INTERNATIONAL BIOLOGY OLYMPIAD e. V. IBO

27th International Biology Olympiad

July 17-23, 2016
Hanoi, Vietnam

Theoretical Test

PART A

Total points: 50
Duration: 3 hours

DEAR PARTICIPANTS,

Please write your **student code** in the given box.
Write down your answers using a pen in the **Answer Sheet**. Only answers given in the **Answer Sheet will be evaluated**.

Part A consists of 50 questions:

- Q1-Q10: Cell Biology
- Q11-Q17: Plant Anatomy and Physiology
- Q18-Q30: Animal Anatomy and Physiology
- Q31-Q32: Ethology
- Q33-Q42: Genetics and Evolution
- Q43-Q47: Ecology
- Q48-Q50: Biosystematics

For each True/False multiple choice question, indicate in the **Answer Sheet** if each of the four statements is True or False. **Mark "√" for True and False statements** in the **Answer Sheet**. If you need to change an answer, you should strikethrough the wrong answer and write in the new one.

Scoring for one question:

- If all four answers are correct, you will receive 1 point.
- If only three answers are correct, you will receive 0.6 point.
- If only two answers are correct, you will receive 0.2 point.
- If only one answer is correct, you will not receive any points (0).

You can use the ruler and the calculator provided.
Stop answering and put down your pen immediately when the bell rings at the end of the exam. Enclose the **Answer Sheet** and **Question Paper** in the provided envelope.

Good luck!!!

CELL BIOLOGY

Q.1

The activities of Wee1 kinase and Cdc25 phosphatase determine the state of phosphorylation of tyrosine 15 in the Cdk1 component of M-Cdk. When tyrosine 15 is phosphorylated, M-Cdk is inactive; when tyrosine 15 is not phosphorylated, M-Cdk is active (**Figure Q.1A**). The activities of Wee1 kinase and Cdc25 phosphatase are also controlled by phosphorylation.
The regulation of these activities can be studied in extracts of frog oocytes. In such extracts, Wee1 kinase is active and Cdc25 phosphatase is inactive. As a result, M-Cdk is inactive because its Cdk1 component is phosphorylated on tyrosine 15. M-Cdk in these extracts can be rapidly activated by addition of okadaic acid, which is a potent inhibitor of serine/threonine protein phosphatases. Using antibodies specific for Cdk1, Wee1 kinase, and Cdc25 phosphatase, it is possible to examine their phosphorylation states by changes in mobility upon gel electrophoresis (**Figure Q.1B**). Phosphorylated forms of these proteins generally migrate more slowly than their nonphosphorylated counterparts.

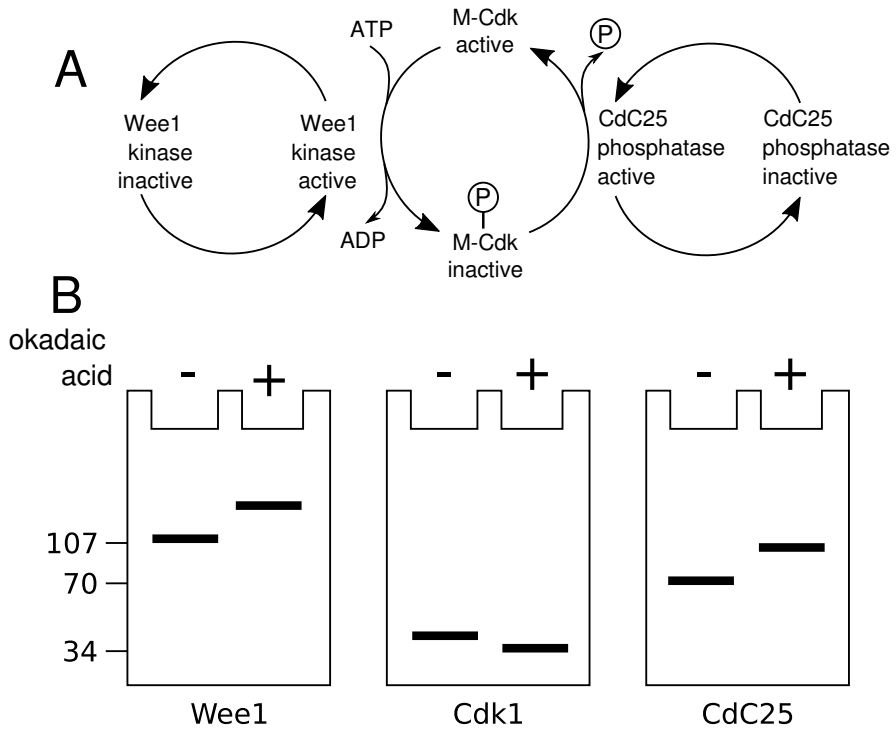


Fig.Q.1. (A) Control of M-Cdk activity by Wee1 kinase and Cdc25 phosphatase; (B) Effects of okadaic acid on the phosphorylation states of Cdk1,Wee1 kinase, and Cdc25 phosphatase

Indicate in the **Answer Sheet** if each of the following statements is True or False

A. Wee1 kinase is active if it is phosphorylated.

B. The phosphatases that control the phosphorylation of Wee1 kinase and Cdc25 phosphatase are specific for tyrosine side chains.

C. Okadaic acid directly affects the activation of Cdk1.

D. If M-Cdk is able to phosphorylate Wee1 kinase and Cdc25 phosphatase, a small amount of active M-Cdk would lead to its rapid and complete activation.

Q.2

Translational rate of a mRNA can be estimated from sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE). In this experiment, a tobacco mosaic virus (TMV) mRNA, which encodes a 116,000-dalton protein, was translated in a rabbit reticulocyte lysate in the in the presence of ^{35}S-methionine. The lysate contained all components of rabbit reticulocite translational machinery. Samples were removed at 1-minute intervals and subjected to SDS- PAGE. The separated translation products were visualized by autoradiography. As can be seen in the figure below, the largest detectable polypeptides get larger with time, until the full-length protein appears at about 25 minutes.

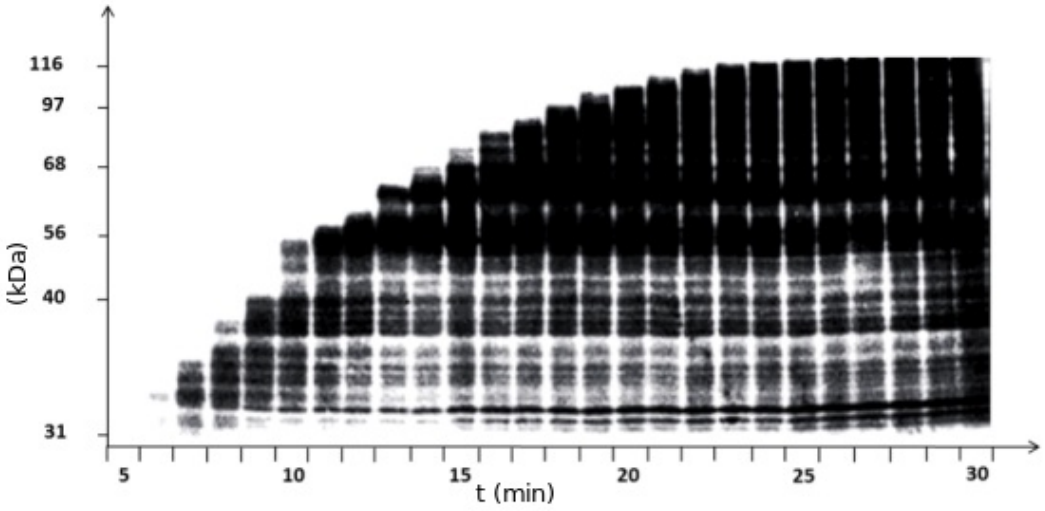


Fig.Q.2. Time course of synthesis of a TMV protein in a rabbit-reticulocyte lysate. Molecular weight (kDa) as a function of time t (min).

Indicate in the **Answer Sheet** if each of the following statements is True or False.

A. The rate of TMV protein synthesis is exponentially proportional to time.

B. With an average molecular mass of an amino acid of 110 daltons, the average rate of protein synthesis is approximately 35 to 40 amino acids per minute.

C. The rabbit reticulocyte lysate contains methionyl-tRNA synthetase

D. The mRNA may contain more than two rare codons in its sequence.

Q.3

Scientists have isolated three different strains of bacteria ProA$^-$, ProB$^-$, and ProC$^-$ that require added proline for growth. One is cold-sensitive, one is heat-sensitive, and one has a gene deleted. Cross-feeding experiments were carried out by streaking the strains out on agar plates containing minimal medium supplemented with a very low level of proline. In cross-feeding experiments, metabolites leaking from one strain can feed a neighbouring strain. After growth at three temperatures, the results were shown in Figure Q.3.

