25th INTERNATIONAL BIOLOGY OLYMPIAD

5 – 13 July, 2014

INDONESIA

THEORETICAL TEST

PART A

QUESTION PAPER

Total points: **48**

Duration: 180 minutes

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

INSTRUCTIONS:

1. **Fill in your STUDENT ID and your country in the Answer Sheet.**
2. **Each question contains four statements which you must indicate as True or False.**
   - **If you answer correctly to all four statements, you will receive 1 point.**
   - **If you answer correctly to only three statements, you will receive 0.6 point.**
   - **If you answer correctly to only two statements, you will receive 0.2 point.**
   - **If there is only one statement with the correct answer, you will not receive any points (0).**
   - **There is no minus system.**

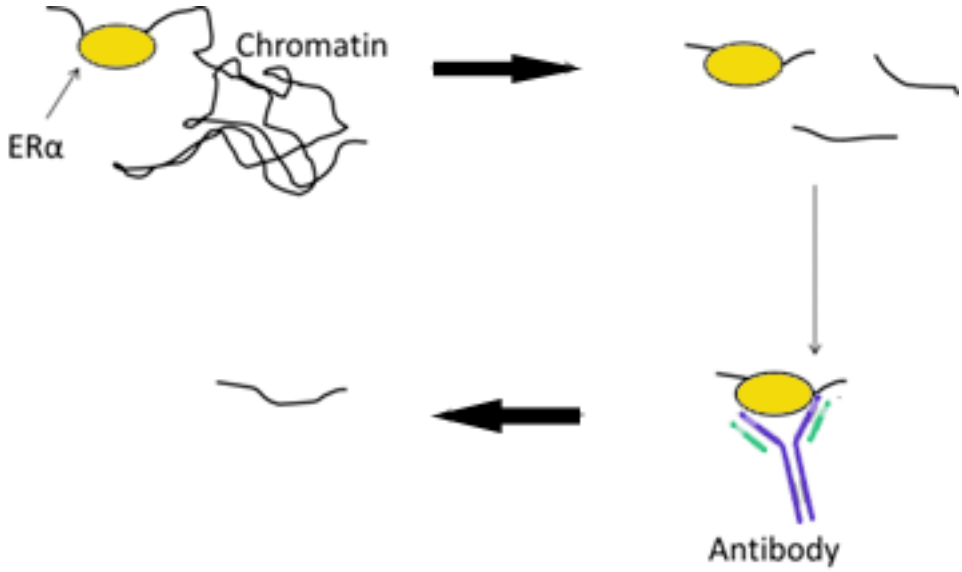
3. **Tick (√) the correct answer in your Answer Sheet using a pen (in ink). If you need to change an answer, you should strikethrough the wrong answer and write in the new one (see the example below). In the table, T=True, F=False.**

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

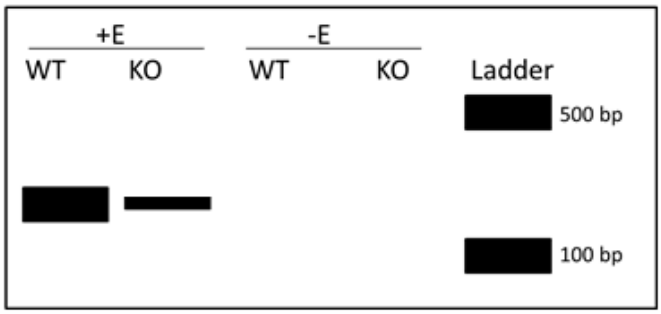
4. **You may use a calculator in your exam.**
5. **GOOD LUCK.**

CELL AND MOLECULAR BIOLOGY

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



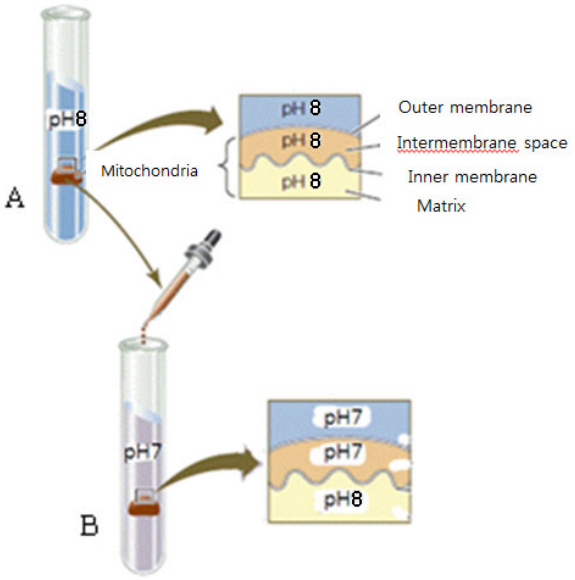
After releasing Erα, the DNA fragments are isolated and amplified semiquantitatively with primers for the promoter region of a gene *a*, known to be upregulated by estrogen. Electrophoresis results are shown below.



Indicate if each of the following statements is true or false.
This experiment suggests that protein X affects the binding of ERα **to...:**

A. **...**the promoters of all gene regulated by ERα.
B. ...the promoter of gene *a*.
C. ...all its possible protein partners
D. ...the protein product of gene *a* .

2. An experiment was performed to study the relation between H^+ concentration and ATP synthesis in mitochondria. Mitochondria were isolated from the cell and placed into a pH 8 media (test tube A), then immediately transferred into a pH 7 media (test tube B). Later, ATP synthesis was verified in test tube B.



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

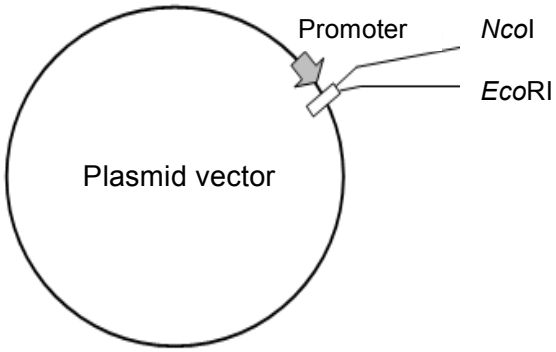
A. In tube B, ATP was synthesized in the matrix-facing side of the inner mitochondrial membrane..

B. In tube B, ATP was synthesized without the help of electron transport system.

C. If mitochondria in tube A was transferred into a pH 9 media, ATP synthesis will occur in the intermembrane space of mitochondria.

D. If mitochondria remains in tube A but glucose is added, there will be ATP synthesis.

3. You plan to insert the gene *PhoQ* from *Tobibacterium* sp into a plasmid vector containing an artificial promotor followed by a restriction site for *Nco*I (CCATGG) and a restriction site for *Eco*RI (GAATTC).



To conduct this experiment you are required to design forward (the sense strand) and reverse (antisense strand) primers. Part of the 561 nucleotide long coding sequence is shown below.

5'-ATGCGACAGTTCATCACCGA... _____....GCGGGACCGGACTGGGGTAA-3'

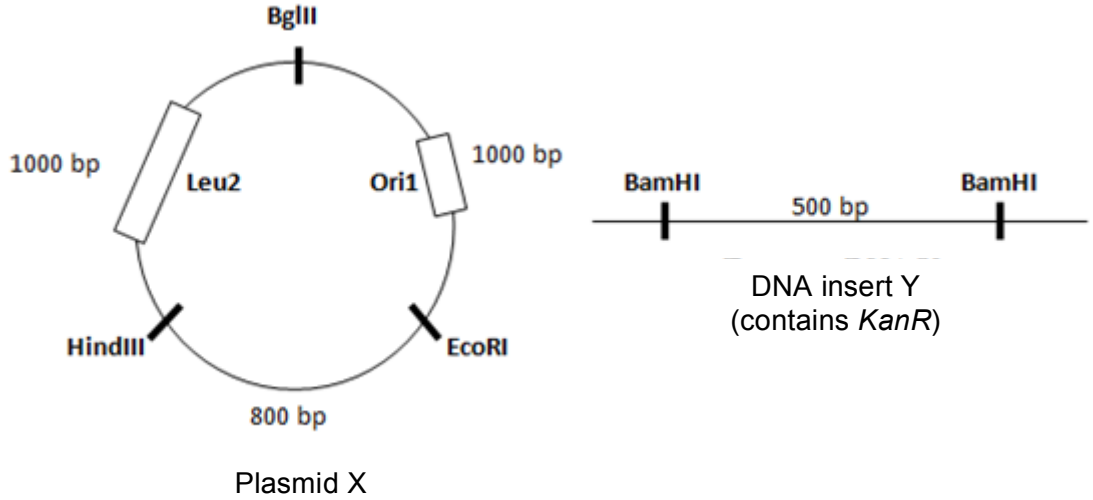
Indicate if each of the following statements is true or false.

A. The use of two different restriction sites avoids wrong orientation of the inserted fragment
B. A possible forward primer for amplification and insertion of *PhoQ* gene will have the following sequence: 5' – GATCCCATGGATGCGACAGTTC – 3'
C. A possible reverse primer for amplification and insertion of *PhoQ* gene will have the following sequence: 5' – GATCGAATTCAATGGGGTCAGGCC – 3'
D. The final gene product will consist of at least 189 amino acids.

4. Indicate if each of the following statements about posttranslational modification of eukaryotic proteins is true or false.

A. Disulfide bond formation on a protein occur in the endoplasmic reticulum.
B. Glycoproteins may be found in viruses that infect human.
C. Oligosaccharide group addition to a protein may occur in both Golgi apparatus and endoplasmic reticulum.
D. Palmitoylation of a protein can change its intracellular localization .

5. An experiment was performed to create a recombinant DNA between plasmid X and DNA insert Y. Plasmid X contains *leu2* gene for leucine biosynthesis while DNA fragment Y contains kanamycin-resistance gene *KanR*. The diagram for X and Y are shown below.

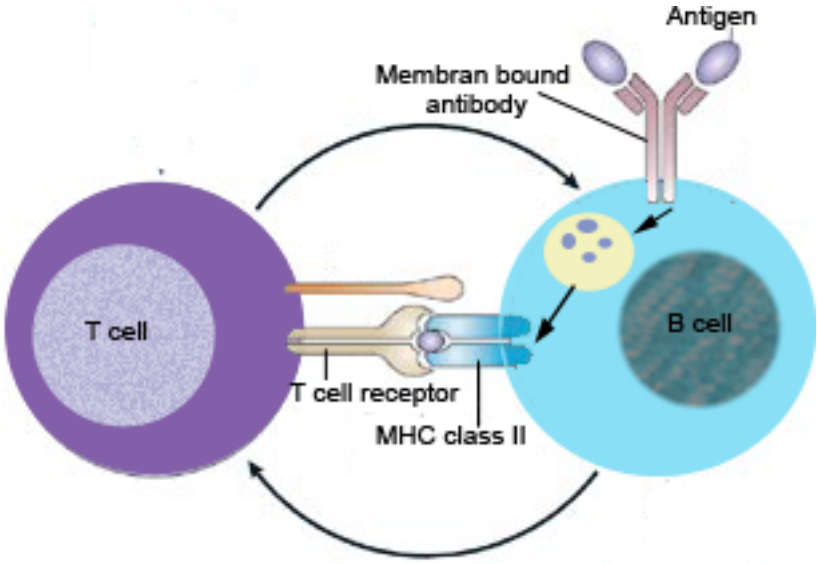


Plasmid X and DNA insert Y were added to a reaction mix containing restriction enzymes *Bgl*II (5'-A*GATCT-3'), *Bam*HI (5'-G*GATCC-3'), and the resulting fragments then transferred to a new reaction mix containing ligase. The resulting DNA was transformed into bacterial culture Z which is sensitive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

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

A. Cutting the plasmid after insertion of Y using *Eco*RI will result in single 2800 bp DNA fragment on the electrophoresis gel.
B. If in the reaction mix HindIII (5'-A*AGCTT-3') was used instead of BglII, the transformed bacteria are capable of growing on a medium containing Kanamycin.
C. The 500 bp insert DNA can be removed from the recombinant plasmid by using restriction enzyme *Bgl*II.
D. The migration pattern of the recombinant plasmid on an electrophoresis gel is different when it is treated with EcoRI or BamHI.

