large usage of anaerobic metabolism by muscle cells. At first, this is not expected to change the RQ at all as lactate fermentation does neither eliminate CO_2 nor absorb O_2. However, through time, Lactate build up leads to an increase in RQ due to an inhibition of fatty acid metabolism. While the students are not required to know the latter, they should know that anaerobic metabolism cannot lead to a decrease in RQ as less O_2 is absorbed.

Own commentary

哺乳類草食動物發展出多種不同策略來消化纖維素。反芻動物(例如：乳牛)利用多個胃，而單胃動物則利用延長的盲腸或直腸。

下列各項敘述正確或錯誤

A. 反芻動物小腸內不同胺基酸之含量與所攝食食物中胺基酸含量不同。

B. 反芻動物可食用他們盲腸消化後所產生的糞便，以補充營養需求。

C. 在單胃草食動物中，營養物質的吸收主要發生於直腸。

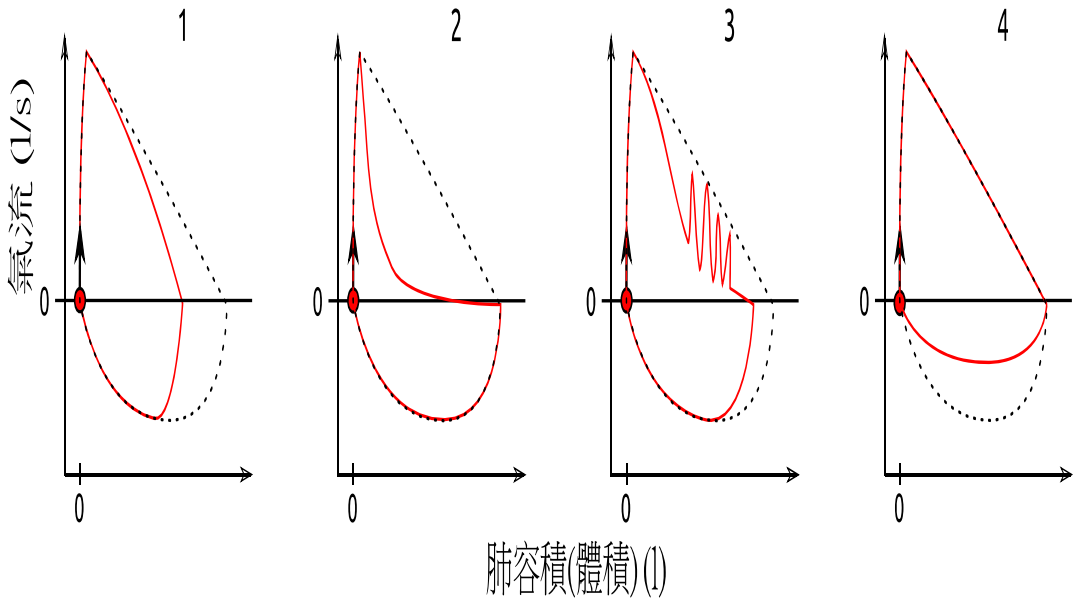
D. 在單胃草食動物的胃中所含之大部分細菌都可產生纖維素分解酶(cellulase)。

A. True **B.** False **C.** False **D.** False

Original commentary
Correct answers
A *true*
Microorganisms metabolise anorganic nitrogen to build their own proteins which have a different amino-acid-pattern than the food they swallowed. In the abomasum, microorganisms are killed by the HCL and their proteins are digested from the ruminant.
B *false*
Not ruminants but monogastric herbivores like rabbits have to eat their faeces from the coecum.
C *false*
In most monogastric herbivores, it is still the small intestine where most nutrients are absorbed. That is why several monogastric herbivores eat their feaces.
D *false*
Monogastric stomaches are not supposed to host bacterias.

Own commentary

為了評估呼吸功能，呼氣的流速及體積要在用力呼氣（正流）後測量，而呼氣的流速及體積要在全力吸氣（負流）後測量。下圖是測量4個罹患呼吸系統疾病的病人所得數值。黑色虛線是正常呼吸功能的數值。



下列各項敘述正確或錯誤

A. 病患1應已摘除左肺

B. 能減輕病患2的症狀之藥物，應是透過副交感神經系統作用於呼吸道。

C. 病患3由於咳嗽之故，而無法得到診斷結果。

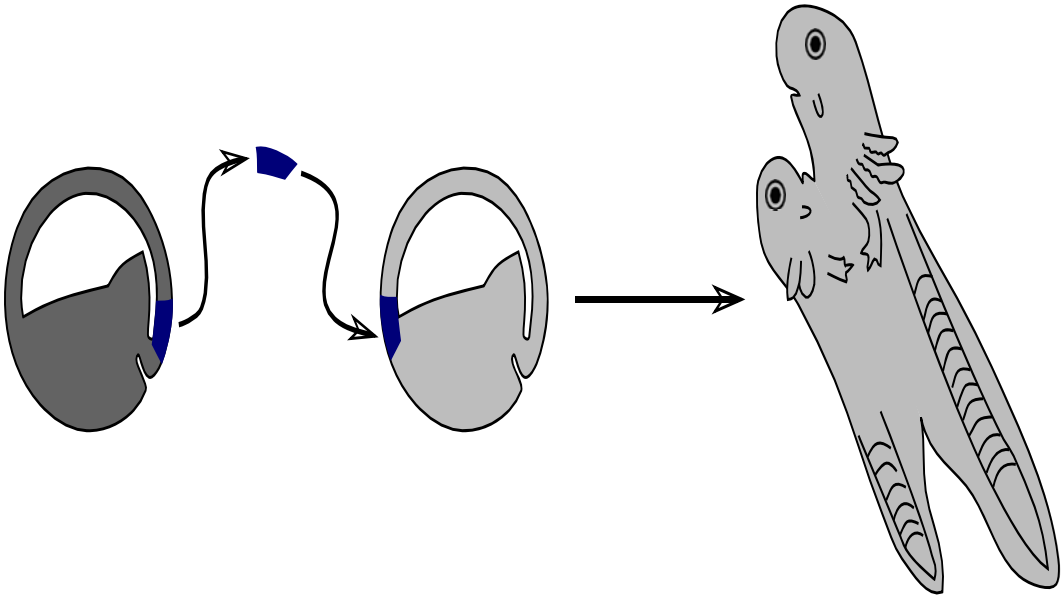
D. 病患4胸腔呼吸道可能阻塞。

A. True **B.** False **C.** True **D.** False

Original commentary
Correct answers
A *true*
Restrictive lung diseases reduce the lung volume which is shown/documented in patients flow/volume graph #1.
B *false*
The patient suffers from a obstructive disease. He's volume is normal, but the flow is reduced. Sympathic effect on the bronchial system causes an dilatation, the parasympathic effect an obstruction. An adaequate drug has either to inactivate the parasympathetic nervous system or activate the sympathetic nervous system.
C *true*
The results shown are indeed typical for a cough attack in which a rhythmic pulse of fast expiration are observed.
D *false*
As mammals have a negative pressure breathing (rise of intrathoracal volume causes a negative intrathoracal pressure leading to inspiration), an extrathoracal stenosis (obstruction) causes a fixed air-flow reduction apparent during inspiration.
The opposite is true for an intrathoracal obstruction, because the negative pressure during inspiration widens the intrathoracal air ways. Vice-versa in expiration.

Own commentary

下圖顯示取自蝌蚪胚胎深色素區的背唇被移植到胚胎淺色素區的外胚層腹側。第二體軸主要由無色素細胞構成。



下列各項敘述正確或錯誤

A. 第二體軸僅來自所移植的背唇。

B. 若將原本的外胚層在神經胚時期移植到蝌蚪胚胎，則會導致此蝌蚪會有2個體軸。

C. 細胞未來的發育是預先設定好的，且由細胞的內在特性所決定，而不受外界影響。

D. 如果將內胚層細胞移植到外胚層，第二體軸的大部分細胞來自色素細胞。

A. False **B.** False **C.** False **D.** False

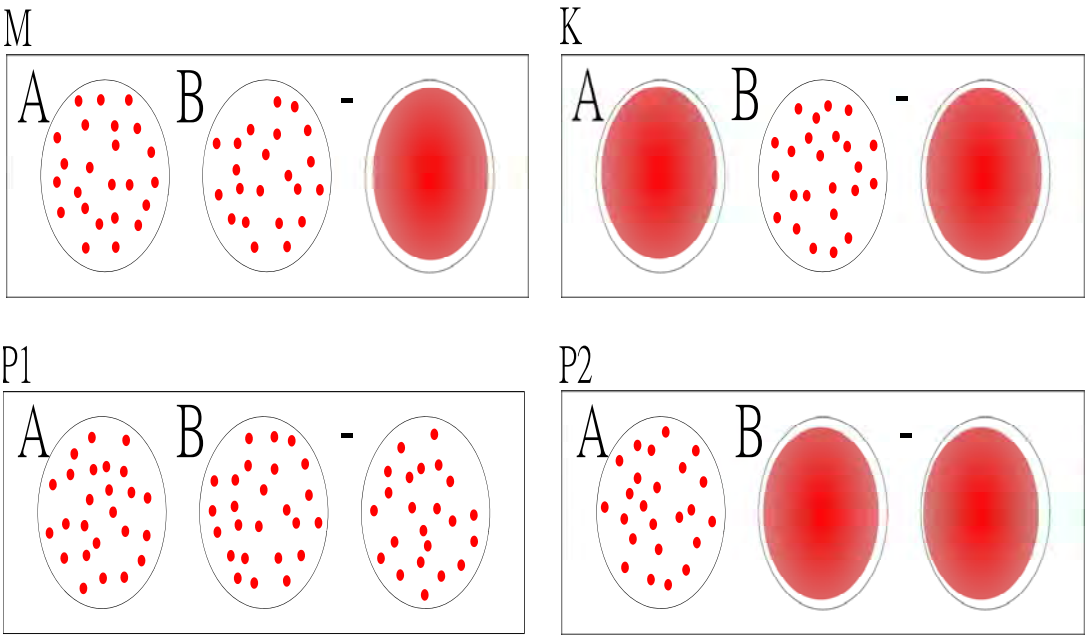
Original commentary
Correct answers
A *false*
The experiment shows, that the resulting tadpole on the ventral side had a lightly pigmented surface too, so this cells originate from the receiving embryo.
B *false*
A second body axis can only be induced when the cells are still able to differentiate in all tissues, this is not anymore the case at the neurula stage.
C *false*
The grafted cells are able to induce neurulation in the receiving embryo where “cell fate” was not to neurulate.
D *false*
The endoderm would not undergo neurulation and hence would not induce the cells to develop a secondary body axis at all.