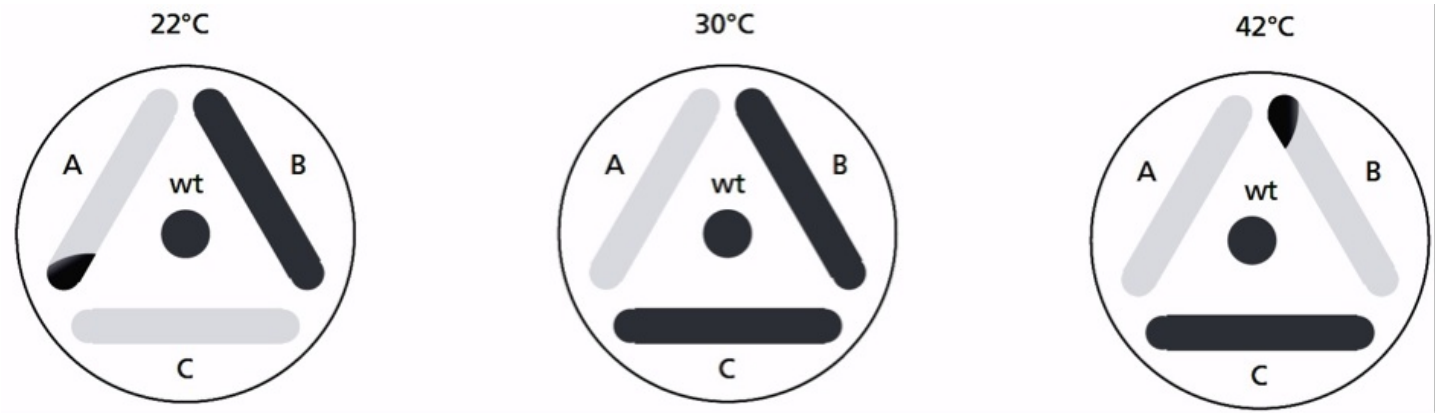


Fig.Q.3. Results of cross-feeding experiments with three strains defective in proline biosynthesis. Dark areas show high cell growth rate; grey areas show low cell growth rate; wt, wild type

Indicate in the Answer sheet if each of the following statements is True or False

A. The intermediate that accumulates in the ProC$^-$ strain comes after the block in the ProA$^-$ strain.

B. The intermediate that accumulates in the ProB$^-$ strain comes after the block in the ProA$^-$ strain

C. There are at least three different genes that affect proline biosynthesis.

D. Under at least one condition, the proline that is produced is rapidly used for protein synthesis and is prevented from being synthesized in excess of needs.

Q.4

When isolated mitochondria are suspended in a buffer containing ADP, Pi, and an oxidizable substrate, three easily measured processes occur: the substrate is oxidized; O_2 is consumed; and ATP is synthesized. Cyanide (CN^-) is an inhibitor of the passage of electrons to O_2. Oligomycin inhibits ATP synthase by interacting with subunit F_0. 2,4-dinitrophenol (DNP) can diffuse readily across mitochondrial membranes and release a proton into the matrix, thus dissipating the proton gradient.

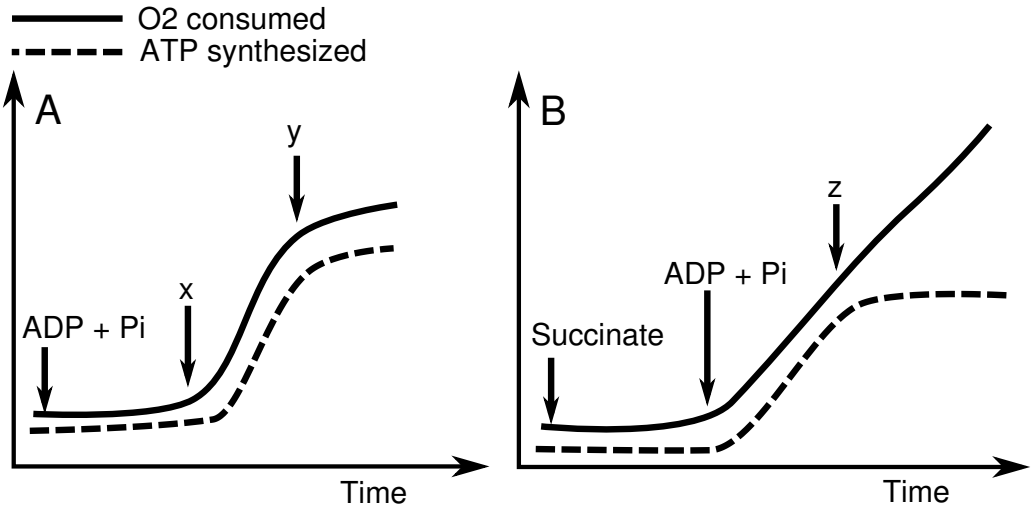


Fig.Q.4. Oxygen consumption and ATP synthesis in mitochondria. The solid lines indicate the amount of oxygen consumed and the dash lines indicate the amount of ATP synthesized

Indicate in the **Answer Sheet** if each of the following statements is True or False.

A. x is the oxidizable substrate.

B. y is either oligomycin or CN^-.

C. z is DNP.

D. If z is a mixture of oligomycin and DNP, the ATP synthesis will not level off.

Q.5

Imagine you are studying a membrane protein represented in the diagram below. You prepared artificial vesicles containing this protein only in the membrane. The vesicles were then treated with a protease cleaving close to the membrane (2) or permeabilised before protease treatment (3). Resulting peptides were subsequently separated using SDS-PAGE (sodium dodecyl sulfate polyacrylamide gel electrophoresis).

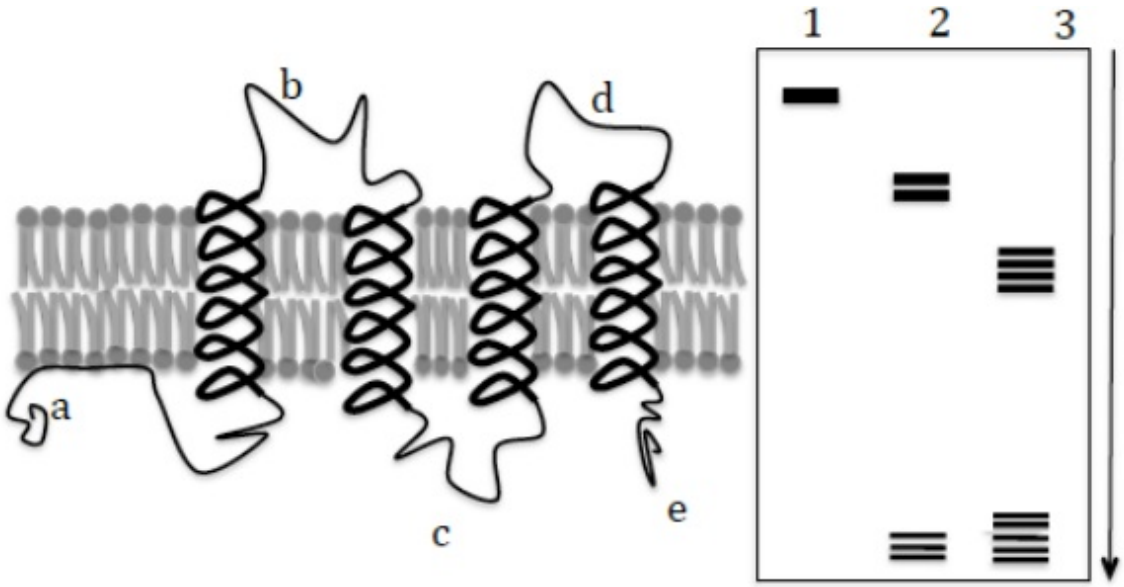


Fig.Q.5. Membrane protein (a, b, c, d, e: domains) and the SDS-PAGE gel
(1. untreated control, 2. peptides after protease cleavage, 3. peptides after permeabilisation and protease cleavage. The arrow indicates the direction of migration).

Indicate in the **Answer Sheet** if each of the following statements is True or False.

A. The bigger fragments in lane 3 are hydrophilic.

B. The smaller fragments in lane 2 represent protein domains protruding outside the membrane.

C. Domain a is rich in leucine or isoleucine.

D. Domains a, c and e protrude into the lumen of vesicles.

Q.6

Ethanol inhibits microbial growth. Nevertheless, some strains of the yeast *Saccharomyces cerevisiae* can adapt to high concentrations of ethanol. Many studies have documented the alteration of cellular lipid composition in response to ethanol exposure.