6. Consider a protein containing four epitopes: an oligosacharide (O) and three peptides (P1, P2, P3). The following figure illustrates the interaction between B and T cells.



(modified from Edwards & Cambridge, 2006)

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

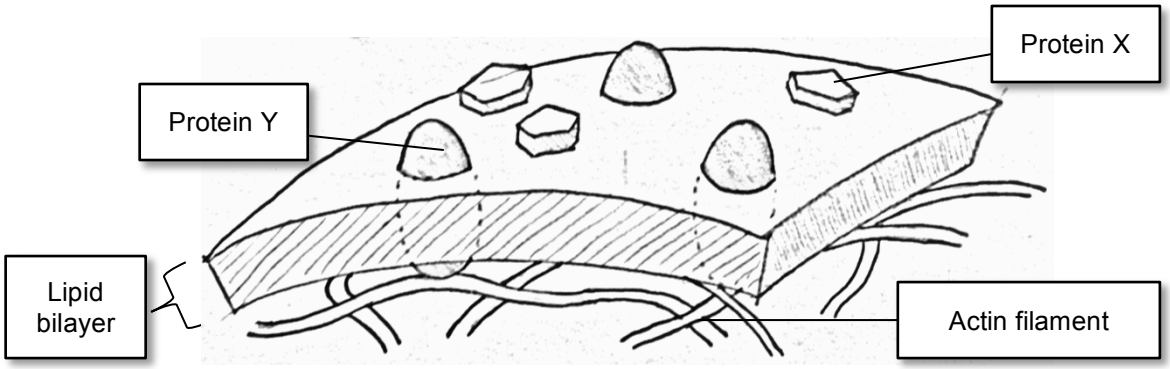
A. Antibody production for epitope O by B cells may occur only when the O epitope is presented by B cells to T cells.

B. All of the four epitopes could be recognized by the population of B cells.

C. A single B cell produces antibodies recognizing only one of the four epitopes.

D. Via MHC II proteins, a single B cell can present diverse protein fragments to the T cells.

7. The diagram below shows the distribution of proteins X and Y on a small area on outer surface of cell membrane.



Protein Y is bound to immobile actin filaments on the inner surface of cell membrane. There is no similar domain found in protein X. An experiment is conducted to show the mobility of Protein X and Y in cell membranes. Those proteins are labeled by different fluorescent dye (red for protein X and green for protein Y with only one fluorescent molecule for each protein) and a small region of the surface is irradiated to bleach the dye molecules, and the intensity of fluorescence is followed over time.

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

A. After long term irradiation, the cell will only show green fluorescence.
B. If the short time irradiation is conducted, the fluorescence of both colors will recover to their initial state in the bleached region.
C. If the actin cytoskeleton was disrupted with cytochalasin, the fluorescence of the cell is bleached completely after long term irradiation.
D. Cooling down the cells to $20^{o}C$ will accelerate the bleaching of the red fluorescence on the cell surface.

8. Six isolates of anaerobic soil bacteria (A-F) were analyzed to study their role in the nitrogen cycle. Each isolates were grown on four different broths: (1) Peptone (short polypeptides), (2) Ammonium, (3) Nitrate, and (4) Nitrite. Only the nitrate broth contained carbohydrate as a carbon source. After 7 days of incubation, the bacterial culture were biochemically tested to observe changes in the medium and the results are shown below:

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

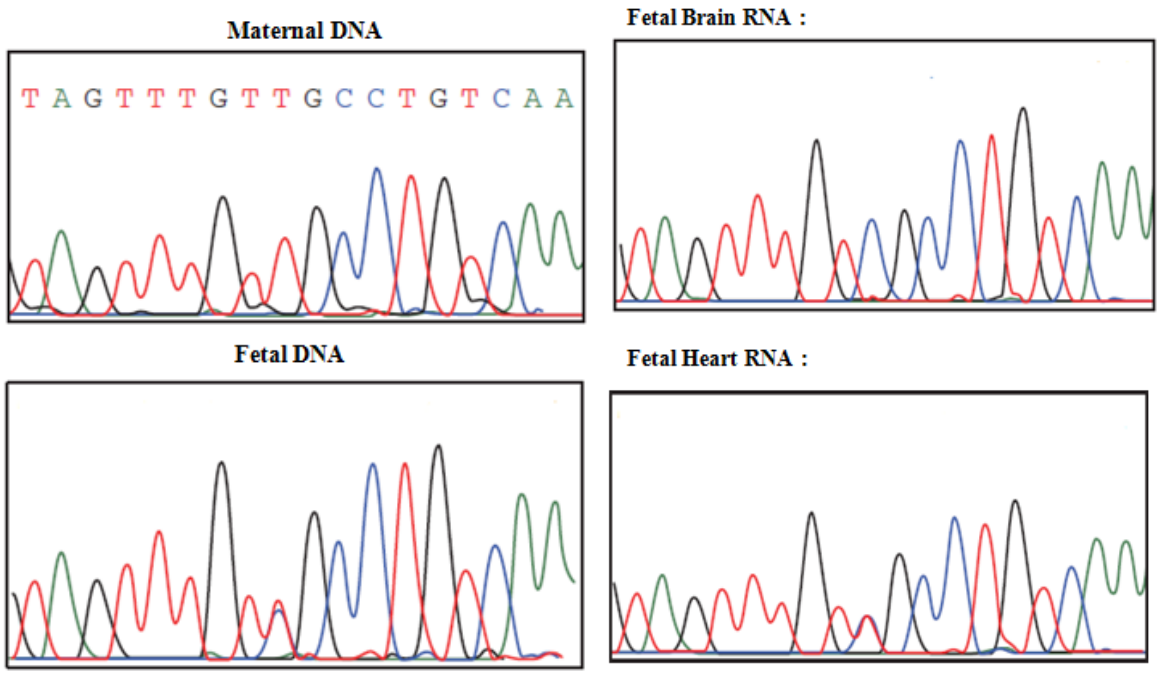
\+ = bacterial growth was observed
\- = bacterial growth was not observed

pH+ = Increased pH of the medium
NO_2^- = Positive result of nitrite test
NO_3^- = Positive result of nitrate test
Gas = Gas production in the medium (detected by using durham tube)

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

A. Isolate C belongs to the group of nitrifying bacteria (oxidize ammonium to nitrite then nitrate)
B. Isolates B and D are denitrifying bacteria (reduce nitrate to molecular nitrogen).
C. Isolates C and E are chemoheterothropic bacteria.
D. Isolates A and F are able to use nitrate as an oxydizer to produce energy.

9. The figure below shows part of the DNA sequence of the autosomal gene X from a mother and her child (fetal). The mRNA was obtained from fetal heart and brain. Before sequencing, mRNA was converted to cDNA and amplified by PCR (see figure below).



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

A. The father must be heterozygous at this locus.
B. In the fetal brain, the gene X was expressed from the maternal chromosome.
C. In the fetal heart, the gene X was expressed from both parental chromosomes.
D. This result suggests tissue specific splicing of gene X.

10. There are several mechanisms in eukaryotic cells to generate a diversity of proteins from a single gene. Alternative splicing of the Down Syndrome Cell Adhesion Molecule (DSCAM) gene, for instance, may result in 38,000 different protein products. , VDJ recombination in the formation of mouse immunoglobulin may result in 144,000 different heavy-chain proteins.

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

A. Protein diversity on the immunoglobulin heavy-chain is generated at the RNA level while on the DSCAM proteins is generated at the DNA level.

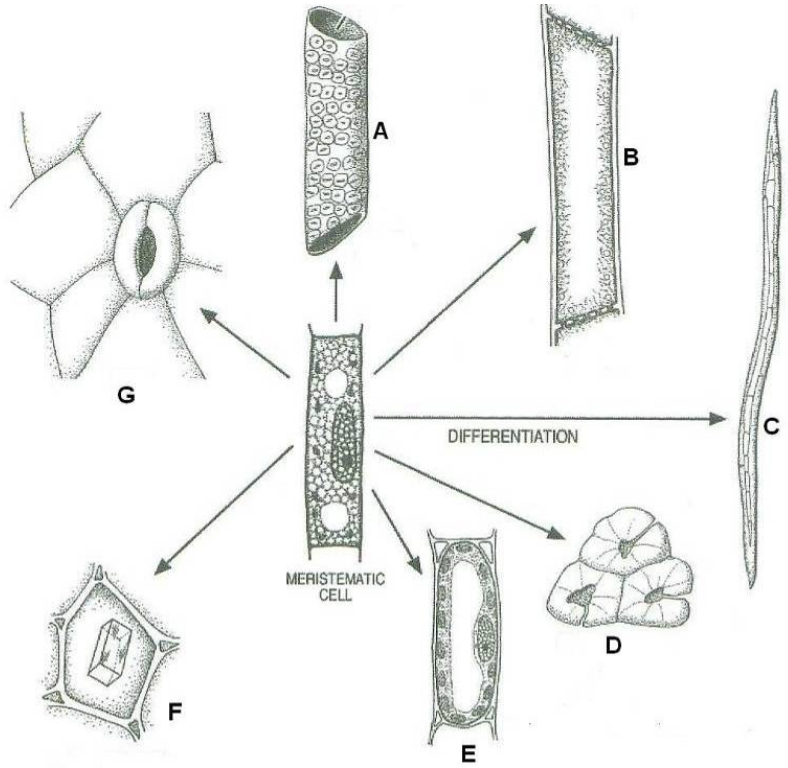
B. Only one type of heavy-chain protein is produced by a plasma cell, while there are often more than one protein types produced by a single cell in which the DSCAM gene is actively expressed.

C. Disorder in the VDJ recombination maybe related to immunodefficiency diseases.

D. Although alternative splicing of DSCAM results in various mRNA sequences, these are all of the same length.

PLANT ANATOMY AND PHYSIOLOGY

11. The following diagram shows representative end products of plant cell differentiation from a meristematic cell.



Indicate if each the following statements is true or false.