Own commentary

貓的血型可分為3型，此三型皆由具3種等位基因的單一基因所決定。其中A等位基因對B等位基因是顯性;而AB等位基因對B等位基因為顯性，但對A等位基因是隱性。大部分A型的貓具有B型抗體，而B型的貓具有A型抗體。而AB型的貓不會產生A型與B型抗體。

抗原	所產生的抗體		
	Anti-A	Anti-B	Anti-AB
A	-	+	-
B	+	-	-
AB	-	-	-

下圖顯示母貓(M)、小貓(K)與2個可能是小貓父親(P1與P2)的輸血相容性結果。卡上含3個孔洞，其內分別含有A抗體(A)、B抗體(B)及不含任一抗體之控制組(-)。當加入血液於這些孔洞時，會產生凝集反應，而使孔洞變為紅色。



下列各項敘述正確或錯誤

A. 混合來自小貓(K)的血液及來自P2公貓的血清會引發凝集反應。

B. 母貓可接受來自P2公貓的紅血球。

C. 若將母貓(M)與小貓(K)回交(back-cross)，則其子代可捐紅血球給P2。

D. 這些結果顯示P1較P2有可能是小貓(K)的父親。

A. True **B.** True **C.** False **D.** False

Original commentary
Correct answers
A *true*
P2 produces anti-B, which are present in its serum and would cause an agglutination of erythrocytes of kitten K.
B *true*
The P2 serum has no anti-A and causes therefor no agglutination with antigens of erythrocytes in M.
C *false*
A cat with the blood group A has anti-B, which react both with AB and B antigens on erythrocytes. Since

the mother has genotype AB/B and the kitten B/B, any offspring of them has either blood group AB or B.
D *false*
The negative control indicates that the test failed. So the genotype of P1 is unknown and hence these results do not suggest anything. Note, however, that if P1 had indeed blood group AB, he would have the same probability as P2 to be the father of K. The corresponding probability for P2 is either 0% if he had genotype A/B or A/AB or 25% if he had genotype A/B.

Own commentary

尿素轉換為肌酸的比例可用來評估腎臟功能，主要計算方法為將血液中尿素含量除以血液中肌酸含量。 尿素與肌酸皆可自由通過絲球體障壁，但肌酸不會被腎小管再吸收;而尿素會有一定比例被腎小管再吸收，且當全身血量下降時會使尿素再吸收量下降。

下列各項敘述正確或錯誤。與健康個體相較，尿素/肌酸比值應會更高.....(接以下選項的描述)。

A. ....., 如果病患罹患急性尿道阻塞(尿路滯留)。

B. ....., 如果病患罹患集尿管(集合管)上皮細胞壞死。

C. ....., 如果病患脫水。

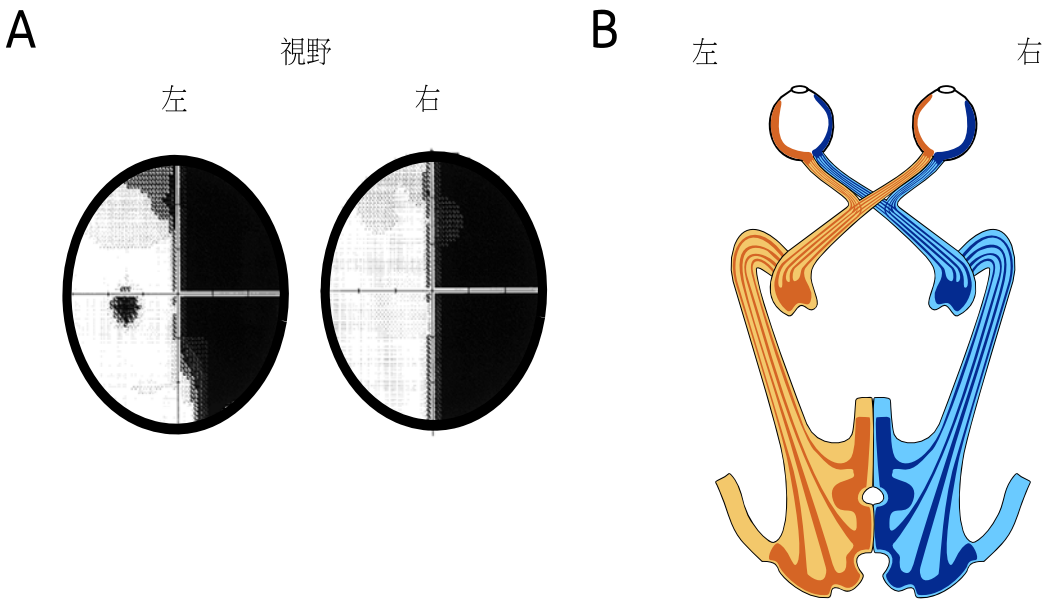
D. ....., 如果健康人劇烈運動後並攝取足夠水分。

A. False **B.** False **C.** True **D.** False

Original commentary
Correct answers
A *false*
Urinary retention affects urea and creatinine equally, and hence does not lead to a change in the ratio.
B *false*
Less urea reabsorption leads to a decrease in the ratio.
C *true*
Due to volume depletion, a higher percentage of urea is reabsorbed in the kidney, which leads to a larger ratio.
D *false*
In case of intensive exercise, muscles release more creatinine, and hence the ratio is decreased.

Own commentary

下圖A顯示了檢驗一個病人左、右眼視野的結果，其中黑色區域代表不良，白色區域代表優良的視覺感受。下圖B顯示了視覺訊息自眼睛接收並傳遞到大腦視覺皮質的通路。



請指出下列各敘述正確或錯誤。

A. 左側大腦視覺皮質受傷後，病人將失去左側的視覺。

B. 位於視交叉下方的一個腦下垂體腫瘤，常會造成雙眼側邊視野喪失。

C. 上述病人的視野，最有可能是由兩眼網膜與視交叉之間的問題所造成。

D. 僅單一個眼睛視覺完全喪失，可能是該眼球創傷，或該盲眼視神經發炎所致。

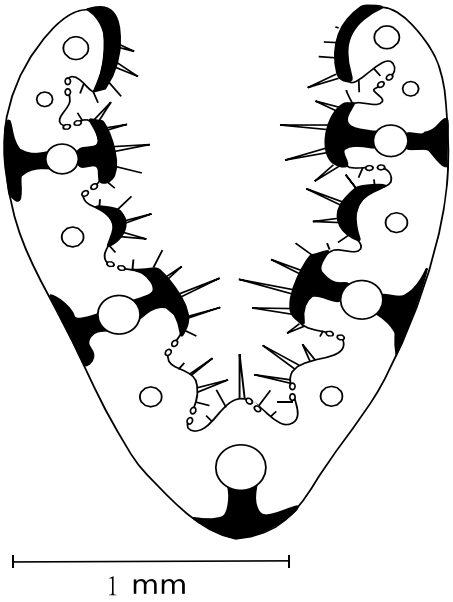
A. False **B.** True **C.** False **D.** True

Original commentary
Correct answers
A *false*
It causes a loss of function of the retinal receptors on the left side of both eyes which causes a visual loss of the right side from patients view.
B *true*
The hypophysis is situated right below the optic chiasm. Tumors of the hypophysis consequently mainly affect those nerves crossing at the optic chiasm, which are the nerves innervating the retinal receptors an the medial part of the retina causing lateral visual field defects.
C *false*
a lesion between the optic chiasm and retinae would affect both eyes but would most likely cause blindness in both visual fields (right and left) of both eyes. A dysfunction of both visual pathways between the optic chiasm and the retinae is much more unlikely to be the reason for the indicated visual field than a single or multiple lesion(s) affecting both orange part of the optic nerve (and not affecting the blue ones at the same time). The visual fields given are typical for a lesion between the optic chiasm and the left visual cortex.
D *true*
A lesion affecting 100% visual field of only one eye is usually located between the optic chiasm and the retina.

References
Duanes's Ophtalmology: E-book: Evaluation of Visual Function

Own commentary

下圖為一被子植物葉片橫切片的示意圖，圖中的圓圈代表維管束，黑色區域代表厚壁纖維，此外還有表皮毛（毛茸;trichome）及氣孔的位置。葉片中的維管束相對位置大致相似。



判斷下列每個敘述的正確或錯誤。

A. 此葉片很可能是單子葉植物。

B. 此植物很可能出現在濕地中。

C. 此整體的葉形可能是細長而非卵形或圓形。

D. 在此葉的新鮮徒手切片中，厚壁纖維可看到明顯的綠色。

A. True **B.** False **C.** True **D.** False

Original commentary
Note
The section belongs to a fescue (*Festuca*) out of the family of *Poaceae*.

Correct answers
A *true*
The regular position of vascular bundles that is constant all along the leaf indicates a parallel pattern of leaf veins without branching. This is a typical trait of monocotyledons.
B *false*
The stomata are situated in cavities of the leaf surface and protected by trichomes. This is a typical trait of drought adapted plants, reducing transpiration.
C *true*
The amount of supporting tissue (sclerenchyma) within the thin leaf is a hint to a very long length. A relatively short (laceolate or round) leaf would not need such a tissue.
D *false*
Sclerenchyma contains dead cells without cytoplasma. Therefore they do not contain chlorophyll and appear colorless in a fresh section.

Own commentary

植物胞器可從植物的細胞裂解液(lysate)經由數次離心及清洗而得。為區別不同胞器，不同的離心分層可藉一些簡單的檢測來進行。在檢測之前 以及/或 在檢測之後，會在某些特定條件下予以培養30分鐘。可能的檢測包括:

- 1) 以Fehling反應來測量葡萄糖及醛糖的濃度。
- 測波長在260 nm下的吸光值，以檢測 DNA 的存在。
- 觀察氣泡。

判斷下列各敘述為正確或錯誤。

A. 在進行Fehling檢測之前與之後，作照光培養，可區分葉綠體與澱粉體。

B. 在進行Fehling檢測之前與之後，加入葡萄糖培養，可區分高基氏體與粒線體。

C. 內質網及細胞核分層的區分方式，是經由與脂肪酶及蛋白酶培養，然後再離心並測定在波長260 nm下，兩種上清液的吸光值。

D. 藉由觀察與過氧化氫(H_2O_2)作用後是否產生氣泡，可用以區分過氧化氫體及核內體(endosomes)。

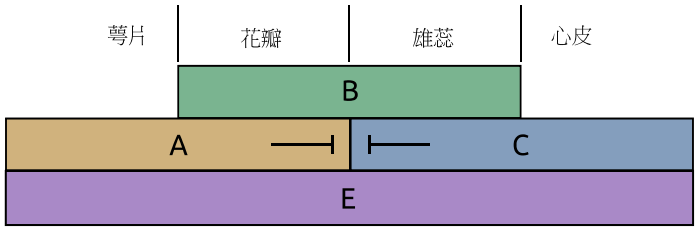
A. True **B.** False **C.** True **D.** True

Original commentary
Correct answers
A *true*
Amyloplasts convert glucose in starch that does not react with the Fehling reagent, whereas in light, chloroplasts produce sugars that will turn the Fehling solution blue.
B *false*
Neither Golgi nor Mitochondria are involved in the central sugar metabolism.
C *true*
Nuclei treated with lipases and proteases will liberate DNA that stays in the supernatant after pelleting the nuclei debris. Endoplasmic reticulum does not contain DNA, therefore even if lipases break it down, no change in absorption at 260nm will be observed.
D *true*
Peroxysomes transform H_2O_2 in H_2O and O_2, thereby liberating O_2 bubbles, whereas endosomes do not.