In this investigation, we systematically altered the fatty acid composition in *S. cerevisiae* by knocking out OLE1 gene coding for integral membrane desaturase, responsible for the formation of monosaturated palmitole*ic ac*id (Δ^9-$C_{16:1}$) and oleic acid (Δ^9-$C_{18:1}$). The knockout strain was then: (1) reconstituted with OLE1 gene by transformation with YEpOLE1 plasmid; (2) transformed with YEp-Δ^9*Hz*, YEp-Δ^9*Tn*, YEp-Δ^{11}*Hz* or YEp-Δ^{11}*Tn* plasmid containing Δ^9 or Δ^{11} desaturases of two lepidopteran insect (moths) *Helicoverpa zea (Hz)* or *Trichoplusia ni (Tni)*. Fatty acid component and growth curves of each transformant were investigated and shown in table and figure below:

Table Q.6. *Composition of major fatty acids in % of S. cerevisiae transformants at mid-log phase.*

Transformant	$C_{16:0}$	$C_{18:0}$	$C_{16:1}$	$C_{18:1}$
	Saturated	Saturated	Monounsaturated	Monounsaturated
OLE1	*45.5 ± 2.2*	*4.7 ± 2.4*	*34.9 ± 0.8*	*14.9 ± 1.0*
Δ^9Hz	*45.5 ± 5.5*	*7.9 ± 2.2*	*31.7 ± 5.6*	*11.0 ± 2.0*
Δ^9Tn	*46.9 ± 4.0*	*8.6 ± 3.9*	*12.8 ± 1.9*	*31.7 ± 5.8*
Δ^{11}Hz	*45.6 ± 3.6*	*11.9 ± 2.8*	*42.6 ± 6.3*	0
Δ^{11}Tn	*49.7 ± 4.8*	*12.5 ± 0.1*	*41.8 ± 11.8*	*11.2 ± 1.5*

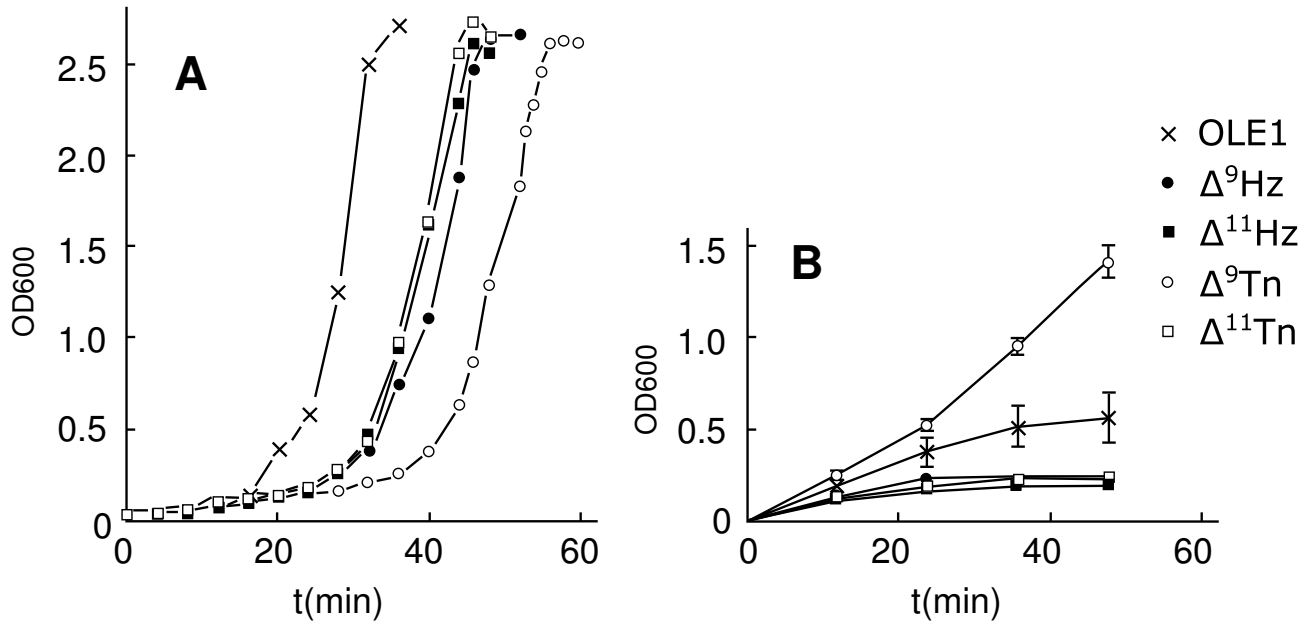


Fig.Q6. Growth curves of *S. cerevisiae* strains transformed with plasmid containing *OLE1* (x), *Δ^9Hz* (●), *Δ^{11}Hz* (■), *Δ^9Tn* (○) and *Δ^{11}Tn* (□) in YPD medium (A) and in YPD medium containing 5% ethanol (B)

Indicate in the **Answer Sheet** if each of the following statements is True or False.

A. The lag phase of transformant *OLE1* in YPD medium is shorter than those of Δ^9*Hz*, Δ^9*Tn*, Δ^{11}*Hz* and Δ^{11}*Tn* due to the presence of native desaturase in yeast cells.

B. Desaturases are equally active in all transformants.

C. The content of mono-unsaturated fatty acids is a good indicator of the ethanol tolerance in *S. cerevisiae.*

D. Higher ratio of Δ^9-$C_{18:1}$ to Δ^9-$C_{16:1}$ causes higher ethanol tolerance in *S. cerevisiae.*

Q.7

Poly(3-hydroxybutyrate) (PHB) is a bacterial storage material which is accumulated by various bacteria, usually when grown under limitation of a nutrient such as oxygen, nitrogen, phosphate, sulphur, or magnesium and in the presence of excess carbon. Fig. Q7 shows the PHB synthesis pathway of *Ralstonia eutropha* from acetyl-CoA, which is regulated by feedback inhibition. In addition, acetyl-CoA can enter the citric acid cycle.

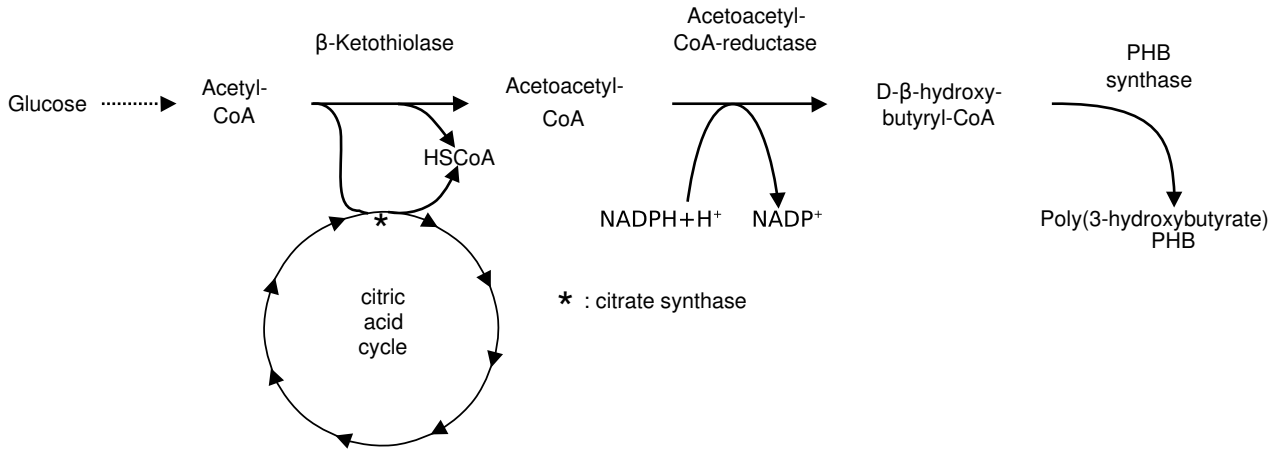


Fig. Q7. PHB synthesis pathway

Indicate in the **Answer Sheet** if each of the following statements is True or False

A. The increase in activity of citrate synthase will reduce the production of PHB.

B. When the intracellular concentration of HSCoA is high, the rate of PHB synthesis will increase.

C. When the rate of PHB synthesis increases, the growth rate of *Ralstonia eutropha* cells will also increase.

D. PHB synthesis is stimulated by low ratios of $(NADPH+H^+)/NADP$.

Q.8

A scientist has isolated five different peptides (1 to 5) containing five amino acids (named A, B, C, D, E). He determined the mass and the sequence of each peptide. The data which he obtained is shown on the table below

Peptide	Amino Acids Sequence	Mass (Da)
1	BCDACCDEDCB	966
2	ABBCAEEDECB	1099
3	BACDAEAEECA	1357
4	CACADBACAEB	1279
5	EDDCABBCCEE	1014

The mass of individual amino acids are shown in the table below

Amino acids	Mass (Da)	Amino acids	Mass (Da)
Alanine	89	Leucine	131
Arginine	174	Lysine	146
Asparagine	132	Methionine	149
Aspartic Acid	133	Phenylalanine	165
Cysteine	121	Proline	115
Glutamic Acid	147	Serine	105
Glutamine	146	Threonine	119
Glycine	75	Tryptophan	204
Histidine	155	Tyrosine	181
Isoleucine	131	Valine	117

Note: The mass of a water molecule is 18 Da.