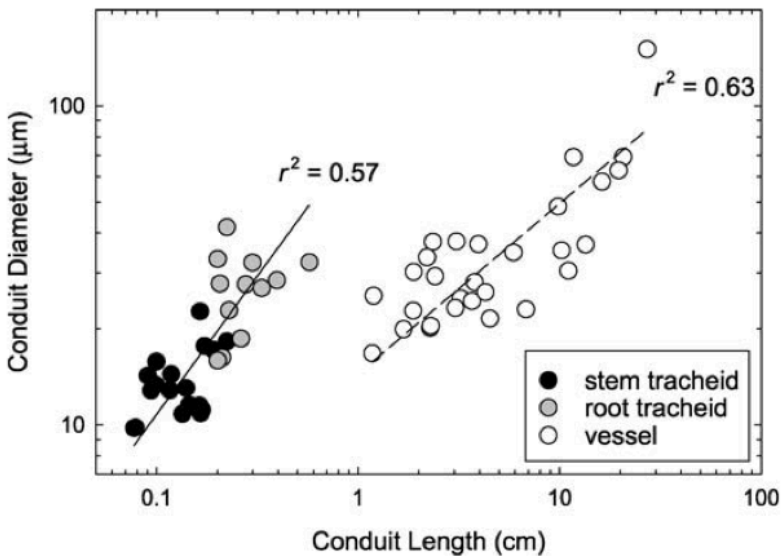
A. B, F, and G are living cells.
B. Differentiation of a meristematic cell into A, B, C and D requires lignin biosynthesis.
C. Cell E can differentiate into Cell D.
D. Cell B can dedifferentiate with particular hormone treatment.

12. Plant xylem transport can be understood only by invoking biomechanics. Conduit diameter and length have major consequences for conducting efficiency, which agree with Hagen–Poiseuille formula as follows:

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

whereas:
r = radius
Ψp = pressure potential
L = length

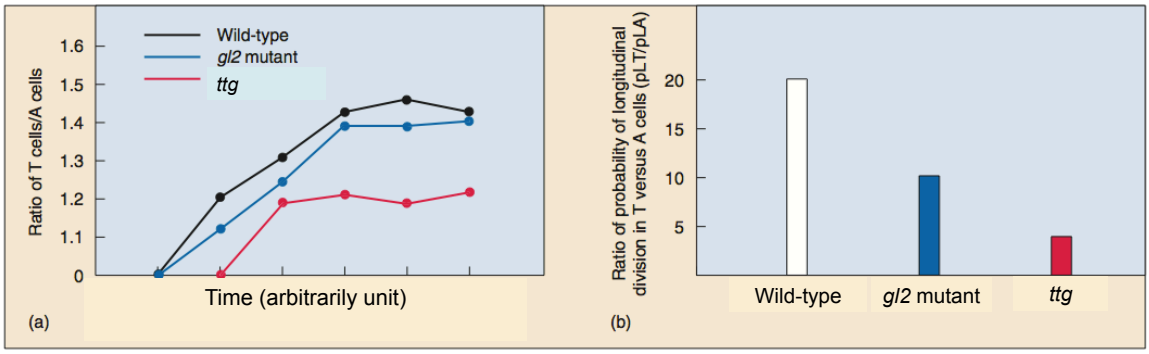
The figure shows the range of conduit diameter and length of tracheid in gymnosperms and vessels in angiosperms.



Indicate if each the following statements is true or false.

A. The largest difference between vessels and tracheids is in the length, rather than diameter.
B. Movement rate in vessels is approximately equal to that in stem tracheids
C. Root tracheids can be wider than stem tracheids because they do not need as much reinforcement to hold up the foliage and to resist bending of the axis.
D. The bigger the diameter of vessels, the smaller its frictional resistance.

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



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

A. *TTG* controls epidermal cell fate specification.

B. *gl2* mutant retains the atrichoblast fate and the A cells remains as undifferentiated epidermal cells.

C. The longitudinal division in root epidermis is more likely to occur in A cell than T cell.

D. Ratio of longitudinal cell division in T versus A is much reduced in the *ttg* mutant, suggesting that it is under the control of TTG.

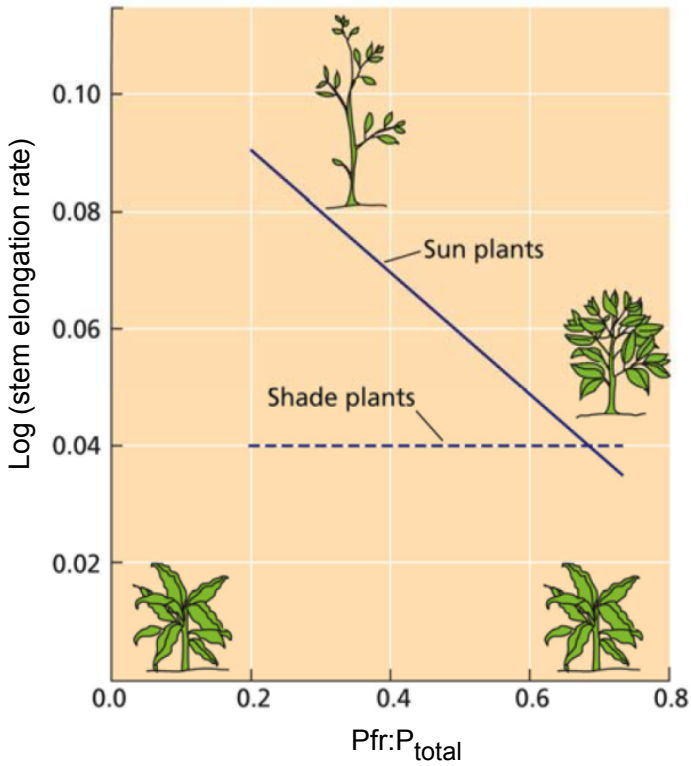
14. The following table shows the adaptation of Plant A and Plant B in response to different conditions.

	Plant A	Plant B
Compensation point of CO_2 ($\mu L\ CO_2\ L^{-1}$)	20 – 100	0 – 5
Quantum yield as function of temperature	Declining	Steady

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

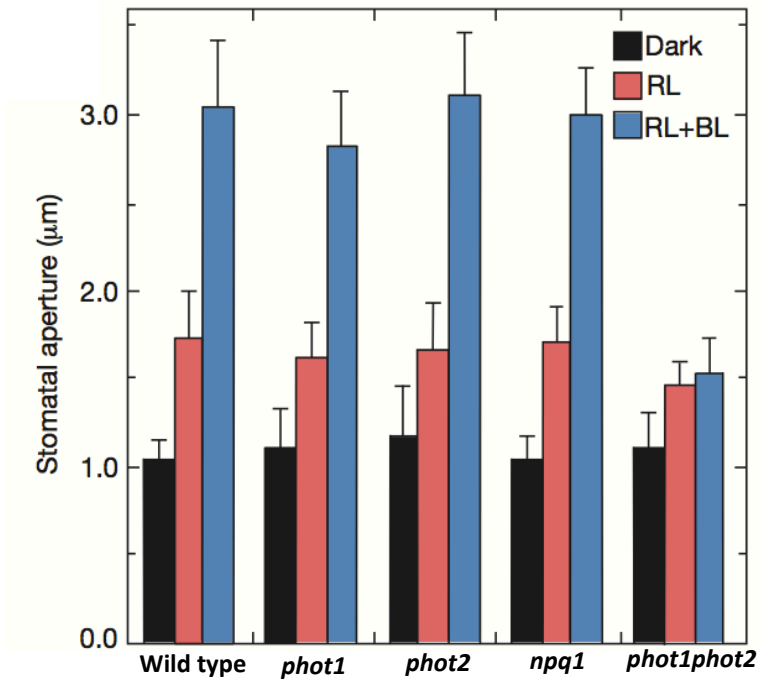
A. Plant B is C_3.
B. Plant A is more competitive in limited water availability and high temperature environment.
C. If atmospheric CO_2 concentration doubles, Plant A is likely to be more competitive.
D. If atmospheric CO_2 concentration doubles, photorespiration in Plant A is likely to be reduced.

15. This figure shows the role of phytochrome in a far red state (P_{fr}) in sun and shade plants. Based on phytochrome-mediated photomorphogenesis, **indicate if each of the following statements is true or false**.



A. Treatment with red light does not affect stem elongation rate in shade plants.
B. Treatment with far-red light decreases stem elongation rate in sun plants.
C. If sun plants are treated in the conditions of sun and shade, elongation rate of plant placed in the sun is higher than one in the shade.
D. Natural forest clearings would give equal opportunity for sun and shade plants to recolonize.

16. An experiment was conducted to study the effect of darkness, red light (RL) and combination of red and blue light (RL+BL) on stomatal aperture. Mutant *phot1* and *phot2* do not express phototropin, while mutant *npq* does not accumulate zeaxanthin. Stomatal apertures less than 1.25 µm are considered closed, while apertures greater than 2.0 µm are considered opened more widely.



Indicate if each of the following statements is true or false

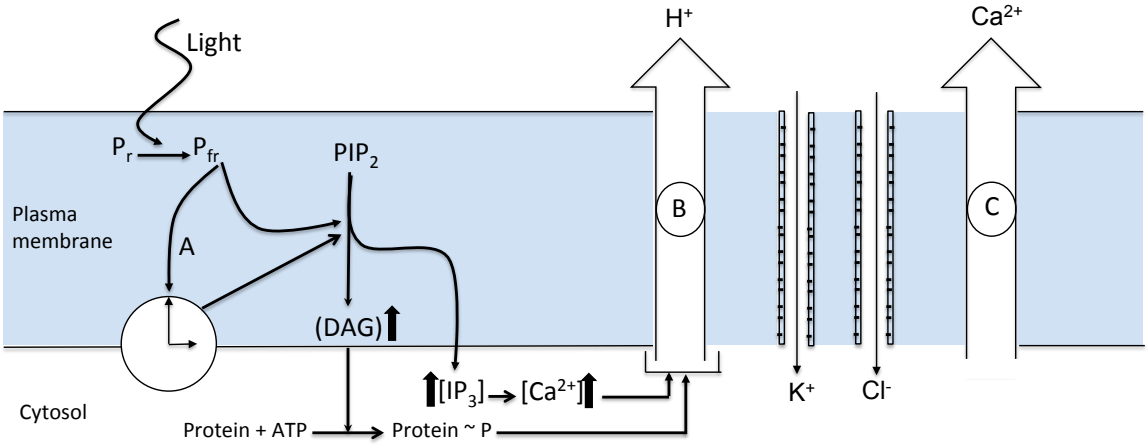
A. Stomatal apertures are closed if treated in darkness and slightly opened in red light illumination.

B. Blue light significantly increases stomatal aperture size in all tested plants.

C. It is likely that the blue light receptor is active in mutant *npq*.

D. The fact that single *phot* mutants respond to blue light and double mutants do not, suggests that *phot1* and *phot2* act redundantly as blue light receptors to mediate stomatal apertures.

17. Nyctinasty is a sleep movement of leaves. The diagram shows a model of the interaction of phytochrome, biological clock, and IP_3 on nyctinasty. Arrow A stands for activation and Arrows B & C stand for active transport.