References
Lang, Plant Cell Rep (2011)
Peroxisome Database

Own commentary

根據花發育的ABCE模式，不同的A、B、 C 或 E群之基因活性會決定花的部位之形成。A群基因的表現為決定萼片及花瓣所必需；B群基因的表現為決定花瓣及雄蕊所必需；而C群基因的表現為決定雄蕊及心皮所必需。A及C群基因會互相抑制表現。每個部位的分化還需要有E群基因的表現。下圖表示ABCE模式，並以阿拉伯芥(A and B)、高山禾草(C)及金魚草的兩朵花(D；箭頭所指為兩側對稱的野生型，而D圖右之的輻射對稱者為突變株)為例作說明。



A B C D

判斷下列各敘述為正確或錯誤。

A. 阿拉伯芥A圖的表現型最適於解釋為B群基因喪失功能。

B. 阿拉伯芥B圖的表現型最適於解釋為A及C群基因喪失功能。

C. 禾草C最適於解釋為E群基因喪失功能。

D. 金魚草D的花對稱性之突變最適於解釋為C群基因喪失功能。

A. True **B.** False **C.** False **D.** False

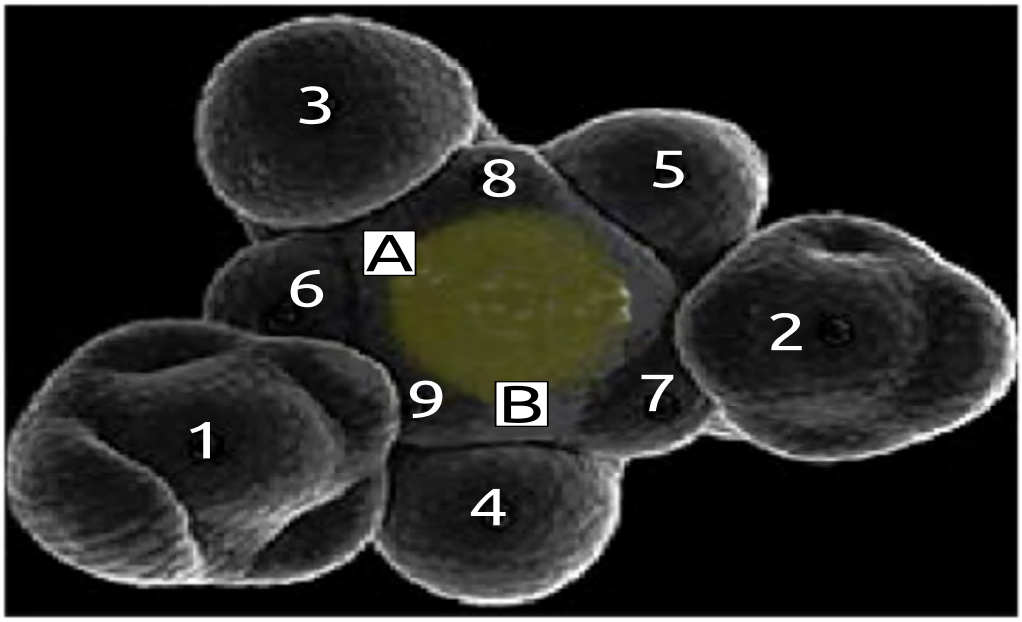
Original commentary
Correct answers
A *true*

B *false*
The best explanation is the loss of only class C genes.
C *false*
The leaves emerging from the flowers represent grass seedlings and not altered flowers with leaves at the position of floral parts. The picture shows a viviparous plant with grains germinating before falling off the mother plant.
D *false*
The mutant shows a loss of bilateral symmetry and not an alteration in the differentiation of floral parts.

References
Krizek, Nature (2005)

Own commentary

在頂端分生組織處的葉原體(將發育為葉子)之排列模式，是由活化的植物生長素所調控。植物生長素會傳送至分生組織的頂端。新生的葉原體是植物生長素的需求區，植物生長素藉由流出攜帶者PIN1 而向外傳送至需求區，並導致附近的分生組織細胞中的植物生長素含量下降。在植物生長素含量高的地方將會有新的葉原體形成。下圖為阿拉伯芥的分生組織，顯示出1-9個葉原體，1是最先形成者。



判斷下列各敘述的正確或錯誤。

A. 假設PIN1只存在於2個最新形成的葉原體中，此兩者所含之PIN1的活動力應該不同。

B. 下一個葉原體將在A處新形成。

C. 若在圖中所示的階段中，PIN1被抑制，則下一個葉原體將在B處新形成。

D. 若有一突變株，其新形成的葉原體是唯一的植物生長素需求區，則葉子的排列方式將為對生。

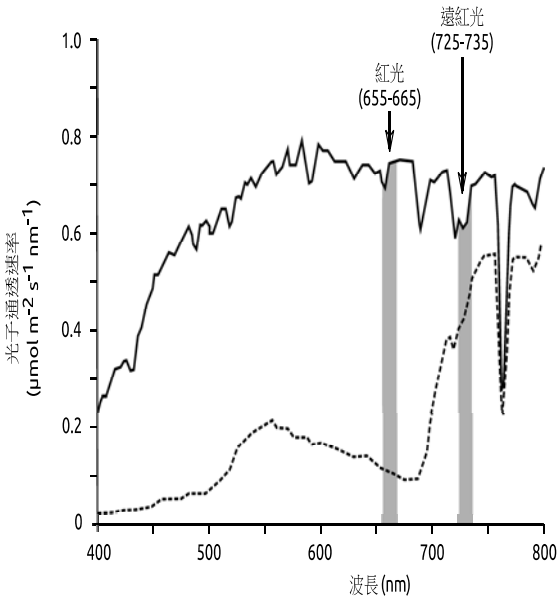
A. True **B.** False **C.** False **D.** True

Original commentary
Correct answers
A *true*
The characteristic angle of 137° between two subsequent primordia can be only explained with the youngest primordium being a stronger auxin sink than the second youngest.
B *false*
According to the order of older primordia the next primordium will emerge between primordium 2 & 5.
C *false*
In this mutant the primordial pattern would be aberrant, as well as the leaf shape. But it would emerge at a random position. There is no reason to assume that it will be position B.
D *true*
In this case the highest auxin concentration would be present directly opposite of the youngest primordium.

References
Reinhard, Nature (2003)

Own commentary

除了其他方式外，許多植物利用紅光/遠紅光的比例來偵測其他競爭光源的植物，以及時做出適應生長來避免遮蔽效應。光敏素負責進行紅光/遠紅光比例的偵測，它有P_X 及 P_Y兩種型式，且可依所吸收的光波而相互轉換。上述光敏素兩種型式的比例代表環境中紅光/遠紅光的比例，當P_X比例高時，可調控負責避免遮蔽的基因表現。下面的光譜圖中，實線代表正常白天光照，虛線代表白天光照穿過菸草植株遮蔽者。菸草A是生長在正常白天光照下的結果，菸草B則是生長在一棵較成熟的植株遮蔽之下的結果。



判斷下列各敘述的正確或錯誤。

A. 當紅光/遠紅光的比例在 3：1 及 4：1之間時，負責避免遮蔽的基因將會表現

B. 紅光比例高時，會造成的P_X 對P_Y的比例增加。

C. 向上直立的葉子是耐遮蔽的物種之典型特徵。

D. 避免遮蔽的表現型也包括活化側生分生組織的作用。

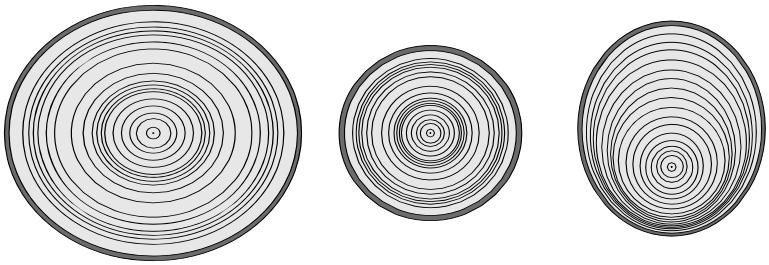
A. False **B.** False **C.** False **D.** False

Original commentary
Correct answers
A *false*
The maximal ratio is observed in normal light and is slightly above 1.
B *false*
The opposite is true. Plant B has the genes activated with a red/far-red ration of about 0.5. As the far-red-converted phytochrome form is dominant, this must be the active form.
C *false*
Shade-tolerant plants do not need to express the plant B-phenotype of growing out of the shade. In the shade they keep the normal leaf exposition, allowing to maximize the amount of photons collected by the leaves.
D *false*
A plant trying to avoid shade by enhanced growth will invest in few elongated stems and not in a multitude of branches that stay in the shade. Plant B doen't show any branching.

References
Vandenbussche, Current Opinion in Plant Biology (2005)

Own commentary

在溫帶樹木中的木材有明顯年輪，且可代表在不同年份及不同個體的生長狀態。下圖的三個木材橫切是來自三棵同種的松柏類植物，在同一年、同一高度所切下者。圖中所示皆在相同比例尺之下所繪。



I II III

根據這些莖的木材切面，判斷下列個敘述的正確或錯誤。

A. 樹木I 和 II可能生長在同一區域，而樹木 III 則生長在相距較遠的另一區。

B. 相較於樹木 I，樹木 III可能在多年期間曾經面臨較大的氣候變異。

C. 樹木 I和II可能源自相同森林。

D. 樹木 III出現不對稱的木材型式可能是因為其長期暴露於強風中，且此情況大約開始於10年前。

A. True **B.** False **C.** True **D.** True

Original commentary

Correct answers

A *true*

I and II show the same pattern of two periods of narrow rings (bad growth conditions) 2-6 and 9-13 years before they have been cut. Thus they have been growing in the same climatic conditions present in one same region. Tree III shows a different, much more regular pattern and did not suffer those two periods of bad years.

B *false*

Tree III has relatively regular rings throughout the lifetime on one side of the section. The asymmetric pattern can be explained by very local effects like a physical obstacle or shadow on one side of the tree.

C *true*

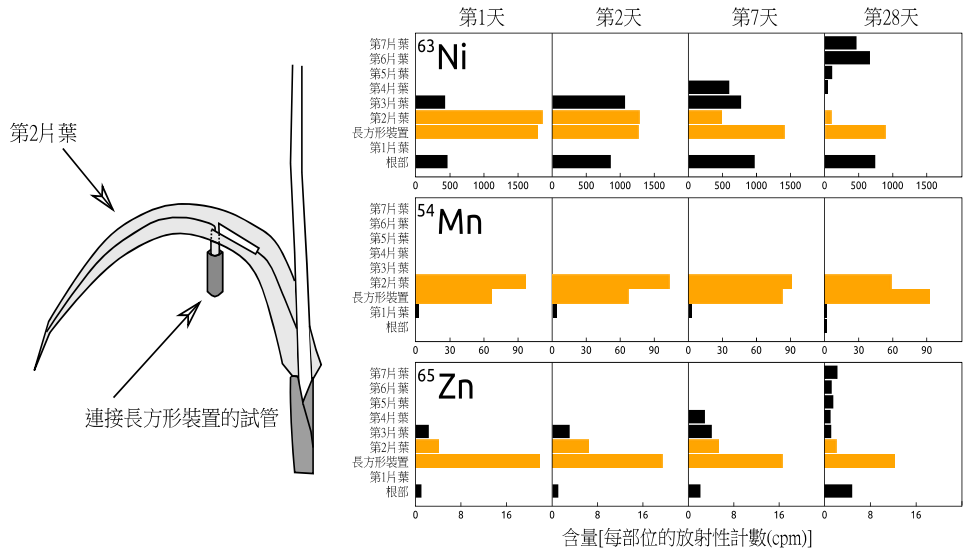
Local ecological factors such as available light or soil conditions can result in very different growth rates even for neighboring trees.

D *true*

The first rings are regular, indicating an equilibrated light supply. The last rings are more and more asymmetric. A likely explanation is that faster growing trees are competing for sunlight on one side of the tree, whereas on the other side the tree is still sufficiently exposed to sunlight.