Indicate if each of the following statements is True or False.

A. Amino acid named C is serine
B. Amino acid named A is tyrosine
C. Amino acid named E is cysteine
D. Amino acid named B is glycine

Q.9

Four different bacterial strains were isolated from the gut of a shrimp to study their probiotic potency through the decrease of their pathogenicity of *Vibrio harveyi*, a common bacteria infecting shrimp culture. In the first experiment, the four isolated bacteria were inoculated in cross-streak plates to observe inhibition zones against 4 bacterial strains (**Fig.9A**). In the second experiment, the shrimp survival rate in presence of *Vibrio harveyi* and each bacterial isolate after 5 days of incubation was measured (**Fig.9B**).

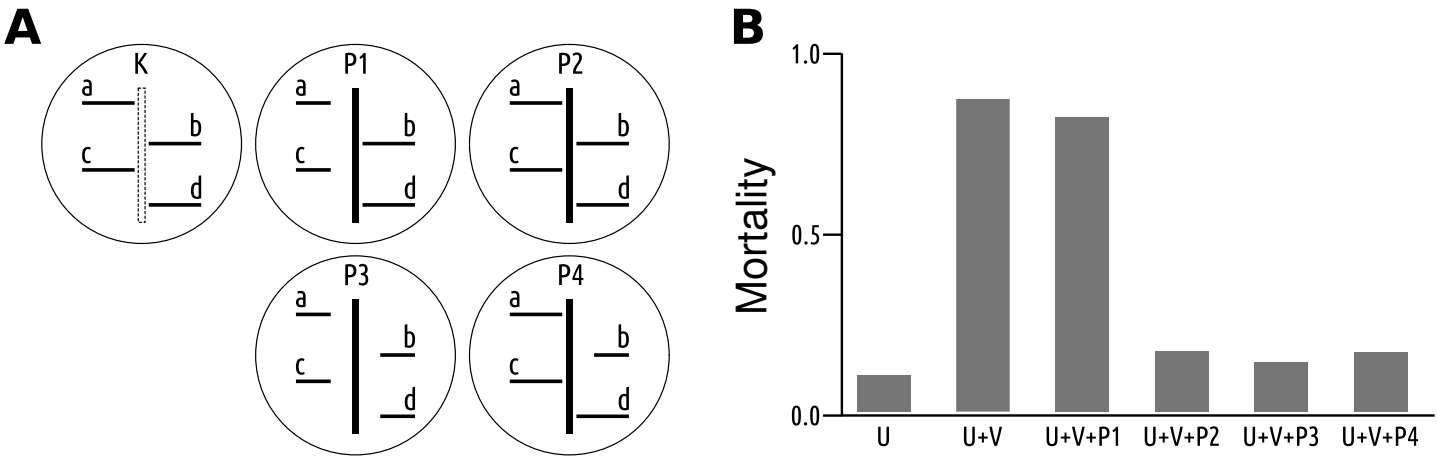


Fig.Q.9. (A) *K = Control (no bacteria streaked on the dash box), P1-P4 = Probiotic candidates 1-4, a = Streptococcus sp. (Gram-positive), b = Vibrio sp. (Gram-negative), c = Bacillus sp. (Gram-positive), d = Salmonella sp. (Gram-negative).* **(B)** *U = shrimp culture alone, U+V = shrimp culture with addition of Vibrio harveyi, U+V+P1-4 = shrimp culture with addition of Vibrio harveyi and a specific probiotic candidate P1-4, respectively.*

Indicate in the **Answer Sheet** if each of the following statements is True or False

A. Candidate No.1 (P1) produced an antimicrobial compound that inhibited Gram negative and Gram positive bacteria.

B. Candidate No.2 (P2) was able to decrease *Vibrio* sp. pathogenicity without killing them.

C. Candidate No.3 (P3) produced an antimicrobial compound targeting the outer membrane.

D. Candidate No.4 (P4) had good effect on the shrimp survival by inhibiting Gram-negative bacteria.

Q.10

An experiment was set up to observe cell cycle length of a strain of yeast. Activated yeast cells were subcultured into a new medium with an initial concentration of 10^6 cells/mL. After 40 h, the number of cells increased to 4 x 10^6 cells/mL. A portion of the culture was taken for a separate experiment. In this experiment, cells were incubated for 15 min into a media containing radioactive thymidine before washing and re-grown on a new media containing non-radioactive thymidine. Cell samples were then taken periodically to measure the percentage of mitotic cells containing radioactive thymidine. **Fig.Q.10** shows the result obtained from the experiment. At each sampling, about 1% of the total cells sampled were undergoing mitosis.

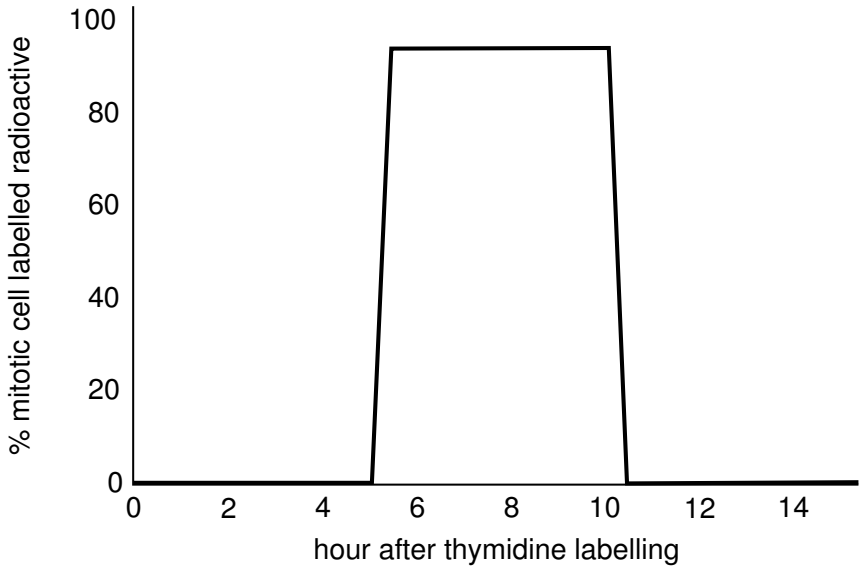


Fig.Q.10. Fraction of mitotic cells that were labeled radioactively during the cell culture experiment.

Indicate in the **Answer Sheet** if each of the following statements is True or False

A. The synthesis rate of histone proteins is relatively high between 6 and 10 hours after radioactive labeled thymidine exposure.

B. S phase of the cell cycle takes about 5 hours.

C. M phase of the cell cycle takes longer than 1 hour.

D. Most of the radioactive thymidine is assimilated in the S phase of the cell cycle.

PLANT ANATOMY AND PHYSIOLOGY

Q.11

Cell walls provide plant cells with a substantial degree of volume homeostasis relative to the large changes in water potential that they experience as the everyday consequence of the transpirational water loss. Cell water potential (Ψ_w) of a plant cell is composed of solute potential (Ψ_s) and turgor pressure potential (Ψ_p). Relative cell volume is correlated with cell water potential and its components as described in the Fig.Q11.

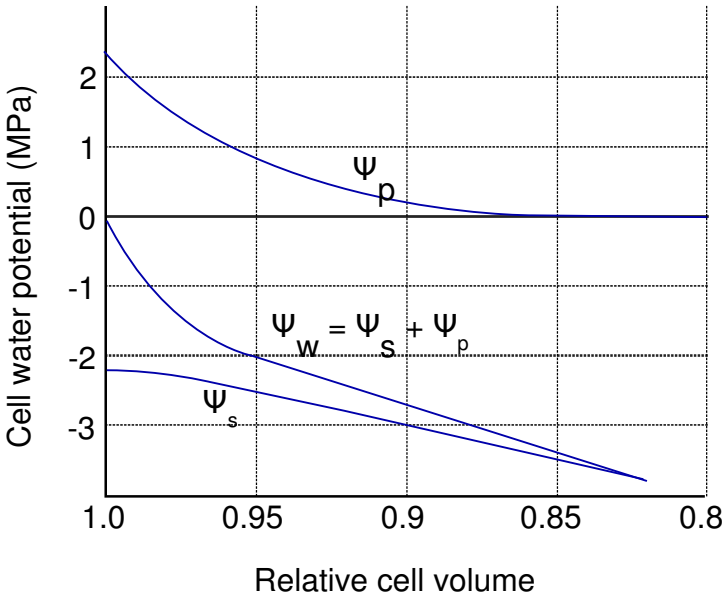


Fig.Q11

Indicate in the **Answer sheet** if each of the following statements is True or False.