Indicate if each of the following statements is true or false

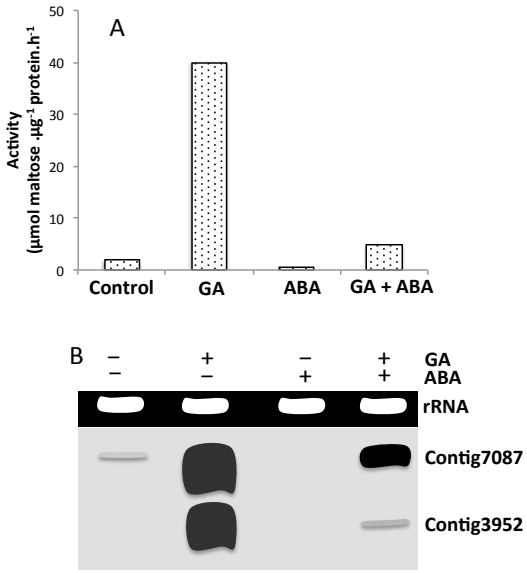
A. Light, mediated by phytochrome and modulated by endogenous clock, increases the level of IP_3 and DAG (diacylglycerol).

B. IP_3 increases release of free calcium and thus stimulate proton extrusion.

C. The changes in electrochemical gradient energizes the uptake of K^+, subsequently reduces cell swelling, and thus causes nyctinastic movement.

D. An active transport (arrow C) extrudes Ca^{2+} as an aid to restoring Ca^{2+} homeostasis.

18. The effect of gibberellic acid (GA_3) and abscisic acid (ABA) on isolated barley aleurons was measured using α-amylase activity and transcriptional responses. Aleurons were treated with 1 μmol/L GA_3 and 50 μmol/L ABA for 15 hours. The activity of α-amylase was measured using maltose as a standard (Figure A). The accumulation of mRNA encoding high pI amylase (Contig3952) and low pI amylase (Contig7087) is shown in Figure B.



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

A. The activity of α-amylase is reduced more than 80% on GA3+ABA-treatment compared to GA3 treatment only.

B. GA3 suppresses both high and low pI amylase gene expression.

C. ABA suppresses the effect of GA3.

D. The GA3 + ABA treatment synergistically induced expression of genes encoding a high pI amylase.

ANIMAL ANATOMY AND PHYSIOLOGY

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

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

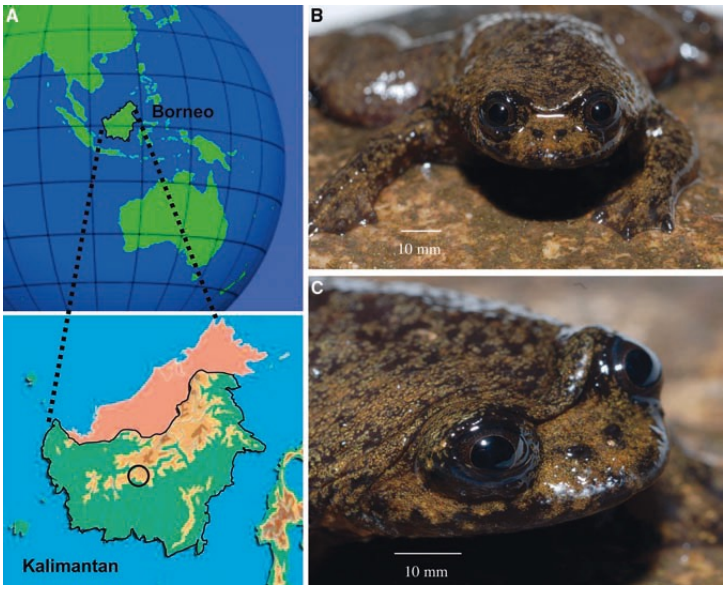
A. A 70 kg lean man drinks 0.5 L beer with an alcohol content of 5% (weight/volume). One hour later his BAL is greater than 0.08 gram alcohol per 100 mL blood.

B. His identical twin drinks 0.2 L of vodka with an alcohol content of 40% instead of beer, and an hour later, his BAL exceeding 0.08 gram alcohol per 100 mL blood.

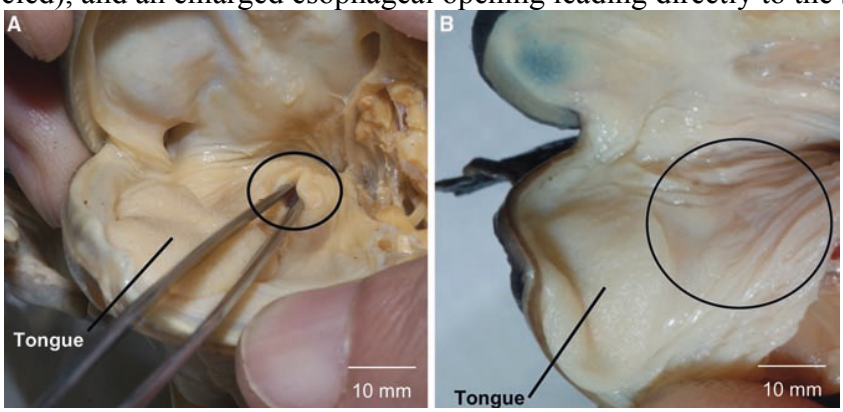
C. The time it takes for the 70 kg person to eliminate a BAL at 0.08 gram alcohol in 100 mL blood is more than 5 hours.

D. A 70 kg breast-feeding woman drinks 0.15 L of wine with an alcohol content of 12% (weight/volume). She then feeds her 5.0 kg baby 100 mL breast milk. 55% of the weight of a baby with normal body weight is water. The BAL of the baby will exceed 0.08 gram ethanol per 100 mL blood.

20. *Barbuourula kalimantanensis,* an indigenous flat frog was found in Kalimantan, Indonesia in 2008 (A). The morphology of the frog (B, C) is shown below.



Comparison of (A) Typical frog mouth and pharynx (*Rana catesbeiana*), showing glottis (circled), tongue, and esophageal opening, and (B) *Barbourula kalimantanensis* showing tongue, lack of glottis (circled), and an enlarged esophageal opening leading directly to the stomach.



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

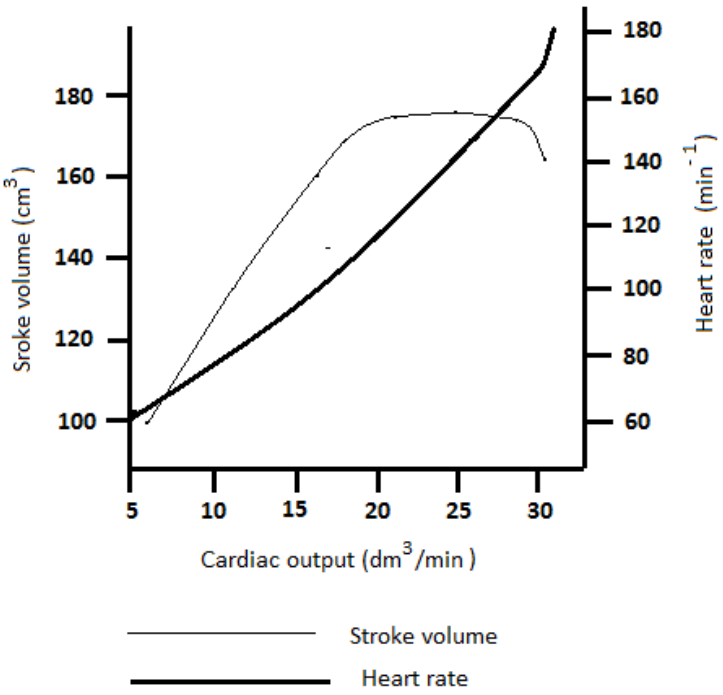
A. The frog is more likely to have stereoscopic vission as compared to ponds frog (*Rana sp*).

B. Skin of this exceptionally flat frog is the only respiratory organ in and gas exchange occurs in the blood vessels located on the skin surface.

C. *Barbourula kalimantanensis* is expected to have a low metabolic rate.

D. *Barbourula kalimantanensis* most probably lives in fast flowing cold water, often close to waterfalls.

21. (Deleted) ~~The diagram shows pulse rate, stroke volume and cardiac output in a healthy IBO student.~~



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

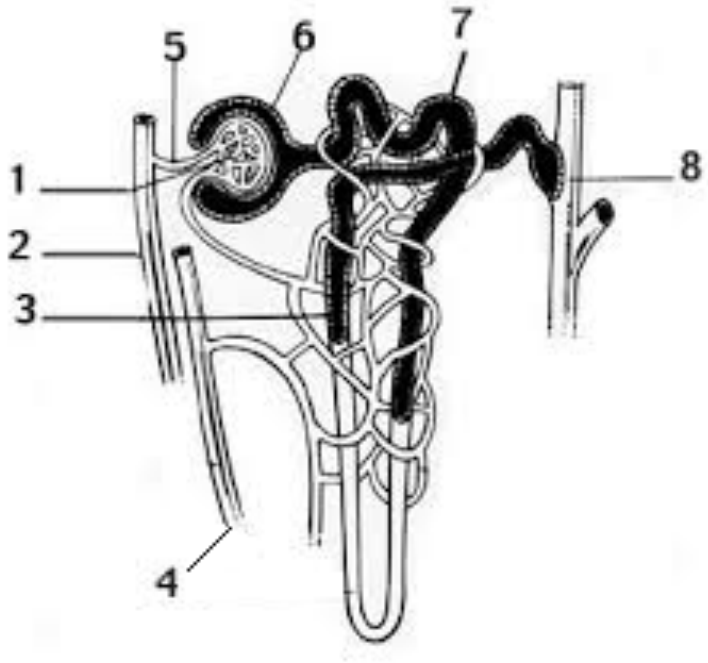
~~A. The meeting point between stroke volume and the pulse rate are equal at a cardiac output of 25 dm^3/min.~~

~~B. The most reliable estimate of the general fitness is obtained by measuring a work pulse within the interval of 120 – 150 min^{-1}.~~

~~C. At high work intensity, an increase in cardiac stroke volume accounts for the increase in cardiac output.~~

~~D. At high work intensity, inadequate filling of the heart during diastole limits the cardiac output.~~

22. The process of urine formation takes place in the nephron.



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

A. Transport from 5 to 6 in the figure, is dependent on blood pressure.
B. The most important process in the structure labelled 7 in the figure is ATP-dependent directly or indirectly.
C. The concentration of HCO_3^- is higher in structure 2 than in 4.
D. The water reabsorption in the structure labeled 8 is driven by a concentration gradient.

23. Growth hormone (GH) is important for humans that raises the concentration of glucose and free fatty acid and promotes postnatal growth through direct and indirect effects on many tissues.

Indicate if each of the following statements is true or false

A. Hyperglycaemia can stimulate the release of GH secretion.
B. Exercising will increase GH production which in turn increases lipolysis.
C. The effects of GH are attenuated by circulating androgen (eg testosterone) at puberty.
D. Administration of GH will stimulate bone mass and muscle growth enhancement.

24. IBO2014 participants are from different continents around the world. Some students experience 'jet lag' due to crossing many time zones to reach Bali. These individuals feel fatigue as the body's 'clock' need to be adjusted to the new environment. Circadian rhythms are regulated by the pineal gland which produces melatonin during the dark.

Indicate if each of the following statements is true or false

A. Generally, for the same distance, flight from west to east (for example, from Europe to Bali) causes worse jet lag than flying in the opposite direction.