Own commentary

在生長中的小麥植株的第2片新葉中段，對稱切開並加入一長方形裝置(如圖)，藉此添加含有具放射性的元素鎳(^{63}Ni)、錳(^{54}Mn)及鋅(^{65}Zn)之營養液。在第1、 2、 7 、 28 天後，分別測量在植株上不同部位的放射性元素含量。在下圖中的橘色橫條分別代表此長方形裝置中的濃度以及第2片葉中的濃度。



判斷下列各敘述是否符合上述結果?

A. 植物在第一次測量之前即吸收完所有添加的營養液。

B. 鎳大多運送至生長中的器官。

C. 錳在韌皮部中的移動能力較鋅或鎳都快。

D. 在第1天後，第2片葉即會成為糖分的淨輸出者。

A. True **B.** True **C.** False **D.** False

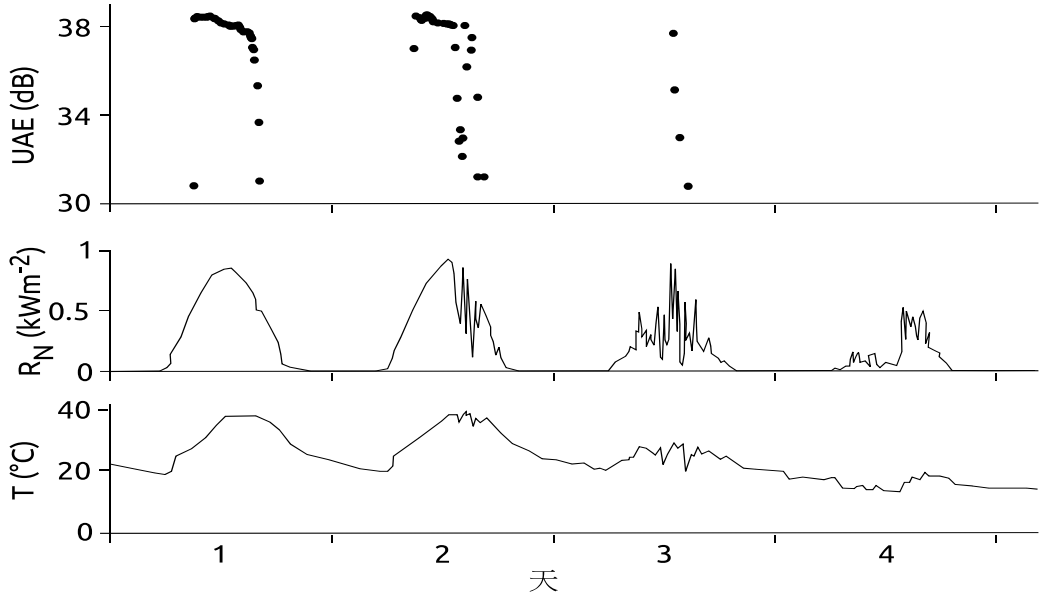
Original commentary
Correct answers
A *true*

B *true*
Nickel is first accumulated in leaf 3, then in leaf 4. After several days when these leaves are grown up nickel is exported again towards leaves 5-7.
C *false*
Manganese (known to have low phloem mobility) stays in the second leaf, whereas Zn and Ni is reduced in leaf 2 and appears in significant amounts in other parts of the plant.
D *false*
Leaf two is an "adult" leaf already at the beginning of the experiment. At day one a fraction of nickel already has been transferred from leaf 2 to 3. As the transfer is done by phloem transport, leaf 2 must already have a net sugar export.

References
Riesen, Journal of Plant Nutrition (2003)
Plant Physiology 5th ed., Lincoln Taiz and Eduardo Zeiger, section “Essential nutrients, deficiencies, and plant disorders” page 108 and following.
Campbell, Biology (9th ed.), table 37.1 page 791.

Own commentary

木質部中，水分輸導過程中偶爾會有空氣栓塞的現象，這是因為空氣進入輸導管中而導致水柱中斷所致。每當空氣栓塞時，會發出一種聲響，稱為超音波聲音放送(ultrasonic acoustic emission；UAE)，這可用特殊感應器偵測而得。下圖為在夏天時，連續4天量測橡樹的數據結果，同時也進行測量光照強度(R_N)及氣溫(T)。



判斷下列各敘述為正確或錯誤。

A. 在木質部水柱中的水分拉力上升時，會發生空氣栓塞。

B. 單一個UAE的聲音強度 與空氣及葉片間的水勢差異有相關性。

C. 發生UAE的情況隨時間而下降的原因，可能是因為雲遮蔽量增加的結果。

D. 空氣栓塞會降低木質部的運輸能力，進而降低遠端的水分供應。

A. True **B.** True **C.** True **D.** True

Original commentary
Correct answers
A *true*
The UAEs are recorded during periods of high radiation and temperatures. During this time the water potential in the surrounding air is very low, leading to increased evaporation. During increased evaporation the difference in water potential between leafs and roots is big and therefore the tension forces within xylem is high.
B *true*
The audibility is indicated by the decibel value. At mornings and evenings the few measured UAEs have lower decibel values and are therefore less loud. Keep in mind that the decibel scale is logarithmic. The difference between the water potential of air and leaves depends on radiation and temperature and is maximal at noon and early afternoon but lesser at morning and evening. Therefore a relation is given.
C *true*
The radiation diagram shows how the cloud covers increases (huge variation within short time), leading to a decrease in overall radiation, and hence to a decrease in water tension within water conduits.
D *true*
Water transport depends on a permanent water clomn. An embolism is leading to the interruption of a xylem conduit. Until it is refilled, further water transport through this conduit will be null or very limited.

References
Zweifel et al, New Phytologist (2008)

Own commentary

一植物的花青素含量受單一基因G控制，此基因只有深色(dark)和淺色(light)兩種等位基因。為了更準確地將G基因在第3條染色體上定位，利用5個在第3條染色體上的不同單核苷酸變異標記(SNV1 ~ SNV5)，在兩個親本純系 (P1 及 P2)和5個F2子代(X1 ~ X5)中分析這些單核苷酸變異標記的重組及花青素含量，如下圖

	SNV1	SNV2	SNV3	SNV4	SNV5	花青素 [mM]
P1	A/A	C/C	A/A	T/T	C/C	120
P2	T/T	T/T	C/C	G/G	G/G	25
X1	A/T	C/T	A/C	T/G	C/G	115
X2	A/A	C/C	A/A	T/G	C/G	123
X3	A/A	T/T	C/C	T/G	C/G	22
X4	A/A	C/T	C/C	T/G	C/C	29
X5	A/T	C/T	A/A	T/T	C/C	118

根據分析結果，判定下列各敘述是否正確

A. X2的兩個親本在這些單核苷酸變異標記間都各發生了1次重組互換

B. F1個體可能會表現中間程度的花青素

C. 在這些單核苷酸變異標記中，SNV3最接近G基因

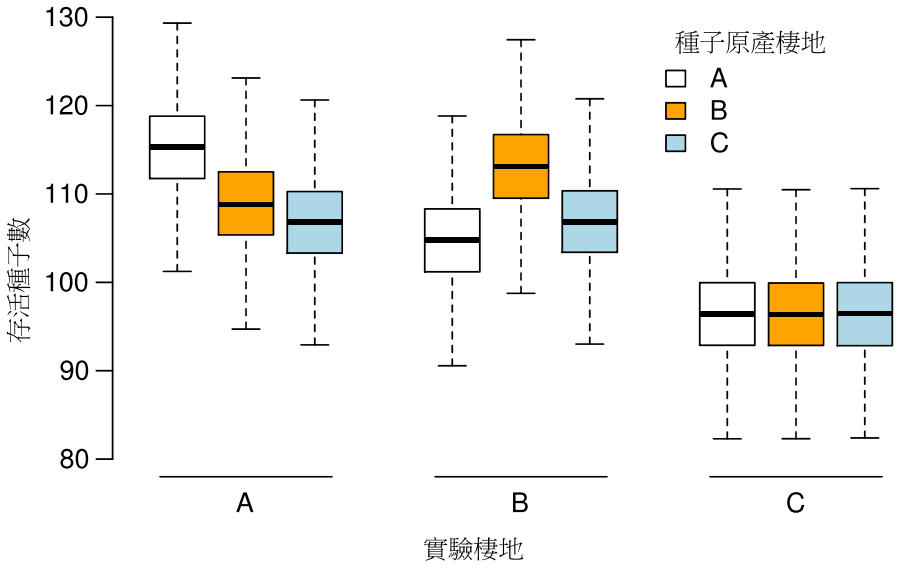
D. X4和X5雜交後代的表現型呈2:1比例分布

A. False **B.** False **C.** True **D.** False

Original commentary
Correct answers
A *false*
Most likely, a single recombination event happened in only one of the parents, as one of the haplotype is parental (ACATC) and the other shows a recombination between SNV3 and SNV4.
B *false*
Gene G is linked to SNV3, and the table lists a heterozygous individual (X1) with an elevated anthocyanin level (which is the dominant allele). But note that the students do not need to identify the most closely linked locus as for each of them heterozygous individuals are given and the conclusion would remain unchanged.
C *true*
This is the only locus for which the genotypes match the phenotypes in a Mendelian fashion.
D *false*
A 2:1 ratio is impossible for any crossing, as we clearly have dominant-recessive inheritance. So it is possible to answer this question even if the truly linked locus is not identified.

Own commentary

同一種植物生長於A、B、C三個棲地，不同棲地的族群其遺傳組成也不同。為了解這些遺傳差異是否是地域適應度所造成，於是進行一個相互栽植實驗：將採自3個族群的種子，栽種於所有3個棲地，一年之後，以各植株所產生的存活種子數，設定為其適應度，結果如下圖：



依據實驗結果去判定下列各敘述是否正確

A. 來自棲地A的植物對棲地A環境具適應性

B. 來自棲地B的植物對棲地B環境具適應性

C. 來自棲地C的植物對棲地C環境具適應性

D. 棲地C比棲地A、B較不適合這些植物生長

A. True **B.** True **C.** False **D.** True

Original commentary

Correct answers

A *true*

Plants grown from seeds collected in habitat A show, on average, a much higher fitness when grown in habitat A than seeds collected form other habitats.

B *true*

Plants grown from seeds collected in habitat B show, on average, a much higher fitness when grown in habitat B than seeds collected form other habitats. Note that the fact that seeds from habitat B perform better in habitat A than in habitat B is likely due generally better conditions in habitat A.

C *false*

Plants grown from seeds collected in habitat C follow the habitat quality, but do not indicate that they are specifically adapted to environment C since they do not perform better there than plants adapted to different environments.

D *true*

All plants perform much worse in environment C than environments A or B, inclusing the individuals originating from this environment.

Own commentary

假設有一個大而穩定的二倍體物種族群，其世代間無重疊，有性生殖在春季發生，等位基因頻率在二性別間無差異，無個體遷移和自然淘汰，在此族群中，由於生殖的本質逢機性使等位基因頻率只呈現有限的變動。

判定下列各敘述是否正確？

A. 如果此族群以指數成長，則等位基因頻率的變動率會變高

B. 如果所有個體產生同樣數目的子代，則等位基因頻率的變動率會變低

C. 即便近親繁殖盛行，等位基因頻率的變動率不變

D. 如果族群在每年冬天驟減，則等位基因頻率的變動率會變高

A. False **B.** True **C.** True **D.** True

Original commentary

Correct answers

A *false*

If a population is growing exponentially, stochasticity in reproduction is reduced due to a larger number of offspring "sampling" alleles from the parent generation, and hence allle frequencies fluctuate at a lower rate.