A. Alterations of plant cell water potential are generally accompanied by a large change in turgor pressure and in cell volume.

B. Disappearance of turgor pressure indicates the ending point of cell plasmolysis with reduction of approximately by 15% cell volume.

C. As the cell volume decreases by 10%, most of the change in cell water potential is caused by the drop in cell solute potential together with little change in turgor pressure.

D. During cell rehydration, cell volume expansion stops when cell wall generates pressure equivalent to turgor pressure and the cell water potential reaches zero.

Q.12

An experiment was carried out on sorghum (*Sorghum bicolor*) and soybean (*Glycine max*) plants in response to low temperature. Plants were grown at 25ºC for several weeks and then at 10ºC for three days, while day length and light intensity and ambient carbon dioxide concentration were kept constant throughout the experiment unless stated otherwise. The net photosynthesis of both plant species at 25^0C are shown in Fig.Q12 below.

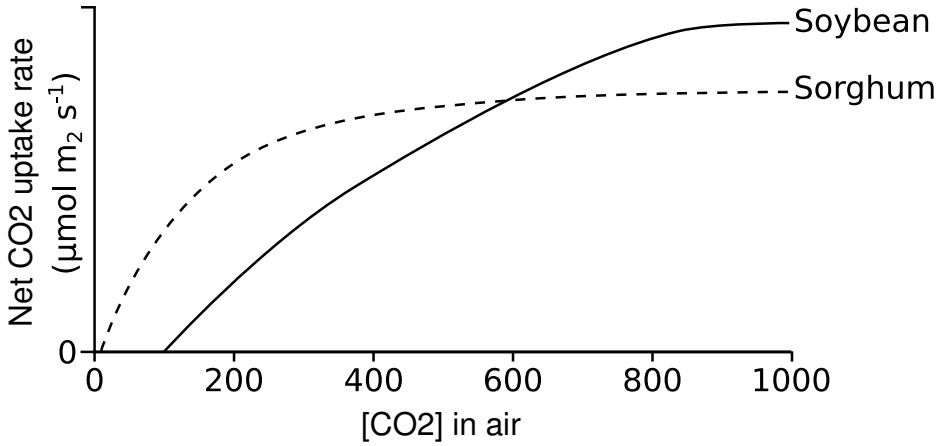


Fig.Q.12

Carbon dioxide uptake per leaf dry mass (mg CO_2 g^{-1})

Days	**before**	**1**	**2**	**3**	**4-10**
Temperature	**25°C**	**10°C**	**10°C**	**10°C**	**25°C**
Sorghum	48.2	5.5	2.9	1.2	1.5
Soybean	23.2	5.2	3.1	1.6	6.4

Indicate in the **Answer sheet** if each of the following statements is True or False.

A. If put at 35ºC, photosynthesis rate of soybean would decrease and that of sorghum would not change.

B. In cool condition, the biomass of sorghum increases faster than that of soybean.

C. Soybean plants are likely to have smaller photosynthetic water use efficiency than sorghum.

D. The reduction of the carbon dioxide uptake in sorghum is mainly due to the decrease of enzyme activity in low temperature.

Q.13

The bacterium *Bradyrhizobium japonicum* can infect soybean (*Glycine max*) roots and form nodules. The nitrogen fixation catalyzed by nitrogenase occurs in the nodules and the nitrogenase activity can be measured easily by acetylene reduction instead of nitrogen reduction. Scientists generated a defective mutation of NAD^+-dependent malic enzyme (*dme* mutant), the enzyme that generates pyruvate and NADH, and infected soybean seedling roots with wildtype and mutant bacteria. The seedlings were grown in nitrogen-free media. After 14 and 28 days of inoculation, the number and weight of nodules in the seedlings and acetylene reduction activity were recorded.

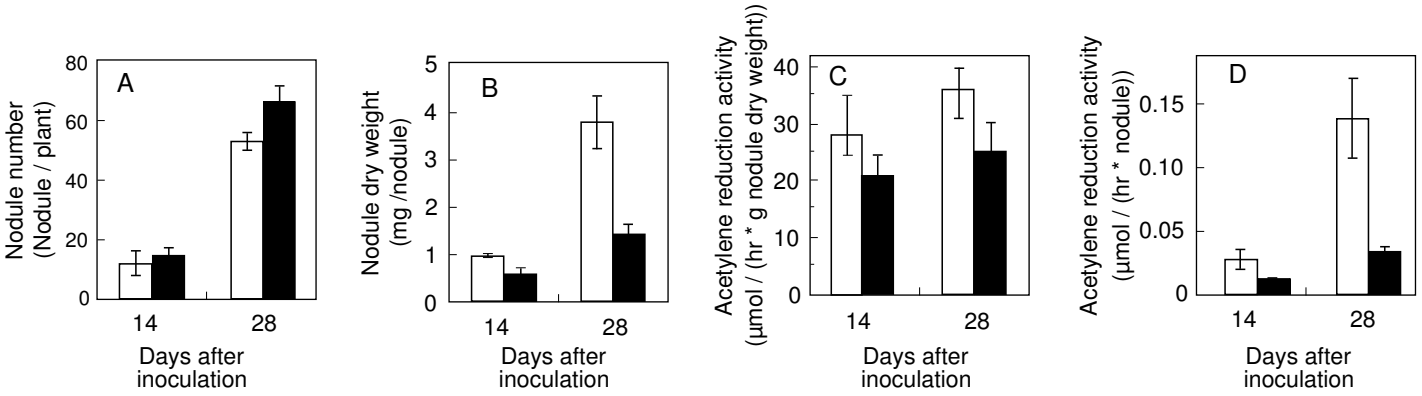


Fig.Q13. Nodule number and dry weight and acetylene reduction acitivity of soybean. Soybean nodules infected with wild-type *B. japonicum* (open bars) and the *dme* mutant (solid bars) are presented.

Indicate in the **Answer sheet** if each of the following statements is True or False.

A. Nitrogen fixation activity in nodules of the same treament at 28 days after inoculation is higher than that at 14 days after inoculation.

B. Both number and size of nodules increase with time from 14 to 28 days after inoculation with *B. japonicum*.

C. The reduction in nitrogen-fixing activity of nodules infected by the mutant at 28 days after inoculation compared to those at 14 days after inoculation is due to the reduction of nitrogenase activity and nodule formation.

D. Nitrogen fixation in *B. japonicum* –induced nodule is down-regulated by NAD^+-dependent malic enzyme.

Q.14

Sucrose is produced in leaves and translocated short and long distance through veins to non-photosynthetic organs such as roots, stems, flowers and fruits. Two principal pathways include symplast and apoplast by which sucrose molecules are transported in phloems of leaves as shown in Fig.Q14.