B. Light affects circadian rhythms and helps to re-establish synchronization with the light-dark cycle.

C. Melatonin released in the morning can advance circadian rhythms, while melatonin released in the evening can delay circadian rhythms

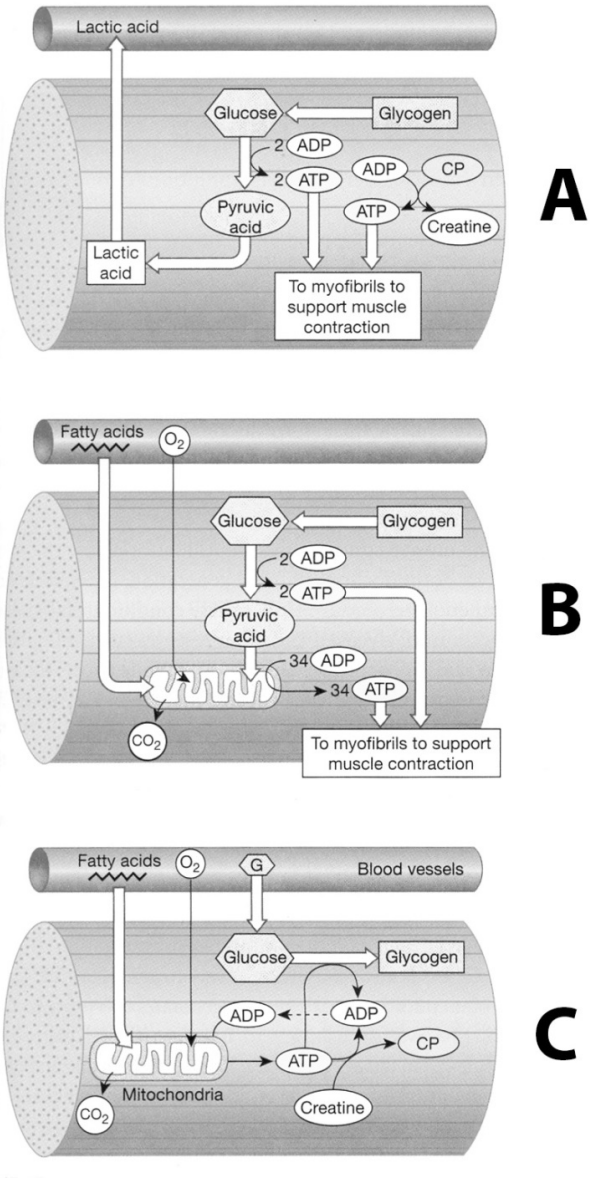
D. Melatonin pills, as possible treatment to avoid jet lag and readjustment with the local light-dark cycle should be taken before the sleep.

25. Tetrodotoxin (TTX), a very powerful toxin, produced by the local puffer fish (*Ferodoxon multistriatus*), selectively blocks voltage gated Na+ channels in the neuron. As a result, TTX causes paralysis and a loss of vagal regulation of the heart. The victim eventually dies from respiratory paralysis.

Indicate if each of the following statements is true or false

A. The pufferfish never gets poisoned by TTX. A possible explanation is that it has a mutated sodium ion channel to the resistant variant.
B. TTX also affects smooth muscle cells in the lungs and keep membrane potential of the smooth muscle cells in the resting state condition.
C. TTX is absorbed in gastrointestinal tract and therefore travel first to the lungs via hepatic vein and interfere with its function.
D. If injected, TTX poison will result in very elevated heart rate.

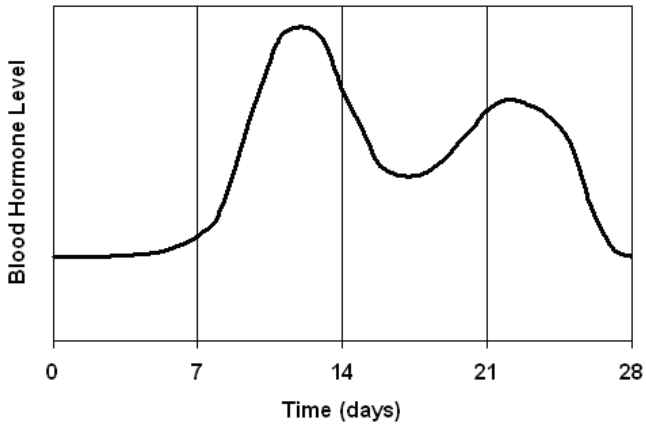
26. The figure shows the scheme of metabolism of a skeletal muscle in three physiological conditions. Identify which scheme of metabolisms corresponds to each of the functional states.



Indicate if each of the following statements is true or false

A. Rest state of the skeletal muscle is shown in figure C
B. Moderate activity of the skeletal muscle is shown in figure B
C. Metabolism of leg muscle fibers during 100m sprint is shown in figure A
D. Metabolism of leg muscle fibers of the trained marathon runner during the marathon competition is shown in figure B

27. Menstruation cycle involves several hormones. One of the hormones in the menstruation cycle has a fluctuation pattern as shown below :



Indicate if each of the following statements is true or false

A. The first peak in the hormone level triggers ovulation.
B. The physiological effect of the hormone is instantly mediated by cell surface receptors.
C. The peaks result from hormones produced by the oocytes.
D. If implantation occurs, plasma concentration of the hormone is maintained at high level.

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

A single estradiol injection greatly stimulates cell division in the uterus 16-18 hours later measured as in vitro[^{3}H] thymidine uptake in ovariectomized wildtype mice but not in ERKO alpha mice.

Vertebral bone density is reduce by about 10% in ERKO-α male mice compared to ovariectomized wildtype. Data is expressed as the percentage of total bone area that exists as compact bone (Figure B).

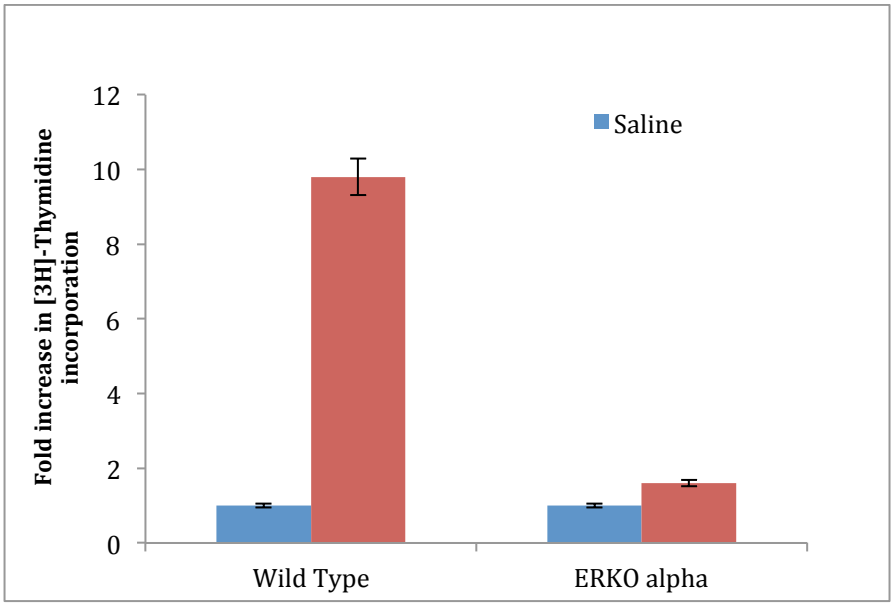


Figure A. Uterus of ovariectomized wild type and ERKO mice treated with estrogen

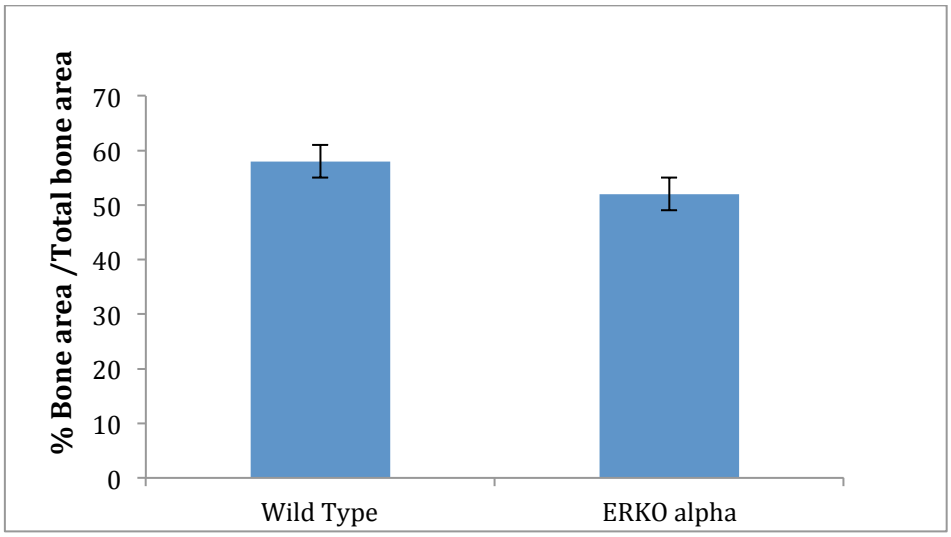


Figure B. Vertebral density of ovariectomized wild type and ERKO male mice

Indicate if each of the following statements is true or false

A. ERKO mice perform normal ovarian cycle as wild type mice
B. ERKO female and male mice bones become more vulnerable to be broken
C. Female ERKO mice are infertile
D. ERKO mice do not produce estrogen hormone

29. X-linked agammaglobulinemia (AGG) disease occurs mostly in boys. X-linked agammaglobulinemia patients have a non-functional bruton tyrosine kinase (BTK), a protein essential for the development and maturation of B cells. The concentrations of several immunoglobulins of a 5-year old boy with AGG were compared with standard normal conditions. .

	Patient values mg mL^{-1}	Standard values mg mL^{-1}
IgG	0.80	6-15
IgA	0	0.50-1.25
IgM	0.10	0.75-1.50
IgE	0	0.005

Indicate if each of the following statements is true or false.
AGG boys:
A. have larger tonsils and spleens than normal children.
B. are more vulnerable to infection by pathogens through the gastrointestinal tract.
C. do not show evidence of this condition in the first six months of life.
D. will not experience allergy to pollen.

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

~~Ratio~~	~~Body mass ratio~~	~~Ratio of O_2 consumption per kg per hour~~
~~A1/A2~~	~~2800~~	~~0.04~~
~~A3/A4~~	~~0.004~~	~~4.1~~

~~Based on the data, indicate if each of the following statements is true or false.~~
~~A. Animal A1 has less effective cardiopulmonary system than A3 and A4.~~
~~B. Animals A1 and A2 are most likely to be warm blooded animals (homeotherms) while A3 and A4 are cold blooded (octotherms).~~
~~C. Surface to volume ration of A4 is lower than that of A3.~~
~~D. Total oxygen consumption (V O_2Lt/h) of A3 will be greater than A4.~~

GENETICS AND EVOLUTION

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

Phenotype	**Percentage**
Normal (wild type)	20.5
Scarlet eyes	20.5
Vestigial wings	4.5
Black body	4.5
Scarlet eyes, black body	4.5
Vestigial wings, black body	20.5
Scarlet eyes, vestigial wings	4.5
Black body, scarlet eyes, vestigial wings	20.5

Indicate if each of the following statements is true or false

A. Crossing two F2 individuals with black bodies and with wild type phenotypes for the other genes results in flies of different wing types.
B. The loci *b* and *vg* are located less than 20 cM from each other.
C. Individuals heterozygous for *b* and *sc* but homozygous for *vg* produce gametes of four different genotypes in equal proportions.
D. When individuals heterozygous for *vg* and *sc* are crossed, 18.75% of the progeny will have vestigial wings.