B *true*

If all individuals had the same number of offspring, allele frequencies are almost constant since each individual leaves a fixed number of copies of his alleles in the population. The only stochastic variation left comes from heterozygous individuals randomly passing one of their alleles per offspring.

C *true*

While inbreeding decreases the frequency of heterozygotes, it does not lead to a faster change in allele frequencies.

D *true*

A population crash in winter leads to a recurrent bottleneck which removes alleles randomly from the population and leaves a smaller number of individuals reproducing in spring. This leads to an increased stochasticity.

Own commentary

基因x　表現出的蛋白質X，是合成白胺酸(leucine)的必要蛋白質，利用單倍體酵母菌來研究基因x各種突變的效應，以下是基因x 密碼股上開始和結束部分的序列。

```
          10          20          30          40              490
          |           |           |           |               |
atg gcg caa gag cag aag cgt ggt acg ggc ttg gat agc gac ... gga cag tag
```

判定下列各敘述是否正確

A. 基因x 在位置13的C → T突變，會轉錄出較短的mRNA

B. 在位置16的A → T 突變，可讓細胞生長在缺少白胺酸(leucine)的培養基

C. 在位置31的T → A突變，只會讓細胞製造出1種不同的蛋白質X*，缺少最前面的10個胺基酸

D. 在位置33和34之間插入額外的1個G，仍然能製造出有功能的蛋白X

A. False　**B.** False　**C.** False　**D.** False

Original commentary

Note
Students are expected to know the start and stop codons. Nevertheless, for those who don't, they can find out by looking at the sequence, that ATG is a start codon and TAG a stop codon.

Correct answers
A *false*
Introducing the mutation C13T results in the TAG stop codon, but the transcription stops only at the transcription termination sequence independently of the codons
B *false*
Introducing the mutation A16T results in the TAG stop codon. With a stop codon at the beginning of the sequence, no functional protein is produced and no leucine can be synthesized by the yeast that would need to take it up from the medium.
C *false*
Introducing the mutation T31A results in the ATG start and methionine codon. This will simply result in a methionine at this position. The eukaryotic ribosome binds at the 5'-cap of the mRNA and starts translation at the first AUG encountered. Further AUG are simply translated into methionine.
D *false*
Introducing a G between positions 33 and 34 results in a shift of the translation frame. Instead of reading ...GAT AGC... (positions 34-39), the ribosome will read ...GGA TAG... and reaches a stop codon. Translation stops there, the protein will not be functional.

Own commentary

有一操縱組表現酵素1和酵素2，此操縱組受到代謝物X　調控，操縱組中有4個功能不詳的區域A、B、C、D，為釐清這些區域的功能，於是分析區域A – D的個別突變對表現酵素1和酵素2的效應，實驗分別在"有"或"無"代謝物X 的情況下進行，結果如下：

	有代謝物X		無代謝物X	
突變所在區域	酵素1	酵素2	酵素1	酵素2
無突變	-	-	+	+
A	-	-	-	+
B	+	+	+	+
C	-	-	+	-
D	-	-	-	-

判定下列各敘述是否正確

A. 酵素1和酵素2可能參與X 的合成

B. 區域A是酵素2的基因序列

C. 區域B是啟動子序列

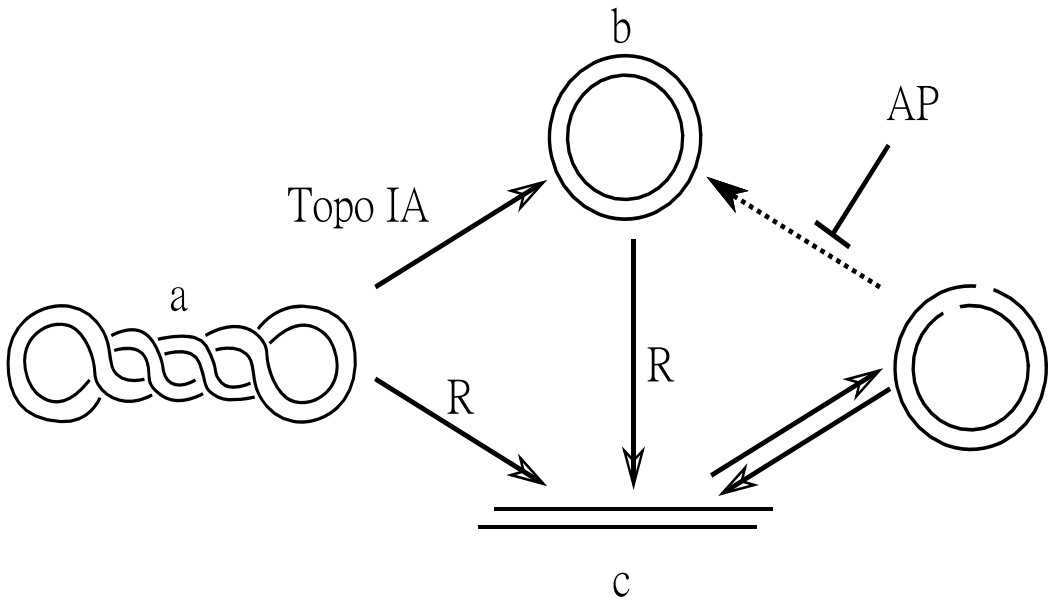
D. 區域D是調控基因

A. True **B.** False **C.** False **D.** False

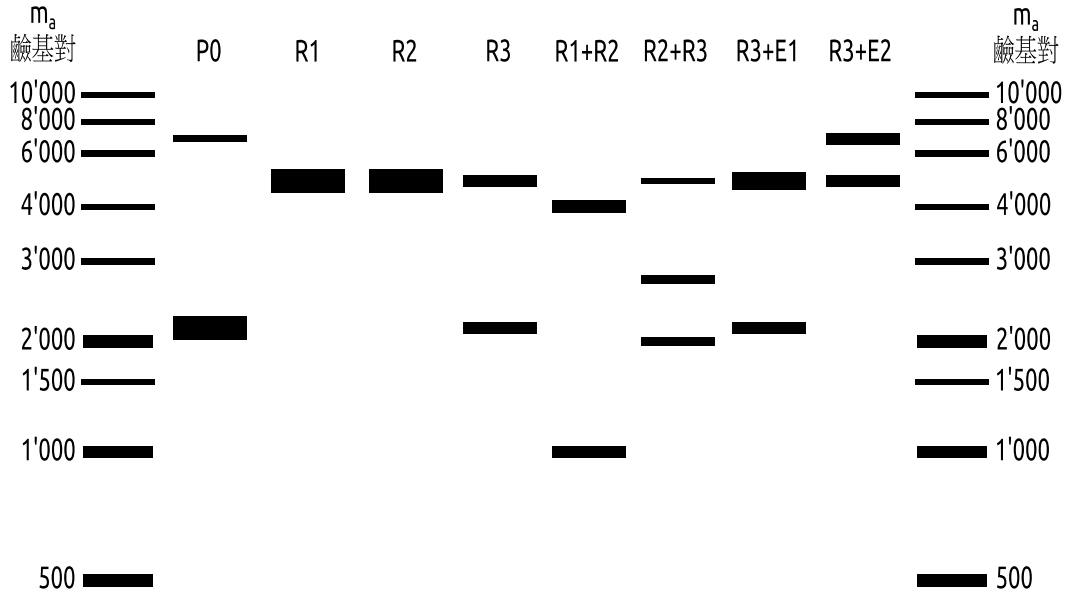
Original commentary
Correct answers
A *true*
This operon is repressed by X. This kind of negative transcriptional regulation is mostly found in biosynthetic pathways.
B *false*
In the absence of X and mutation in A, enzyme 2 is still produced, enzyme 1 isn't, therefore A codes for enzyme 1.
C *false*
In the case of a mutation in B, enzymes 1 and 2 are produced even in the absence of X, therefore B corresponds to the regulatory gene.
D *false*
In the case of a mutation in D, neither enzyme is produced, even in the absence of X, therefore D corresponds to the promoter region.

Own commentary

細胞中大多數的質體是以超螺旋狀態存在(下圖a)，拓樸異構酶IA (TopoIA)可將超螺旋質體轉變成鬆解態環狀質體(下圖b)；限制酶(R)可將超螺旋或鬆解態質體切割成線性質體(下圖c)。線性質體可自發性進行黏接成鬆解態環狀質體，此黏接反應可被磷酸酶(AP)抑制。



某一個質體分別用3種限制酶(R1，R2，R3)在相同條件下處理，接著以電泳膠分離，電泳時並比較未處理樣品(P0)、尺標DNA，以及R3+ TopoIA、R3+ AP (以R3+ E1 和 R3+ E2標記)



判定下列各敘述是否正確

A. 在此質體上，R2切位距R3切位比R2距R1要近

B. 此質體大小約為5000 bp

C. 在此實驗中，R1切割質體比R3有效率

D. E1代表AP，E2代表TopoIA

A. False **B.** True **C.** True **D.** True

Original commentary
Correct answers
A *false*

R1 and R2 are distant from 1000 bp, R2 and R3 from 2000 bp, even if 2 vector maps are possible:
R1 – 1000 bp – R2 – 2000 bp – R3 – 2000 bp –
R1 – 1000 bp – R2 – 3000 bp – R3 – 1000 bp –
B *true*
Since the shape of DNA plays a role in the migration, the length of DNA can only be determined by comparing fragments with the same shape. The plasmid is linearized when using only 1 restriction enzyme. The supercoiled plasmid from P0 (thick band) is converted to linearized DNA which migrates around 5000 bp (see R1 or R2).
C *true*
In R3, some uncut supercoiled is still present, only about half was cut, whereas in the same time, R1 could cut everything
D *true*
Treatment with AP removes prevents re-formation of relaxed circles, the slowest migrating band disappeared in R3+ E1. Treatment with E2 converted the uncut supercoiled plasmid into relaxed circles, this corresponds to Topo IA.

Own commentary

有一對健康父母生下1個罹患罕見遺傳疾病的小孩，這個小孩有1個健康的姊姊 。

判定下列各敘述是否正確

A. 如果這種疾病在父親家族內出現，則此疾病較有可能是體染色體遺傳，而非性聯遺傳

B. 如果這種遺傳疾病是隱性性聯遺傳，則姊姊有50%的機率是帶原者

C. 如果這種遺傳疾病是隱性體染色體遺傳，則姊姊有50%的機率是帶原者

D. 如果這種疾病並未在雙親家庭出現，則此偶發突變或為隱性體染色體遺傳，或是這位小孩特有發生

A. True **B.** True **C.** False **D.** True

Original commentary
Correct answers
A *true*
X-linked recessive would imply that the father was affected.
B *true*
In this case, the mother is carrier and the father healthy. Hence the sister inherits an unaffected X chromosome from the father and has a 50% chance to inherit the affected chromosome from the mother.
C *false*
In this case, both parents are carriers. But since we know that the sister is healthy, the probability is 2/3 (and not 1/2).
D *true*
A rare autosomal recessive disease is likely not to show up in an outbred family for many generations. An alternative explanation for the disease, however, might indeed be a spontaneous mutation being unique to the child.