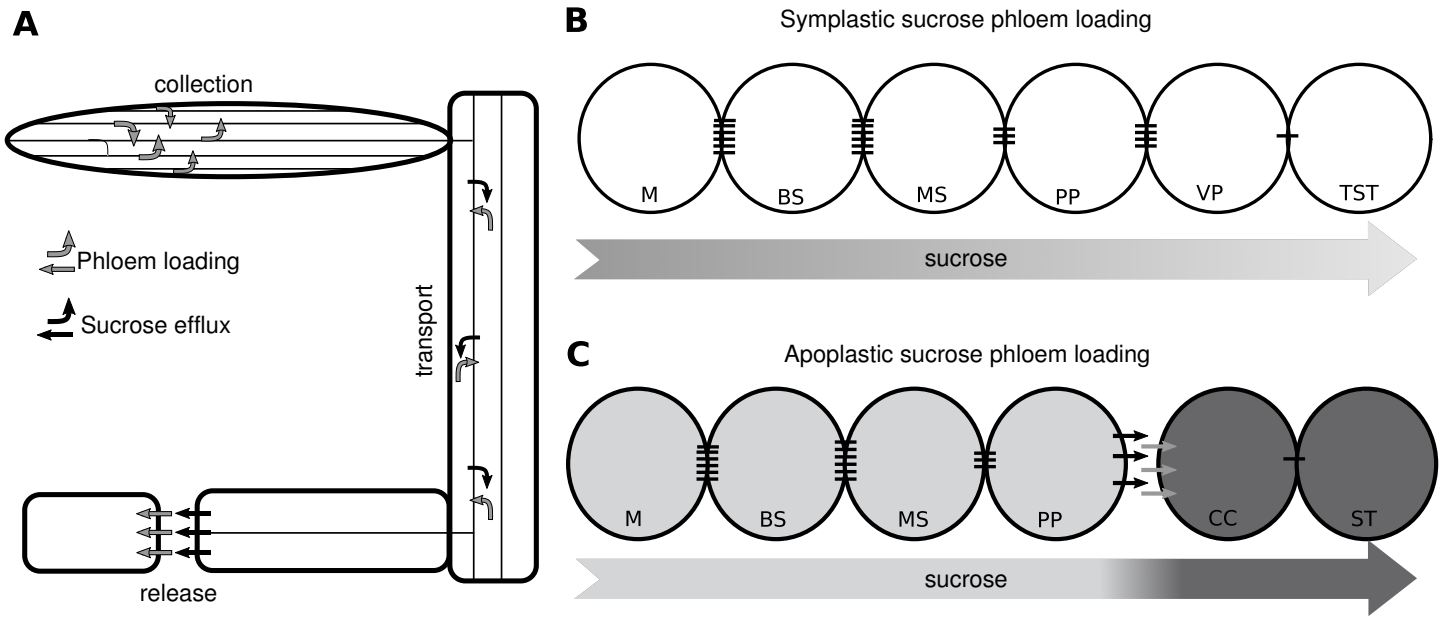


Fig.Q14. Diagram of the whole plant phloem network. M - Mesophyll, BS - Bundle sheath, MS - Mestome sheath, PP - Phloem parenchyma, VP - Vascular parenchyma, CC - Companion cell, TST - Thick walled sieve element, ST - Sieve element.

Indicate in the **Answer sheet** if each of the following statements is True or False.

A. Sucrose is synthesized in leaves and transported long distance through phloem to sinks under hydrostatic pressure gradient.

B. Loading sucrose in apoplastic pathway requires energy in several steps due to the movement across secondary wall of living cells.

C. In the symplastic pathway, sucrose molecules are passively loaded through plasmodemata.

D. Unloading sucrose molecules at the sinks requires no energy release because of movement down a gradient concentration of sucrose.

Q.15

Scientists measured length and height of rhizophores of mangrove plant (*Rhizophora mangle*, Fig.Q15A). They also made cross sections of rhizophores and observed their anatomical characteristics. The results are shown in Q15B and Q15C.

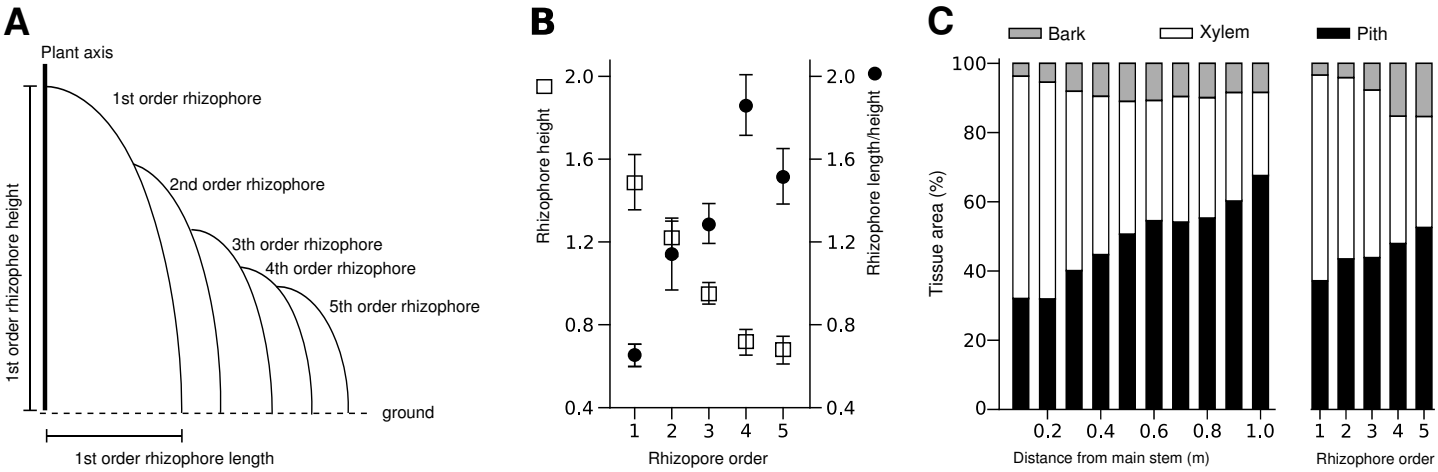


Fig.Q15. Rhizophores of *Rhizophora mangle* plants. **A**: Rhizophore height and length measurement. **B**: Change in height (empty square) and in length/height proportion (full circle) in five sequential orders of rhizophores. **C**: Relative proportions of bark (including aerenchyma), xylem and pith along the length of individual first-order rhizophores (left), and at the base of rhizophores of sequential orders (right).

Indicate in the **Answer sheet** if each of the following statements is True or False.

A. There are monotonic decreases in rhizophore height and the length/height proportion in the rhizophores as a function of the rhizophore order.

B. Within first-order rhizophores, the xylem proportion in the cross-section is larger when closer to the main stem, and decreases progressively as the rhizophore approached the ground while increasing the proportion of bark and pith.

C. When rhizophore order changes from 1 to 5, bark and pith proportion decreases, while xylem propotion increases.

D. The supportive function is likely enhanced in the first-order rhizophores, with lower length/height proportion, and higher proportion of xylem compared with bark and pith.

Q.16

Arsenic (As) in the soil has become an environmental concern worldwide because it is difficult to remediate and can adversely impact human health. The fern, *Athyrium yokoscense* is well known as a Cd hyperaccumulator as well as a Cu, Pb and Zn tolerant plant. However, no information is available on As accumulation by *A. yokoscense*, although it often grows in soils containing high levels of several heavy metals and As. To understand As accumulation in *A. yokoscense*, a student conducted an experiment in which young ferns collected from a mining area were grown in media containing As-spiked paddy soils or mine soil in a greenhouse for 21 weeks. Before transplanting fern biomass was 0.26 ± 0.08 g plant^{-1} DW and As concentrations of young and old fronds were 7.8 ± 0.3 and 57.7 ± 2.2 mg kg^{-1}, respectively.

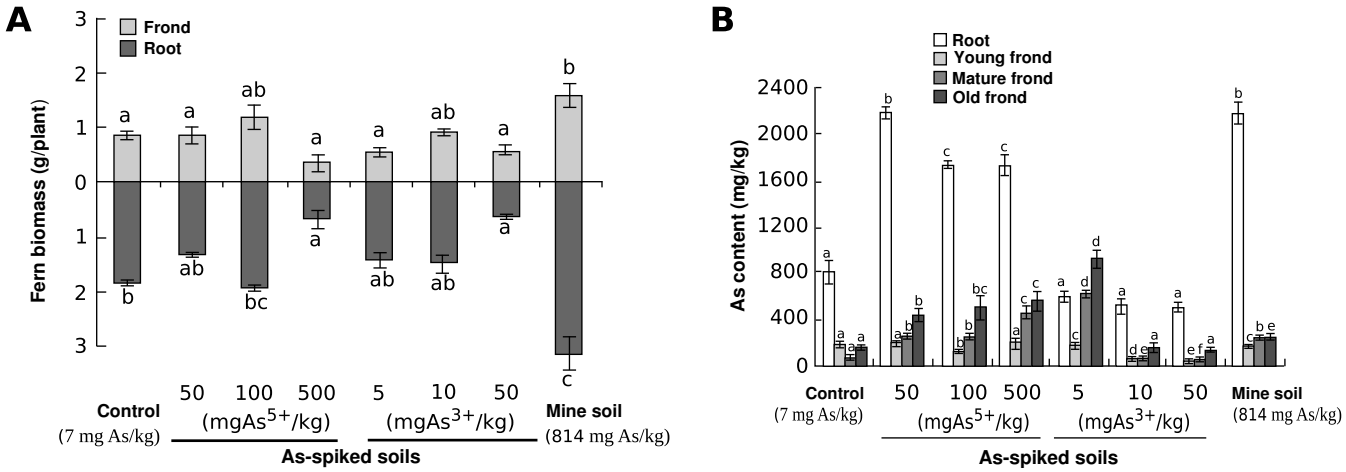


Fig.Q16. A: *Dry biomass of A. yokoscense after 21 weeks of cultivation in a greenhouse.* **B***: Arsenic concentration in different parts of A. yokoscense cultivated in As- spiked soils and mine soils.*

Tukey's test, a multiple comparison procedure and statistical test was used. The statistical significance of the difference between treatments for a given organ, are shown using the letter *a – f* above the bar. The same letter means there is no statistical difference for that organ.