32. In a mouse population, there are three different coat colors: Yellow (Y), Agouti (A) and Black (B). To understand their inheritance, the following crosses were conducted:

No	Crosses (Parental Phenotypes)	Ratio of Phenotypes
1	Y x Y	2Y : 1A
2	Y x Y	2Y : 1B
3	A x A	All A
4	A x A	3A : 1B
5	B x B	All B
6	A x B	All A
7	A x B	1A : 1B
8	Y (F1 from cross 1) x A (F1 from cross 3)	1Y : 1A
9	Y (F1 from cross 1) x B (F1 from cross 5)	1Y : 1A
10	Y (F1 from cross 2) x A (F1 from cross 3)	1Y : 1A

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

A. Coat color in mouse is coded by one gene with multiple alleles. The dominance of the alleles is agouti > yellow > black.

B. A ratio of 1Y:1B is expected among the progeny of a cross between a Y offspring of cross 2 and a B offspring of cross 5.

C. A ratio of 3Y:1A is expected among the progeny of a cross between Y offspring of crosses 1 and 2.

D. A ratio of 1A:2Y:1B is expected among the progeny of a cross between a Y offspring of cross 2 and an A offspring of cross 7.

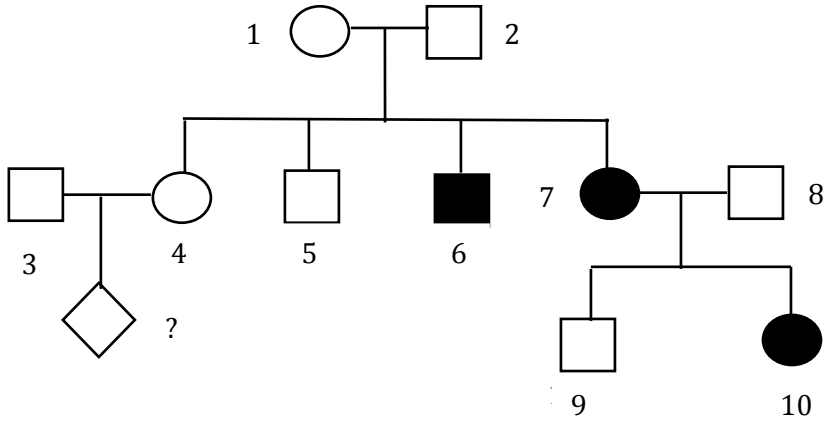
33. Consider a polygenic and additive inheritance of height in which a tall (uppercase letter) and a short (lowercase letter) allele segregate at each implicated gene and all tall alleles increase height by the same amount. In a species with two implicated genes, for instance, individuals with genotypes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

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

Indicate if each of the following statements is true or false

A. Three genes are involved in determining the height of the plants.
B. Six different phenotypes was observed in F2.
C. There are seven possible genotypes for plants with a height of 21 cm.
D. In F2, the number of 11 cm plants was similar to the number of 26 cm plants

34. The pedigree of a family is shown below in which some members (shown in black) are affected by a genetic disease with a prevalence of 9% in the population. The phenotype of the individual marked with ? is unknown.



Indicate if each of the following statements is true or false

A. The disease is most likely caused by autosomal recessive allele.
B. Individual 5 is heterozygous with a probability of 50%.
C. Under the assumption that the disease-causing allele is in Hardy-Weinberg equilibrium, individual 3 is heterozygous with a probability of 46%.
D. If affected individuals had a reduced fertility, the disease-causing allele would be eliminated from a population.

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

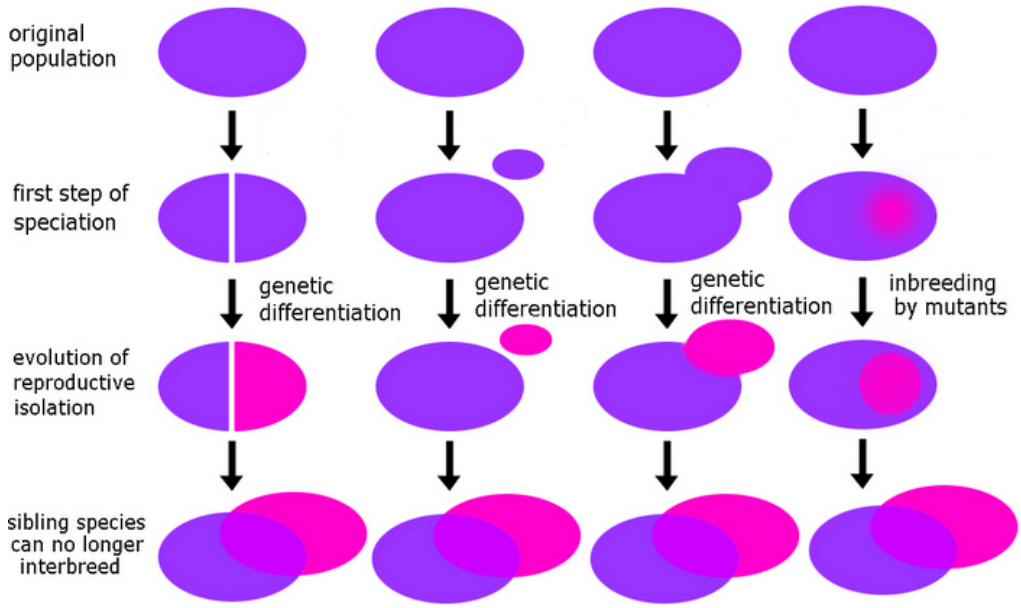
In an experiment, wild type *Neurospora* were crossed with two mutant strains *poky* and *cyt* showing slow growth due to mitochondria malfunction. The growth phenotype of 400 offspring per cross is shown in the table below.

First Parent	**Second Parent**	**Frequency of growth phenotype**	
		wild type	***slow***
cyt	*wt*	197	203
wt	*cyt*	209	191
poky	*wt*	0	400
wt	*poky*	400	0

Indicate if each of the following statements is true or false

A. *poky* mutation is a mutation located on the gene in nuclear DNA.
B. *cyt* mutation is a mutation located on the gene in mitochondrial DNA.
C. 50% of the offspring of a cross between *cyt* (first parent) and *poky* (second parent) are expected to show slow growth.
D. All offspring of a cross between *poky* (first parent) and *cyt* (second parent) are expected to show slow growth.

36. The following figure shows four possible speciation mechanisms, each involving several stages



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

Indicate if each of the following statements is true or false

A. Only one mechanism of speciation from the above involves a geographic barrier.

B. A small sub-population emigrates into an uninhabited island, and over time evolves. Later, the new island and original populations come into secondary contact but are not able to interbreed. This is an example of "Mechanism 3"..

C. In a plant species, some individuals evolve a shift in the color of their flowers. This may lead to speciation according to "Mechanism 4".

D. A change in ploidy can provoke immediate speciation.

37. The following is a list of mutational changes. For each of the specific mutations described below, **indicate if the stated possible cause of the mutation is true or false**.

A. The change of AT base pair in the wildtype gene to a GC pair might be caused by deamination.
B. The change of the sequence AACGTCACACACACATCG to AACGTCACATCG might be caused by DNA polymerase slippage.
C. The change in the order of genes from *bog-rad-fox*^{1}*-fox*^{2}*-try-duf* to *bog-rad-fox*^{1}*-mel-qui-txu-sqm* might be caused by gene conversion.
D. The change of the sequence AAGCTTATCG to AAGCTTTATCG might be caused by ultraviolet light

38. In ethnic Tibetans, living mostly above 4000 m, a gene (*EPAS*1) coding for the Endothelial PAS domain-containing protein 1 (*EPAS*1) was found to be a promising candidate gene for adaptation to high altitude. EPAS1 is a transcription factor involved in the response to hypoxia. A single-nucleotide polymorphism (SNP) in *EPAS1* is associated with erythrocyte abundance. The frequency of Allele A of this SNP is 78% higher in Tibetan than Chinese samples, .

Indicate if each of the following statements is true or false

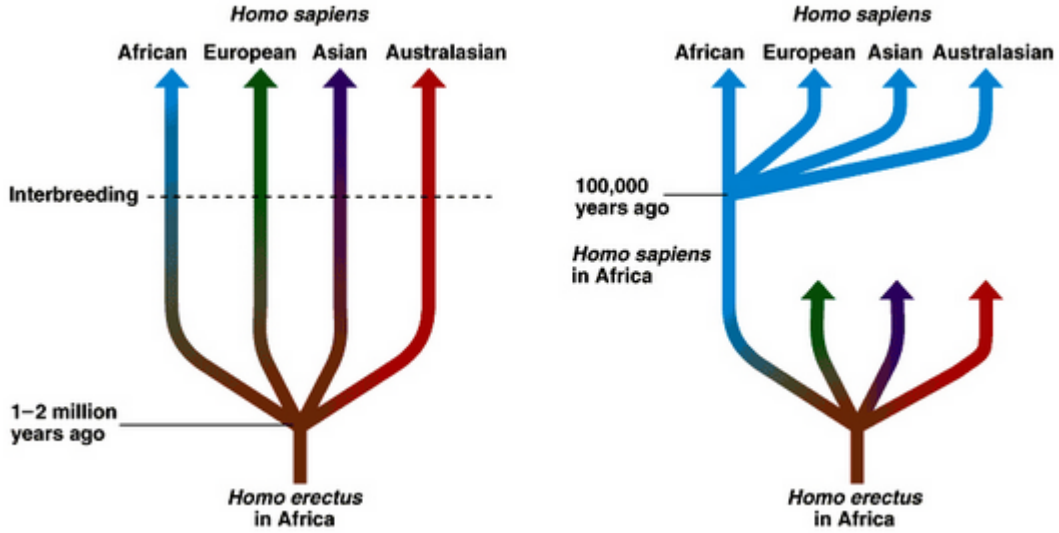
A. This SNP affects their capability to take up oxygen at low partial pressure of oxygen.
B. These results suggest that this phenotypic response likely includes multiple genes.
C. The amino acid sequence of EPAS1 may vary among carriers of Allele A.
D. The SNP is likely to be under balancing selection in Tibetans.

39. Several population of a particular species of fish inhabit nearby but isolated fresh water ponds. In the predator-rich ponds, fish tend to swim in short, fast bursts. In ponds with few predators, fish tend to swim continuously for a long time. When placed together in the same body of water, the two kinds of female fish exhibit exclusive breeding preferences.