Own commentary

在一個小型草原內取樣500個屬於兩種近親的蝸牛，遺傳分析顯示，有一基因座沒有任何一個個體是異型合子，而此基因座在此兩種蝸牛中各有2種等位基因。此二物種及所有基因型皆隨機分布在均質的環境中。

蝸牛種	基因型	蝸牛數量
A. sulfis	AA	126
A. sulfis	BB	125
A. andea	CC	122
A. andea	DD	127

請指出下列各敘述是否可能解釋所觀察到之現象。

A. 這些蝸牛一般是自體受精。

B. 兩物種由於族群數量小，皆面臨極強的基因漂變。

C. 這些蝸牛雌雄同體但以異體交配的方式生殖。

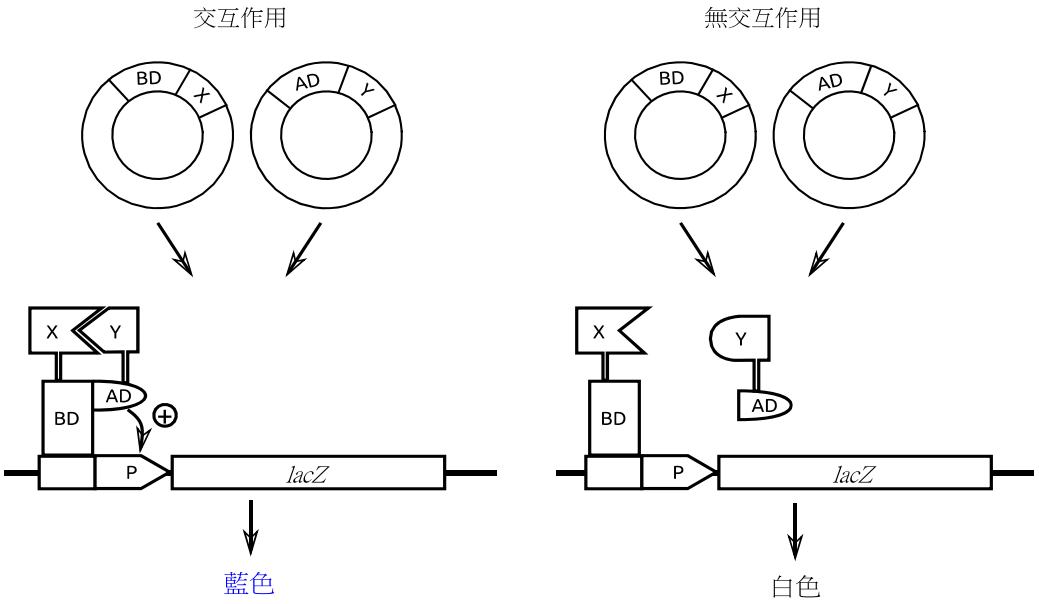
D. 這些蝸牛傾向與具相同基因型的個體交配。

A. True **B.** False **C.** False **D.** True

Original commentary
Correct answers
A *true*
Self-fertilization would indeed lead to all snails being homozygous.
B *false*
If the populations were experiencing strong drift through low population sizes, this would lead to a reduction in diversity. However, there is no reason why this should affect heterozygous individuals preferentially.
C *false*
Hermaphroditic reproduction does not have any impact on allele frequencies as long as mating is random.
D *true*
If snails mate only with snails of the same genotype, heterozygous individuals would be very rare in the population.

Own commentary

酵母菌雙雜合分析(Y2H)可測試蛋白質X 和蛋白質Y 是否會發生交互作用(如下圖)。首先建構2個含雜合基因的質體：表現蛋白質X 的基因會和表現1個轉錄因子的DNA附著區域(BD)基因序列相接合；表現蛋白質Y 的基因會和轉錄因子的活化區域(AD)基因序列相接合，將這二個質體轉殖入一個含*lacZ*基因的酵母菌中，此*lacZ*基因的啟動子P 只會專一地被前面提及的BD辨認。將此酵母菌轉殖株培養在含X-gal的培養基時，如果蛋白質X 和蛋白質Y 發生交互作用，會將AD帶至BD處，進而活化*lacZ*基因而表現LacZ蛋白去切割X-gal，結果使菌落變藍色。



判定下列各敘述是否正確

A. 如果當BD單獨存在時也可活化轉錄，則酵母菌雙雜合分析(Y2H)依然可用

B. 酵母菌雙雜合分析(Y2H)可用於檢測細胞膜鑲嵌蛋白間的交互作用

C. 如果X和Y透過其它蛋白質間接發生交互作用，則酵母菌雙雜合分析(Y2H)會呈現錯誤的藍色陽性結果

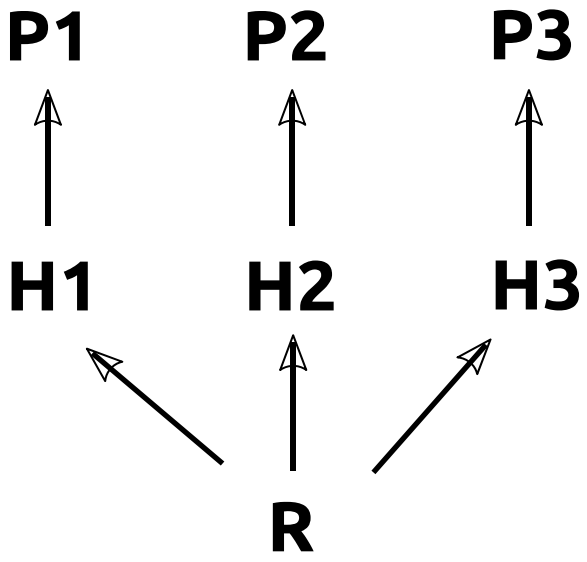
D. 如果蛋白X上與Y發生交互作用的位置太靠近其與BD相接合處，則酵母菌雙雜合分析(Y2H)會呈現錯誤的白色隱性結果

A. False **B.** False **C.** True **D.** True

Original commentary
Correct answers
A *false*
The assay works correctly only if BD and AD by themselves are not enough to activate transcription, but are both needed.
B *false*
This in vivo assay works only for soluble proteins. To study interaction of membrane proteins, the membrane proteins need to be properly folded, which is only possible if they are in lipidic environment.
C *true*
If I binds to a third protein which binds to II, the assay can give positive results, even if I and II do not interact directly.
D *true*
The binding site can be distorted if it is too close to the junction to the transcription factor domain.

Own commentary

假設在一個目前穩定的生態中，有3種掠食者的昆蟲種類P1、P2及P3生活其中，每種分別只靠捕食一種草食性昆蟲H1、H2或H3維生。而此3種草食性昆蟲皆吃同種有限的植物資源R。



請指出下列各敘述是正確或錯誤。

A. 如果植物資源倍增，P2的數量將會增加。

B. 如果H1競爭能力強於H2，移除P1將導致P2增加。

C. 如果H3受到天敵極強大的壓力，移除P3將導致P2減少。

D. 引進高層掠食者來捕食P1及P2，可能導致P3增加。

A. True **B.** False **C.** True **D.** False

Original commentary

Correct answers

A *true*

Doubling the resource should lead to a doubling of all abundances in the system in the long term since the interactions remain unchanged.

B *false*

Population size of predators depend on populations size of herbivores. H1 now lacking a predator will increases on cost of H2. As a consequence the abundance of P2 decreases as well. This is expected unless H2 is limited almost completely by its predator and not by competition with H1, but even in that case the abundance is expected to remain unchanged, but not increase.

C *true*

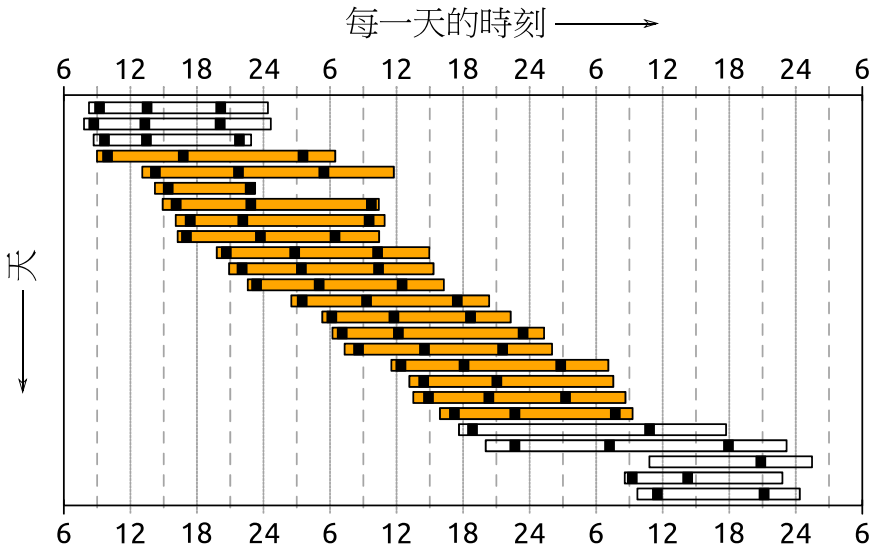
Population size of predators depend on populations size of herbivores. H3 when having its predator removed, is able to reduce H2, P3 must be a limiting factor for H3. H2 when having its predator removed does not seem to be able to affect H3. Therefore the effect of the predator is not limiting enough to lead to significant loss of competition against H3.

D *false*

The top-predator will decrease the abundance of P1 and P2 and therefore lead to an increase of H1 and H2. As both those herbivores are in competition with H3, the abundance of H3 is likely to decrease, leading to a dcrease in the abundance of P3.

Own commentary

下圖顯示的實驗結果，是有關一個人（受測者）單獨在房間內，可藉由開燈及關燈，自由選擇清醒及睡眠時段。圖中的長條表示每天連續的光照時段，長條中的黑色小段表示受測者選擇用餐的時間。長條為橘色時，表示該時段受測者沒有外界時間的線索；長條為白色時，表示該時段此房間接受外界自然光的照射。



請指出下列各敘述是正確或錯誤

A. 沒有外在的時間線索，此受測者選擇更長的光照時間。

B. 此受測者的生理時鐘是每天28.5小時。

C. 此研究結果顯示，光照是延後睡眠階段的線索。

D. 此研究結果顯示，此受測者的生理時鐘可能在2天內完全地重行調適。

A. False **B.** False **C.** True **D.** False

Original commentary

Correct answers

A *false*

While the periods of light were extended in the absence of external cues, there us no indication the those periods got longer during the experiment.

B *false*

Firstly, this experiment does not measure the endogenous clock since the bright light is an effective, external cue to delay the endogenous clock. Secondly, the the observed rhythm is on the order of about 26 hours (average over the 17 days).

C *true*

The person chose extended periods of light, without extending the periods of sleep much. This is an indication that the bright light resets the clock and delays the desire to go to sleep. A good example can seen at the beginning of the experiment where the person stay up for more than 20 hours on the first two days and apparently got very tired on the third day.

D *false*

The transition back to normal conditions took the person at least four days. This can be seen best with the irregular eating times.