Indicate in the **Answer sheet** if each of the following statements is True or False.

A. Moderate As levels in soils promote the growth of ferns.

B. Concentration of As in root grown in arsenite-spiked media (As^{3+}) is lower than those in arsenate treatment (As^{5+}), resulting in the increase of total biomass.

C. Arsenic concentration increases from young to old fronds and is positively correlated to As levels in the soil

D. The transfer of As from root to frond of *A. yokoscense* in mine soil over time is similar to that in arsenate-spiked soil.

Q.17

To study the effect of phytohormone on fruit maturation, researchers used abscisic acid (ABA) and ethephon to treat of sweet cherry fruits and afterward to evaluate the expression of *PacNCED1* gene which encodes 9-cis-epoxycarotenoid dioxygenase, a key enzyme in ABA biosynthesis. They also checked the expression of PacACO1 gene encoding 1-aminocyclopropane-1-carboxylic acid oxidase enzyme that involves in ethylene biosynthesis. The transcript of PacACT1 (one b-actin cDNA fragment was cloned and designated as *PacACT1*) was used to standardize for all expression (Fig.Q17-D).

Treatment	Firmness of pulp	Soluble solids content/ titratable acidity	Anthocyanin(U.g^{-1})
Control	20.3a	14.4a	13.4a
Ethephon	19.6a	15.3a	14.4a
ABA	11.9b	16.8b	23.8b

(a and b show values that are significantly different).

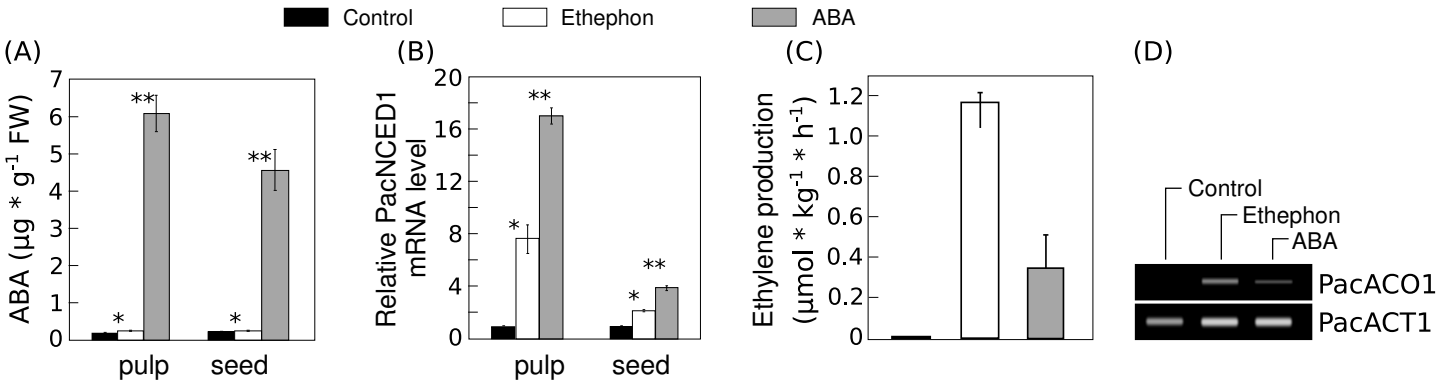


Fig. Q17. Effects of ABA and ethephon application on ABA content (A), accumulation of *PacNCED1* (B), ethylene production during ripening (C) and *PacACO1*(D). * and ** indicate significant differences compared to control.

Indicate in the **Answer sheet** if each of the following statements is True or False.

A. Both ABA and Ethephon stimulate the expression of *PacACO1* and *PacNCED1* genes in sweet cherry fruit.

B. The expression of PacNCED1 and ABA accumulation in pulp are higher than in the seed in the treatments of ABA

C. ABA induces the maturation of sweet cherry fruit via stimulation of ethylene production.

D. Ethephon shows lower effect on anthocyanin and endogenous ABA production than exogenous ABA does.

Q.18

A 55-year-old man has a resting cardiac output of 7000 mL/minute. His arterial pressure is 125/85 mmHg. His heart rate is 100 beats/min and his body temperature is normal. Figure Q.18 represents the changes in left ventricular pressure and blood volume during a cardiac cycle.

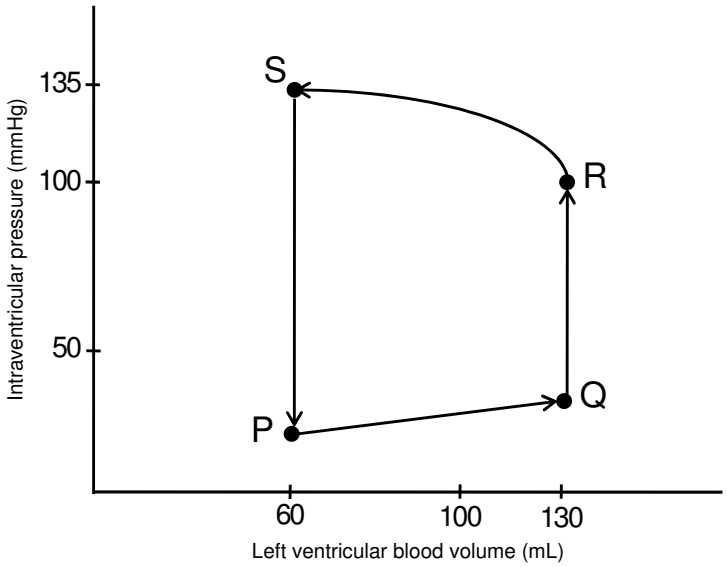


Figure Q.18.

Indicate in the Answer sheet if each of the following statements is True or False.

A. At Q, the left atrioventricular valve is opened.

B. Ventricular ejection ends at S.

C. The distance from S to P should be longer if there is a narrowing of the aortic valve.

D. In period R-S, blood does not flow into both atria and ventricles.

Q.19

Cardiac output (CO) is the volume of blood pumped by the heart in one minute. Cardiac output is affected by the stroke volume (SV) and the heart rate (HR). Cardiac output can be measured indirectly using the Fick's equation: CO = Q/(A-V), where Q is the rate of oxygen consumption (mL/min), A-V is the difference between oxygen concentration in the oxygenated blood (A) and in the deoxygenated blood (V). The data below were measured from a healthy person before and during physical exercise.

Parameters	**Before Exercise**	**During Exercise**
Rate of oxygen consumption (Q)	250 mL/min	1500 mL/min
Oxygen difference (A-V)	50 mL/L blood	150 mL/L blood
Heart rate (HR)	60 beats/min	120 beats/min

Indicate in the Answer sheet if each of the following statements is True or False.

A. Cardiac output increased by two-fold during exercise.

B. Stroke volume during exercise was higher than that before exercise.

C. Physical exercise caused a reduction in hemoglobin's binding for oxygen in tissues, resulting in a three-fold increase in the amount of oxygen released to tissues.

D. The number of heart beats required to supply a tissue with 3000 mL of oxygen during exercise is 240.

Q.20

Figure Q.20 shows the models of four types of common human congenital heart defects.

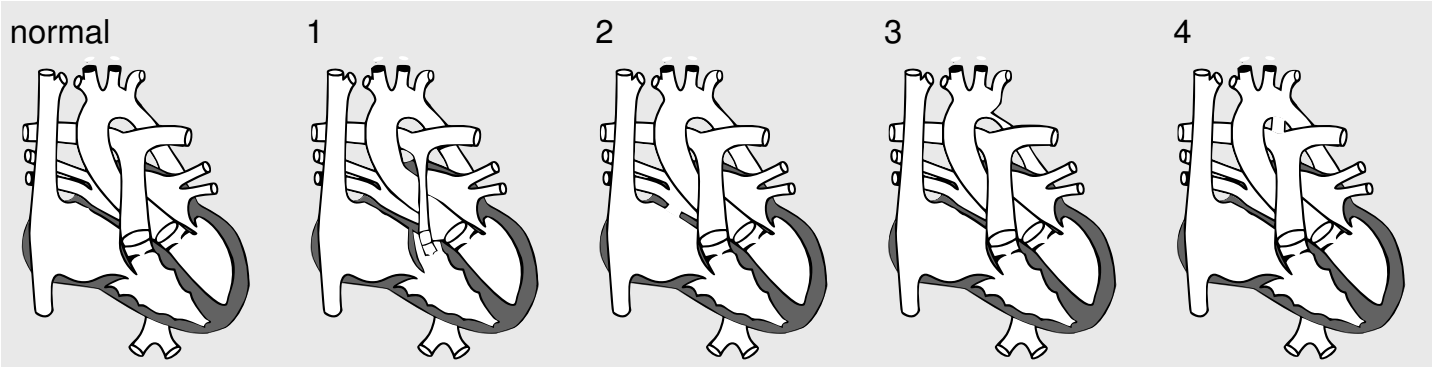


Figure Q.20.