Indicate if each of the following statements is true or false

A. When fish from both populations were put together in the same pond hybridization did not occur due to the result of natural selection.
B. Sexual selection increases the divergence between fish populations
C. By building canals between the ponds through which the fish, but not their predators may migrate, genetic diversity would be maintained.
D. Reciprocal transfer of females from one population to another will restore swimming style variation in predator rich ponds.

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



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

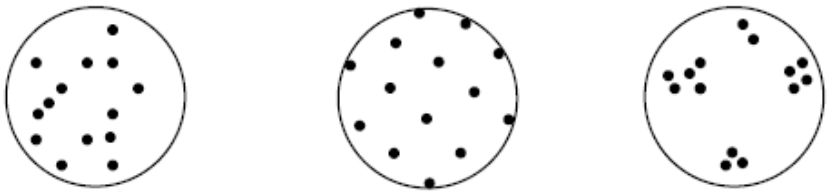
i. African people has greater mitochondrial genetic diversity compared with people from other continent
ii. mtDNA genetic variations in modern human populations are low.

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

A. Using mtDNA genetic markers was an advantage over nuclear genetic markers due to the lower mutation rate and absence of recombination of mtDNA.
B. Under the 'Out of Africa' theory, mtDNA extracted from a 200,000 years old skeleton found in a Himalayan cave, is expected to be more similar to the mtDNA of modern day Asians than modern day Europeans..
C. According to the 'Multiregional' theory, gene flow between populations explains the mtDNA genetic variation in modern human populations.
D. The greater mtDNA genetic diversity among African people support the 'out of Africa' theories.

ECOLOGY

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

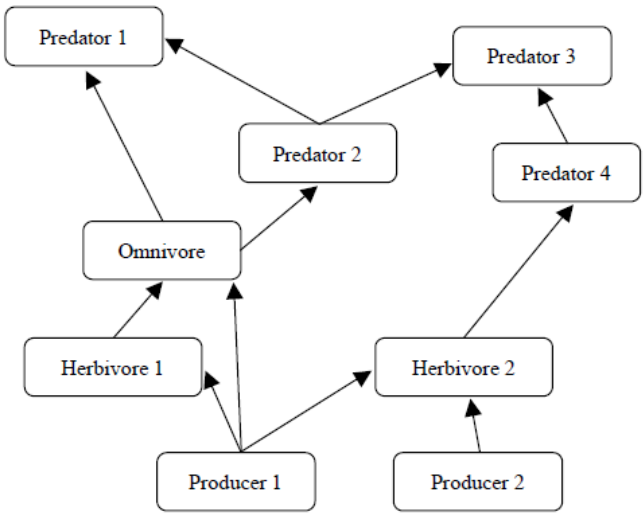


I II III

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

A. Pattern I suggests strong interactions among individuals.
B. Pattern II suggests antagonistic interaction among individuals.
C. Pattern III suggests symbiotic interaction among individuals.
D. Pattern I suggests the attraction of individuals to a common resource.

42. In the food web below, the population of Predator 4 has been declining sharply due to hunting by humans. This is expected to affect the populations of other species.



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

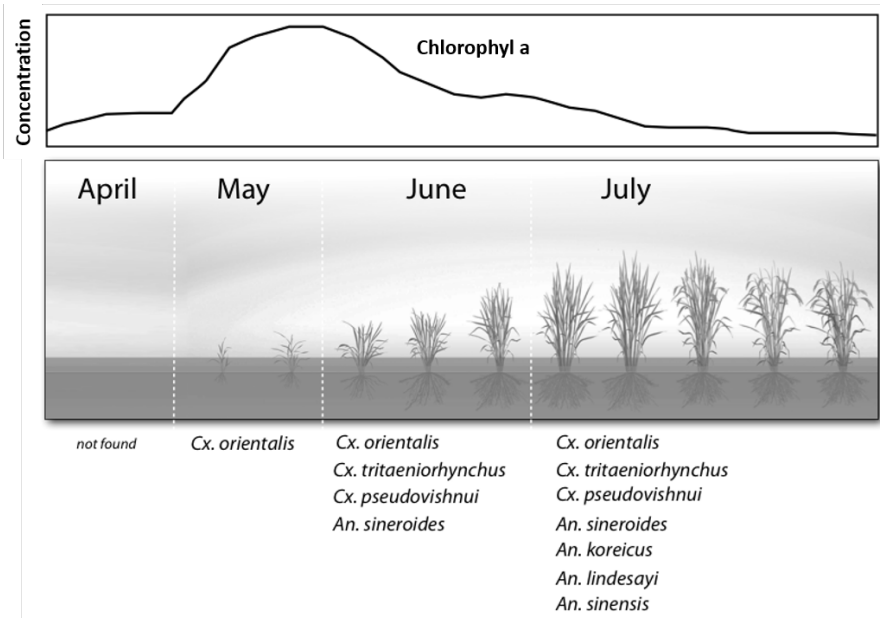
A. A population decrease in Predator 4 will result in an increase of Herbivore 2.
B. A population decrease in Predator 4 will result in an increase of Predator 3.
C. A population decrease in Predator 4 will result in a decrease in the Omnivore.
D. There are four tertiary consumers in the food web above.

43. The Sumatran elephant (*Elephas maximus sumatranus*) seen in the Bali Safari Park is a protected herbivore in Indonesia. Despite this, elephant populations are threatened by poaching and habitat loss, including the conversion of forests into oil palm plantations and cultivated lands. This has led to the fragmentation of forest areas. Consequently, elephants often enter human inhabited areas, damaging plantations and increasing human-elephant conflict. Elephants tend to strongly avoid areas intensively used by humans.

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

A. Elephants often cannot fulfil their dietary needs in the forest and are attracted to cultivated plants.
B. Elephants will enter human settlements because they are part of the elephant's natural home range.
C. Elephants occupy the top position in the food chain.
D. Habitat fragmentation may **not** lead to the formation of elephant metapopulations because elephants are very adaptable.

44. Paddy (rice) fields in Indonesia are habitats for many aquatic organisms, including mosquito larvae and the phytoplankton they feed on. Phytoplankton depend on water and sunlight availability for their growth. The figure below shows the relationship between the four-month variation in the amount of phytoplankton (expressed as chlorophyll-a concentration) and the community composition of *Anopheles* (*An.*) and *Culex* (*Cx.*) mosquitoes.

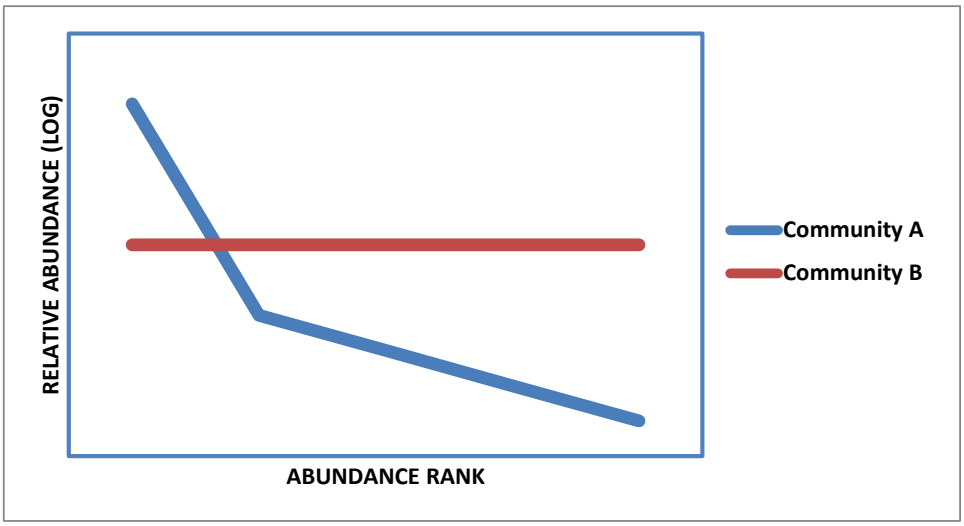


Indicate if each of the following statements is true or false:

A. *An. sineroides* and *An. koreicus* have similar light intensity requirements.

B. *Cx. orientalis* can avoid interspecific competition due to its relatively high tolerance to heat.
C. The lower chlorophyll-a concentration in July is due only to heavy predation of phytoplankton.
D. Paddy biomass is positively correlated with richness of mosquito species.

45. A rank-abundance curve portrays the relative abundance and diversity of species within a plant community. The rank of each species is plotted along the horizontal axis according to decreasing abundance. The vertical axis plots the abundance of each species on a log scale. The following graph compares rank abundances in Plant Communities A and B.

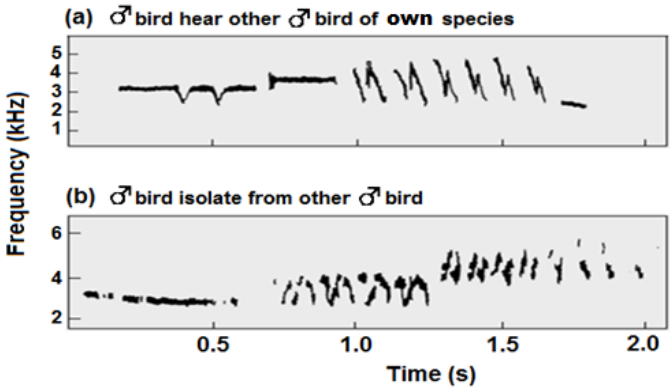


Indicate if each of the following statements is true or false:

A. Plant Community A has a lower species richness than Plant Community B.
B. Plant Community A has a lower species evenness than Plant Community B.
C. Plant Community A has a lower diversity index than Plant Community B.
D. Plant Community A is likely to be exposed to more generalist herbivores than Plant Community B.