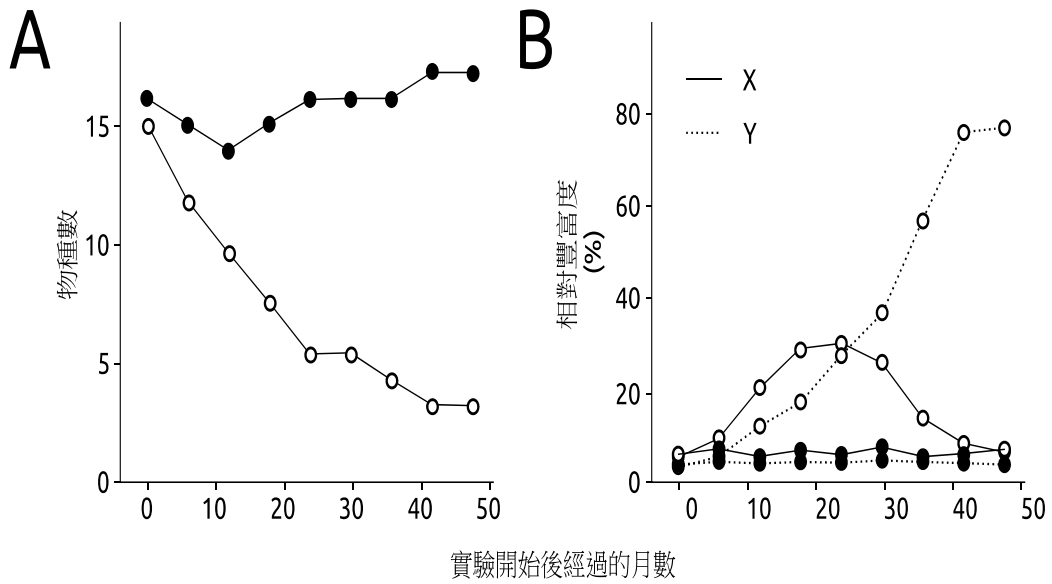
References

Charles et al, Science (1999)

Own commentary

某一個草食性昆蟲H 以2種樹種X 及Y 的幼苗維生。在一個實驗中，選擇林中2塊地，其一為實驗組，另一為對照組。在實驗組中，樹種X、Y的幼苗受保護（下圖中以空心圓點表示）；在對照組中，樹種X、Y的幼苗則未受保護（下圖中以實心圓點表示）。下圖A部分，顯示具幼苗樹種的平均物總數；下圖B部分，顯示樹種X、Y 幼苗的相對豐富度。

請指出下列各敘述是正確或錯誤。



A. 樹種Y 的幼苗競爭力較弱。

B. 此樹林的群集包含了一個由上而下的管控機制。

C. 樹種X 的幼苗受到另一種草食性動物很大的影響。

D. 此草食性昆蟲在此生態系中扮演了關鍵物種的角色。

A. False **B.** True **C.** False **D.** True

Original commentary

Note

The two prey species must be excellent competitors, not inferior ones; otherwise they would not be able to dominate the experimental plot communities in the absence of the predator (78% vs. 27%). When community organization is regulated in this way, as opposed to the availability of nutrients — recall seedling growth was not limited by light availability — it follows a "top-down model" and not a "bottom-up model" (p. 1206). A top-down regulatory role for the predator is predicated on there being interspecific competition between prey and non-prey species for space when the prey are largely sessile, which plants are (p.1205 top of Fig. 54.17). In this way, the predator pre-empts interspecific competition among seedlings to promote local alpha diversity in the forest.

Correct answers

A *false*

Competition of species Y is only controlled by herbivore H. Without this control it dominates the tree seedlings in the forest within a few years. Moreover it is clearly able to outcompete species X when both species are lacking herbivore H.

B *true*

The diversity of tree species is regulated by the presence of herbivore H, a species at a higher position in the food chain. This feature qualifies a top-down process.

C *false*

After removing herbivore H, species X increases rapidly over two years, before diminishing again when being exceeded by species Y. This feature is best explained by competition between species X and Y. A potential regulation by another herbivore would be likely to prevent the initial strong increase of species Y.

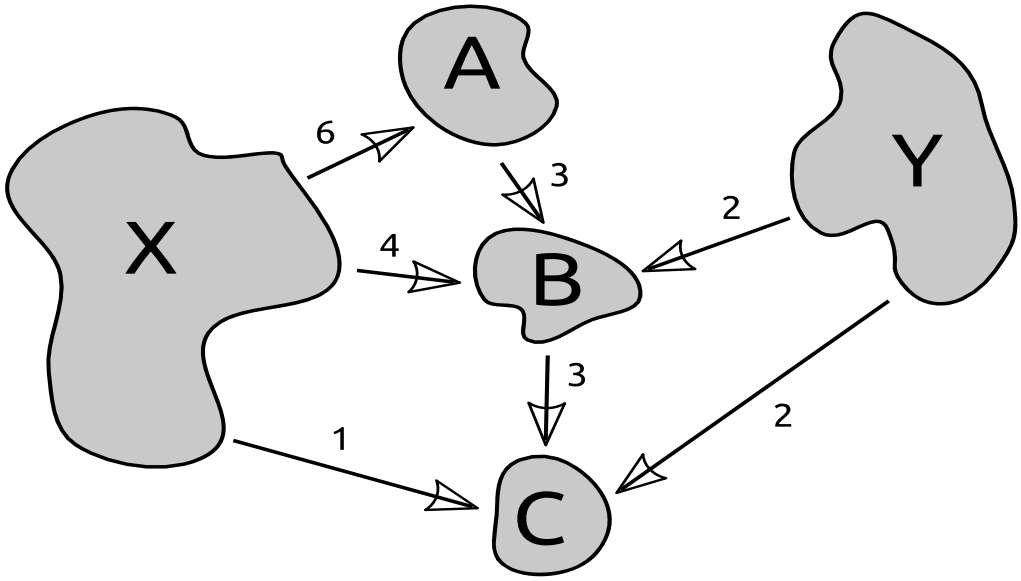
D *true*

The predator not very abundant in the community, as both its host species only have a cumulative

abundance of about 10%, but it clearly plays a pivotal ecological role in structuring the community by preventing potential dominance by prey, so it therefore qualifies as a "keystone species" (p. 1204; Campbell Biology 9th ed., 2010)

Own commentary

關聯族群（meta-population）的概念是在描述於一棲息區塊的族群大小 與出生率、死亡率及遷徙的關係。下圖為一假想的關聯族群，包含了2個資源區塊X 及Y，在此兩區塊中，族群的出生率超過死亡率；另有3個沒落區塊（A、B及C），生活其中的族群沒有繁殖。每年於不同次族群（即生活於不同區塊的族群）間，淨遷徙數是固定的，於下圖中以箭號表示。在每次遷徙季節結束時，每一個沒落區塊中有6個個體死亡。在1年內，各個體只能遷徙1次。此3個沒落區塊初始的族群大小分別為A=22、B=9、C=12。



請指出下列各敘述正確或錯誤。

A. 區塊A的次族群，於8年後第1次全部死亡。

B. 在幾年內，次族群X及Y 的基因交流被隔絕。

C. 如果區塊C中每年有50%的個體（並非前述的6個個體）死亡，則C區塊的次族群個體數不會降到低於7。

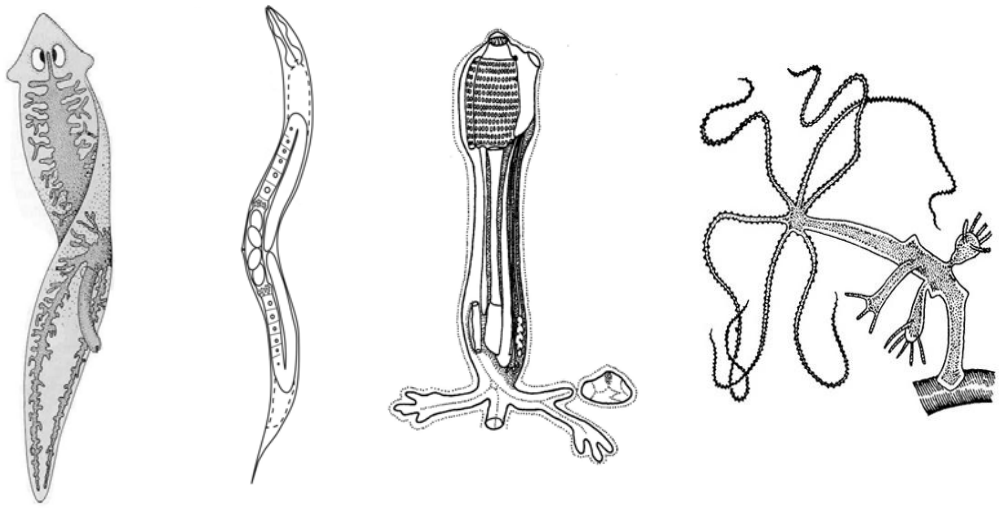
D. 若採取一種保育的方式，將A區塊次族群死亡率降低50%（每年3個個體死亡）時，則可保護所有的次族群。

A. True **B.** True **C.** False **D.** True

Original commentary
Correct answers
A *true*
Net migration for patch A is 3. With a mortality of 6 individuals a year the sub-population declines 3 individuals each year. After 8 years, the population will reach 0.
B *true*
With the given migration and mortality, all sink population have a negative long-term trend and will die out. First, population A will die out so migration between A and B will be interrupted. Without this migration, population B and subsequently population C will die out as well. So no individual will be able any more to migrate between X and Y.
C *false*
With a constant net migration of 6 individuals into patch C, the population will fall below 7 individuals within three years, but will not fall below 6 individuals.
D *true*
This reduction in mortality prevents A from dying out. Therefore all other subpopulations will not die out either.

Own commentary

給你4張圖，表示4個主要後生動物群(metazoa)的典型代表物種。



I II III IV

請指出下列各敘述正確或錯誤。

A. 個體 I 屬於某種分類群，其主要特質是消化系統的開口僅1個，且缺乏特化的呼吸系統。

B. 個體 II 屬於某種分類群，其主要特質是具有液壓骨骼（hydrostatic skeleton）、厚角質、具有兩端開口的管狀消化系統，且體細胞的數量受遺傳管控而經常是固定的。

C. 個體 III 屬於某種分類群，其主要特質是幼蟲期具有神經形成的神經管，成體期行固著生活，且身體被外鞘所包覆。

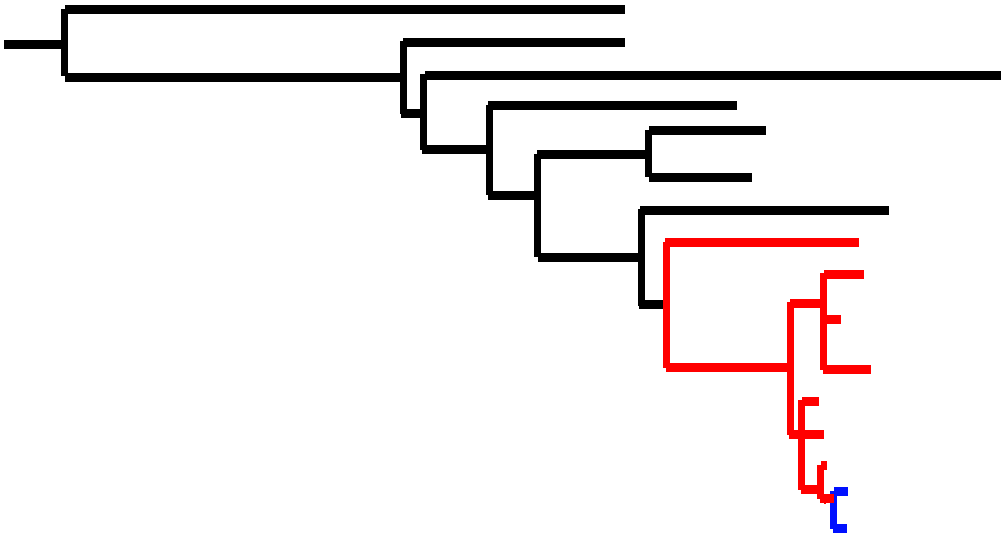
D. 個體 IV 屬於某種分類群，其主要特質是具有鈣質墊的內骨骼，並具充滿液體的水管系統，以行使包括用管足移動在內的各種不同功能。