ETHOLOGY

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



Indicate if each of the following statements is true or false

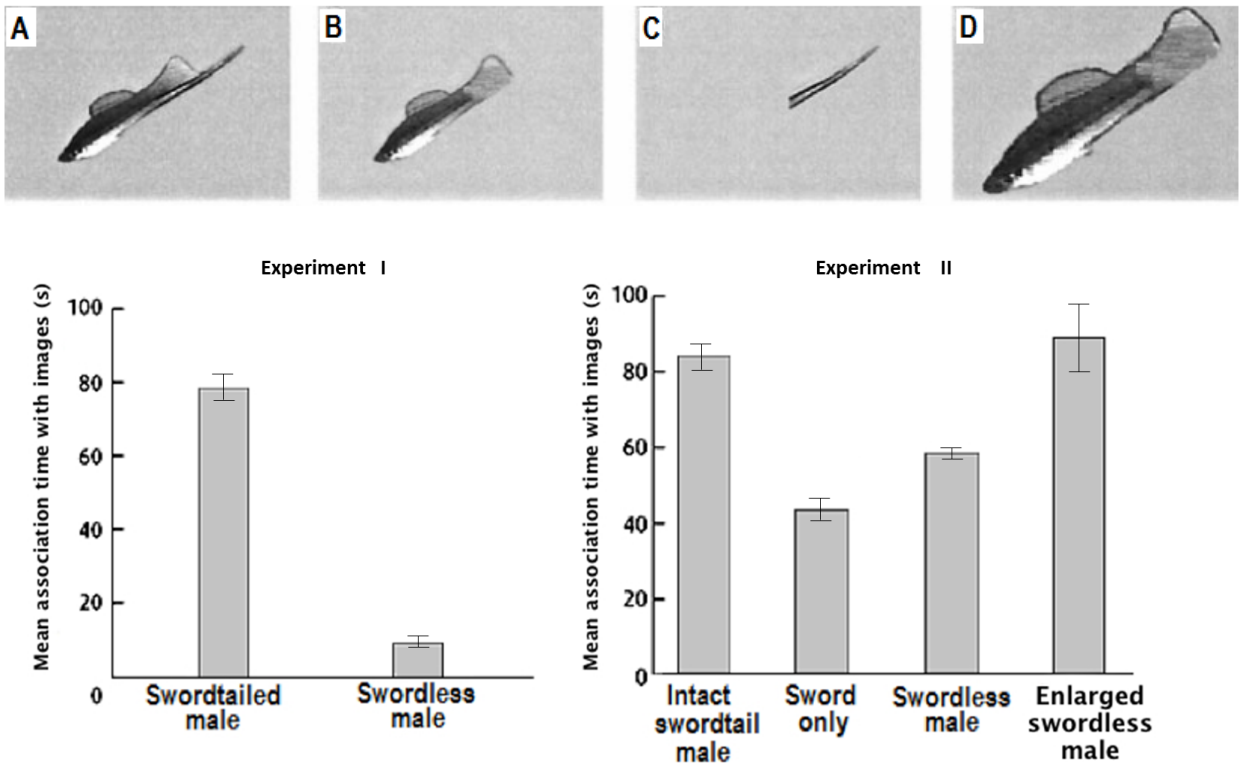
A. When young birds hear their own species' song, they selectively learn songs which match their genetic template and thus improve their song output.

B. Isolated birds' songs do not contain any elements of adult songs.

C. The males that do not learn songs from conspecifics may lose their reproductive advantage.

D. Auditory feedback from conspecifics affects predominantly the syllable types that appear in a song.

47. Selection experiments based on sexual signals have demonstrated that a male trait and female preference can coevolve. An experiment, shown below, was conducted to examine the responses of female swordtail fish *Xiphophorus helleri* to animated video images of: A. Intact swordtail male, B. swordless male, C. sword only, and D. enlarged swordless male. The Y axis shows the association of females with the respective images.



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

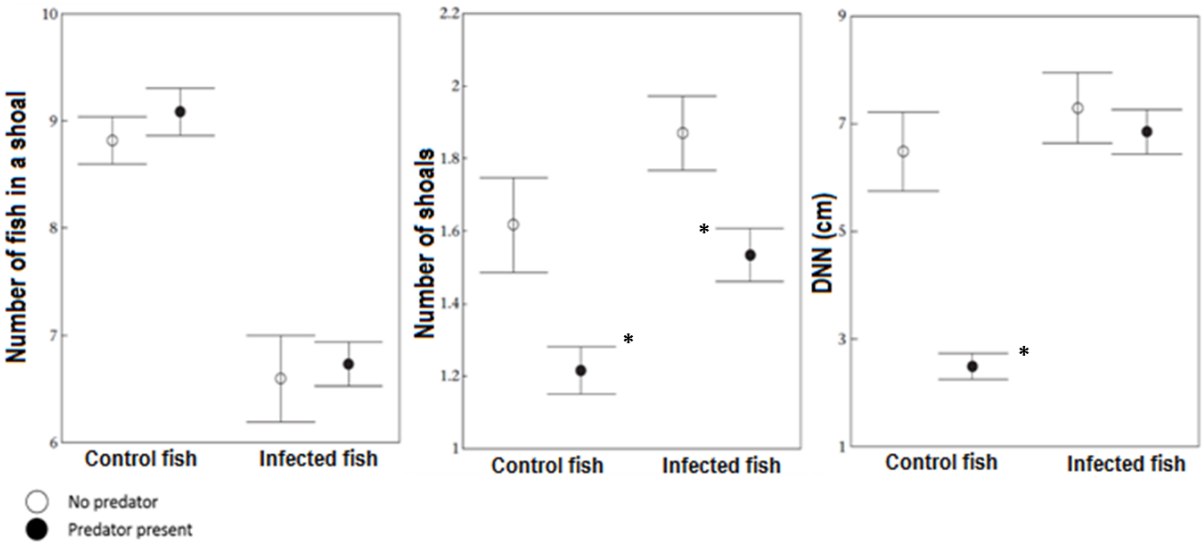
A. Females favor the more exaggerated male traits and find them attractive

B. Body size is a stronger cue than swordtail for female preference

C. An extravagant trait is metabolically expensive to produce and is expected to increase a male's chances of survival.

D. Swords offer males a more metabolically inexpensive signal to attract females than an enlarged body

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



(*) Indicate significant value

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

A. Infected fish tend to form smaller shoals.

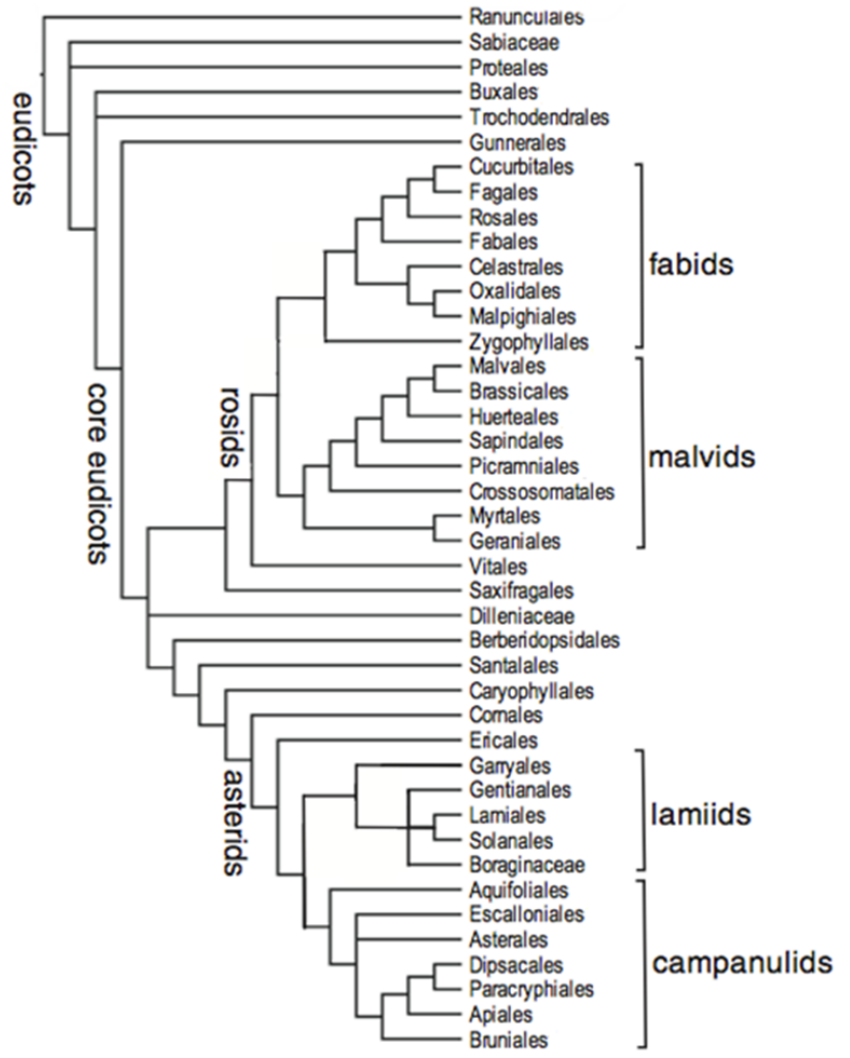
B. The tendency of fish to aggregate and form fewer shoals, when they encounter predators, is independent of infection.

C. Infected fish are more likely to be detected by predator because they form larger number of shoals.

D. The confusion effect of shoaling is less effective with infected fish.

BIOSYSTEMATICS

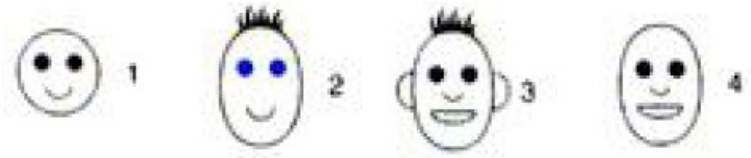
49. Assuming that the branches of a phylogenetic tree reflect taxon age, phylogenetic diversity is a measure of biodiversity, which includes information about the phylogeny of taxa. It can be estimated as the sum of branch lengths, including that of the group of interest, where the length of the smallest branch is one. A phylogenetic tree of eudicots is shown below.



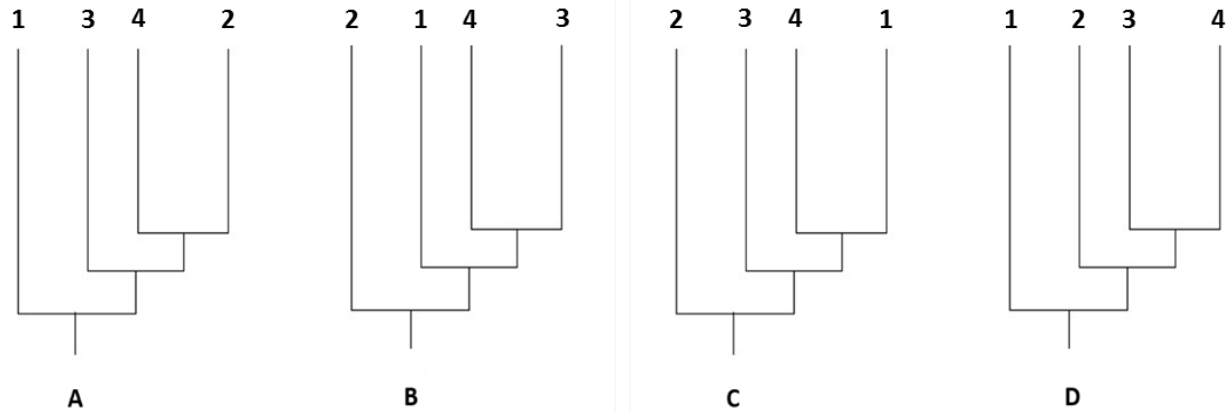
Based on the phylogeny tree, indicate if each of the following statements is true or false.

A. The phylogenetic diversity of malvids is higher than that of fabids.
B. Dilleniaceae and Saxifragales are closer phylogenetically than are Malpighiales and Cucurbitales.
C. The group consisting of Lamiids and Aquifoliales represents an adaptive radiation.
D. Malpighiales species may serve as outgroup to resolve the complete phylogeny of all Fabid species.

50. Inspired by traditional masks of Indonesia, some imaginary taxa are shown below. They differ from each other in head shape, eye colour, mouth shape and the presence of ears, nose and hair.



The ancestor of these taxa has a round head, black eyes, no mouth, no nose, no ears, and no hair.



Based on information above, indicate if each of the following statements is true or false.

A. Trees A and C require the same minimal number of character changes.
B. Of the trees shown, tree B is the least parsimonious.
C. Of the trees shown, tree D is the most parsimonious.
D. In general, there are more than seven different rooted topologies for four taxa.

END OF TEST