A. True **B.** True **C.** True **D.** False

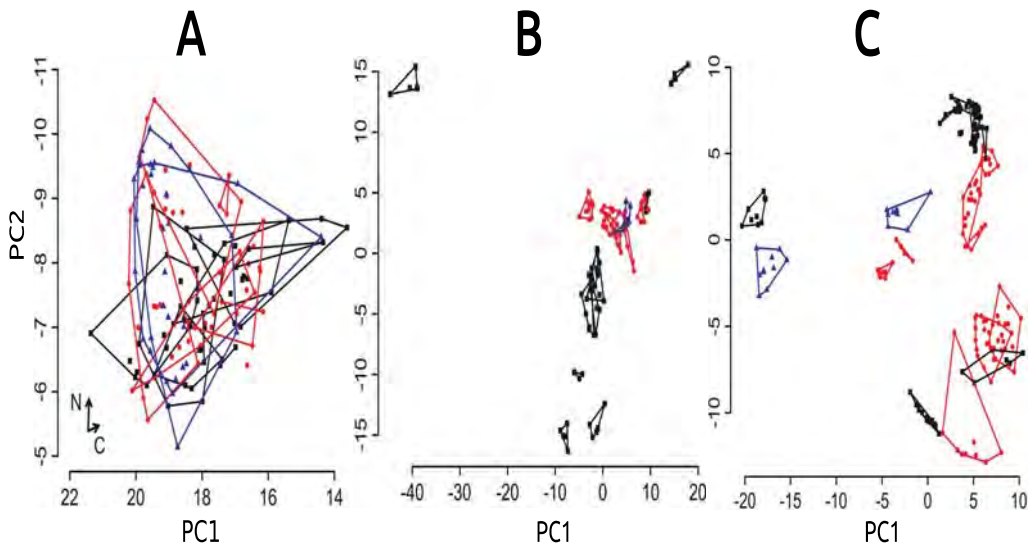
Original commentary
Correct answers
A *true*
Both the drawing and the description are referring to the group of *Plathelminthes* (*Tubularia*).
B *true*
Both the drawing and the description are referring to the group of *Nematoda*.
C *true*
Both the drawing and the description are referring to the group of *Tunicata* (*Chordata*)
D *false*
The drawing shows a representative of the group of *Cnidaria* (*Hydra*) with typical polyps, whereas the description refers to a typical representative of the group of *Echinodermata*.

Own commentary

下圖顯示幾種象鼻魚科（Mormyroidea）的共域魚種之親緣關係。該類群能發出天敵無法偵測到的微弱電流信號來進行溝通，且此溝通信號的傳遞不受環境因素影響。



每一個魚種選擇數隻個體進行測定，測量的項目包括營養階層（A）、身體形狀（B）、電流信號的波形及頻率（C）。下圖為前述3種測量項目之主成分分析(principal components analysis)圖，分別顯示各魚種所有個體的測量值在主成分空間的分布，且同種的所有個體皆涵蓋在一個多邊形內。下圖中的顏色即代表上圖親緣關係位置。主成分分析是一種利用變換軸的方式，來找出最大變異性的關聯之統計方法。



請指出下列各敘述正確或錯誤。

A. 這些魚種間，親緣關係的距離對於說明兩分類群間的溝通系統之分化情形，是很有用的資訊。

B. 剛分化成姊妹種的種化現象，很可能來自性擇對溝通系統的影響，而非來自天擇中的生態差異。

C. 在各分類群間的形態變異，與紅色與藍色支系開始分化時的棲地類型增加是一致的。

D. 這些魚種的電流信號的波形或頻率，強烈受限於其形態上的得失(trade-offs)。

A. False **B.** True **C.** False **D.** False

Original commentary

Correct answers

A *false*

Recently evolved sister species are as different or even more different in their communication signals than phylogenetically distinct pairs.

B *true*

Currently diverged sister species are very distinct in their communication signals but show only limited differences in trophic ecology and morphology. Information (no predator with receptors able to track EOD's, no effect of typic ecological parameters like water turbidity and pH on communication system) given in the text make ecological driven effects responsible for the pronounced differences in signals very unlikely.

C *false*

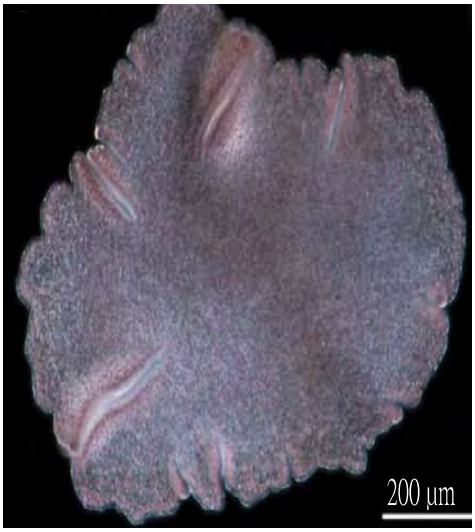
Morphospace is mainly determined by phylogenetically very distinct taxa and therefore not created by recent changes of habitats. Recently evolved taxa do differ only marginally in body shape.

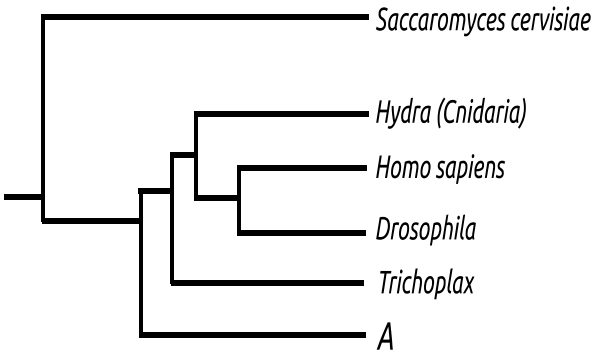
D *false*

There is no obvious correlation between body shape and electric signals of *Mormyridae*. In addition, morphologically very similar species differ heavily in their communication signals.

Own commentary

絲盤蟲（*Trichoplax adhaerens*）是扁盤動物門（*Placozoa*）唯一所知的動物。牠的外觀呈扁碟狀，是只由極少數的不同類型細胞所組成之極簡單構造，不具神經、感覺細胞及肌肉細胞。下圖是電子顯微鏡下的絲盤蟲影像；另有一根據分子資訊而得的枝狀圖，其顯示絲盤蟲與其相關物種間的親緣關係。





請指出下列各敘述是正確或錯誤。

A. *Drosophila*與*Trichoplax*的關係，比人類跟*Trichoplax*的關係近。

B. 枝狀圖內所列的分類群A，較可能為海綿（*Porifera*），而不是蝸牛（*Mollusca*）。

C. 絲盤蟲沒有體腔，也沒有管狀消化道系統。

D. 絲盤蟲很可能是兩側對稱（指動物具有明顯的背側及腹側、前方及後方）的代表。

A. False **B.** True **C.** True **D.** False

Original commentary

Correct answers

A *false*

As *Placozoa* are a sister group of all *Eumetazoa*, they are equally related to both humans and *Drosophila*.

B *true*

Taxa A has a more basal position than *Cnidaria*. *Porifera* are known to be the most basal group of metazoa, whereas *Mollusca* are representatives of bilateria and therefore in the same group as humans or *Drosophila* are.

C *true*

Coelom and gastric tube are traits of higher *Metazoa*. *Cnidaria* do not yet have those organs, and *Placozoa* have even a more basal position than *Cnidaria*. Moreover, these organs would demand for more distinct cell types than *Placozoa* has.

D *false*

Placozoa have a more basal position than *Cnidaria*, which is a group of organisms that do not yet belong to *Bilateria*.

References

Srivastava, Nature (2008)

Own commentary

哺乳動物中有些物種雄性與雌性之體型差別很大，但也有些物種雌雄個體的體型無差異。此種性別上的差異，經常可由物種的生態及求偶系統來解釋。

請指出下列各敘述正確或錯誤。雄性顯著大於雌性個體的情況，會出現在.....

A. ...一種非常小的羚羊（<5 kg），雌雄共同防衛一個小區域（<10公頃），其內有豐富的食物資源、水及棲所。

B. ...一種海豹，已知雄性會在離岸水域中進行長距離的移動來覓取散布在各處的食物，及與任何牠所遇到的發情雌性個體交配。

C. ...一種羚羊，雄性個體在乾季會聚集在湖畔的沙灘邊，每隻個體會積極地防禦一塊牠所佔有的20 m ^{2}區域。

D. ...一種小型的食肉動物（體長約20 cm），雌雄混居成群，居住於天敵環伺的環境中。子代極端依賴雙親的照顧，雄性個體以具有超大睪丸聞名。

A. False **B.** False **C.** True **D.** False

Original commentary

Correct answers

A *false*

Both sexes defend the small territory as a full time job year-round against conspecifics, therefore selection pressures are the same for both sexes.

B *false*

This particular case of fission-fusion mating selects more for agile, fast travelling males and resource-rich females than for heavily built competitive males.

C *true*

This territory is evidently too small and of bad food quality to serve as home range. Male-male interaction is permanent and highly competitive, females choose under many males - selection to show good genes and heavy bodies.

D *false*

This species is social and group members have similar functions. Male-male competition is limited since cooperation is very important to limit own mortality and to increase survival rate of offspring. In this system it is likely that females mate with several partners that cause sperm competition.

References

Floyd, Journal of Mammology(1998)

Own commentary

在生態學上，常用2種不同方式來測量生物多樣性：alpha多樣性代表某一區的生物多樣性，beta多樣性代表棲地間的生物多樣性。Shannon　index是一種好用的alpha多樣性估算方式，其計算公式如下

$$H = -\sum_{i=1}^{S} p_i \cdot ln(p_i)$$

其中，加總（sum）包括在一棲地中的所有物種1至S；pi代表物種i 的相對豐富度。

下表顯示分布在溫帶生態系中原始與受干擾的4個區塊中的8個樹種（A到H），其成熟植株的豐富度。

區塊	情況	A	B	C	D	E	F	G	H
1	原始的	19	0	56	332	0	76	0	0
2	原始的	3	0	12	456	0	5	0	0
3	受干擾的	13	135	0	101	5	0	0	0
4	受干擾的	0	143	12	178	0	4	13	7

請指出下列各敘述正確或錯誤。

A. alpha多樣性在區塊1高於在區塊2。

B. 在此生態系中，干擾似乎增加了beta多樣性。

C. 物種B可能是一種先驅物種。

D. 在成熟植株存在時，物種D的小苗生長情形最好。

A. True　**B.** True　**C.** True　**D.** True

Original commentary

Correct answers

A *true*

While the number of species present is the same in both plots, their relative abundance is rather different in that species D dominates the system much more in plot 2 than plot 1, leading to a lower alpha diversity in plot 2.

B *true*

Beta diversity is much higher among plots 2 and 3 than plots 1 and 2. The students should be able to see this without calculating anything since exactly the same species are present in plots 1 and 2, but several species are restricted to either plot 3 or 4.

C *true*

Pioneer species are the first species to colonize a damaged / disturbed habitat. While other species are also present uniquely in either plots 3 and 4, none of them is present in both nor in that number, suggesting that species B.

D *true*

This is a typical characteristics of a species capable of dominating tree ecosystems, as species D is capable of doing in the pristine state. Seedling of other trees only get a chance after disturbance through external factors.

Own commentary