Indicate in the Answer sheet if each of the following statements is True or False.

A. In type 1, the blood volume going to the lungs is lower than normal.

B. In type 2, the stroke volume of the left ventricle is increased.

C. In type 3, the systolic blood pressure at the arms is higher than that in the normal type.

D. In type 4, the pulmonary blood pressure is increased.

Q.21

Figure Q.21 shows how lung ventilation is affected by physical activity. As the intensity of exercise increases, humans respond to the increased need for gas exchange in two ways: increase in ventilation rate and increase in tidal volume. The experimental data for a well-trained runner on a treadmill are shown in Figure Q.21.

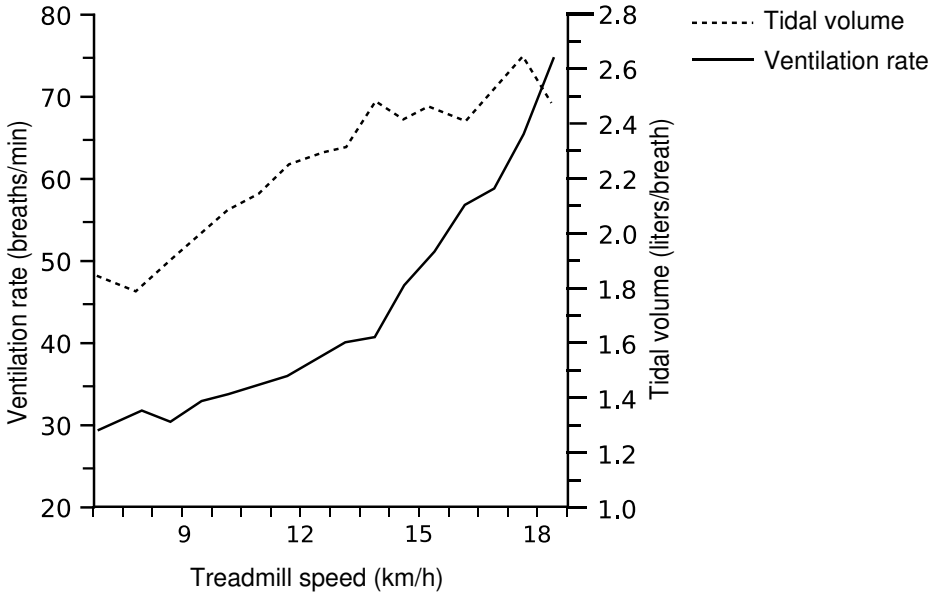


Figure Q.21

Indicate in the Answer sheet if each of the following statements is True or False.

A. The increase in ventilation rate is faster than the increase in tidal volume when the treadmill speed increases from 9 km/h to 12 km/h.

B. In intense physical exercise (> 15 km/h treadmill speed), the increase in the ventilatory minute volume is mainly caused by increased ventilation rate.

C. At the treadmill speed of 15 km/h, the ventilatory volume per minute is approximately 120 L.

D. In an adult human, a tidal volume of 0.2 L and ventilation rate of 30 breaths per minute can provide equally effective gas exchange as a tidal volume of 0.6 L and a ventilation rate of 10 breaths per minute.

Q.22

In an experiment, a researcher isolated a neuron and placed it in the standard Ringer solution (isotonic physiological solution). He measured the resting membrane potential of the axon, then stimulated the axon and measured its action potential (Record A, Figure Q.22). Subsequently, he repeated the experiment several times, each with a different modified Ringer solution. Figure Q.22 shows some of the results (Records B to E).

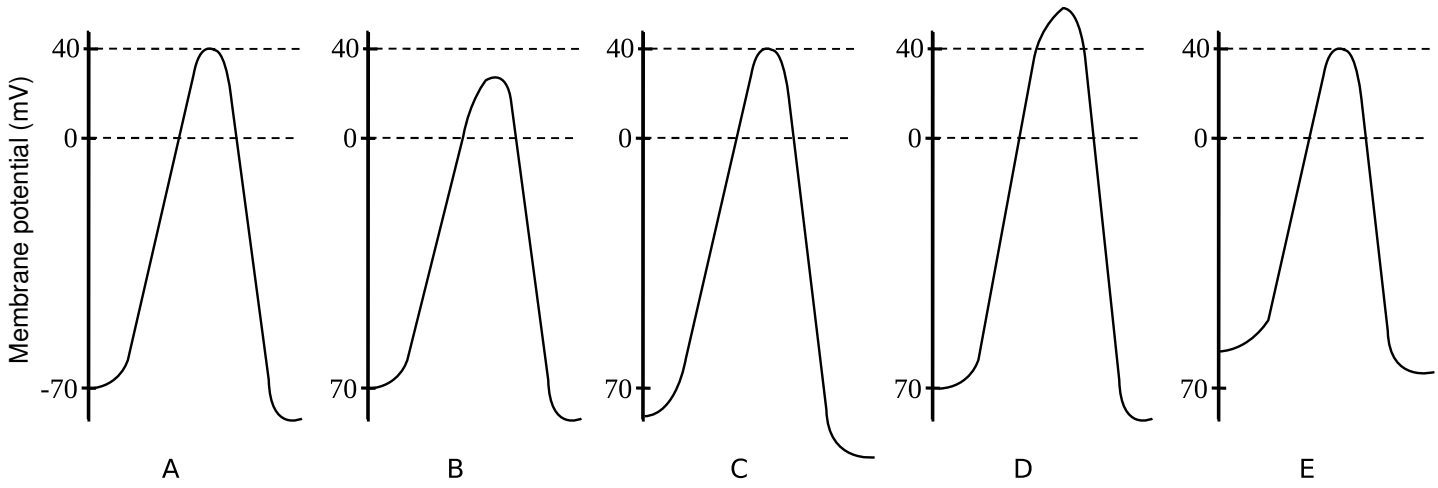


Figure Q.22.

Indicate in the Answer sheet if each of the following statements is True or False.

A. If the modified Ringer solution contained a lower concentration of Na^+ than the standard Ringer solution, the action potential is Record B.

B. If the modified Ringer solution contained a lower concentration of K^+ than the standard Ringer solution, the action potential is Record C.

C. If the modified Ringer solution contained a substance that increased membrane permeability to K^+, the action potential is Record D.

D. If the modified Ringer solution contained a substance that increased membrane permeability to Cl^-, the action potential is Record E.

Q.23

A group of researchers conducted an experiment to study the effects of phlorizin on some physiological indices in blood and urine of normal mice and diabetic mice. Phlorizin is an inhibitor of SGLT2 which is the channel of glucose reabsorption in the kidney. Assume expression of SGLT2 gene is positively correlated with urine glucose level and blood glucose also correlates positively with blood pressure.
Mice were divided into four groups:
Group 1: Normal mice were injected with phlorizin
Group 2: Mice with severe type 2 diabetes induced by streptozotocin injection
Group 3: Streptozotocin induced-type 2 diabetic mice were injected with phlorizin
Group 4: Normal mice as controls
After the four-week experiment, physiological indicators of blood, urine and renal SGLT2 expression of the mice were measured.

Indicate in the Answer sheet if each of the following statements is True or False.

A. The blood pressure of Group 3 mice was lower than that of Group 2 mice.

B. The SGLT2 gene expression levels in the kidneys of Group 2 mice were lower than those of Group 4 mice.

C. The volume of urine of Group 1 mice was higher than that of Group 4 mice.

D. The quantity of SGLT2 molecules in the kidney medulla is higher than that in the kidney cortex.

Q.24

Polycystic ovarian syndrome (PCOS) is a common disorder of women characterized by increased levels of testosterone and by chronic failure in ovulation. The ovary can be stimulated to produce more testosterone when insulin levels in the blood are high.

Indicate in the Answer sheet if each of the following statements is True or False.

A. PCOS patients are more likely to have acne than healthy people.

B. PCOS patients have progesterone level higher than healthy people.

C. Obese women have a higher risk of PCOS than normal-weight women.

D. Follicle-stimulating hormone (FSH) and Luteinizing hormone (LH) can be used to increase the probability of PCOS women to conceive.

Q.25

In the gills of freshwater teleost fishes, the blood plasma is separated from the freshwater by a thin epithelium so that the blood plasma tends to lose ions such as Na^+ and Cl^- to the ambient water across the gill epithelium and H_2O tends to enter the plasma from the ambient water across the gill epithelium. There are transport mechanisms by which inorganic ions and water cross the gill epithelium and they help to maintain the difference in the ion composition between the plasma and the ambient water. Figure Q.25 shows the transportation of four ions across the gill epithelium.

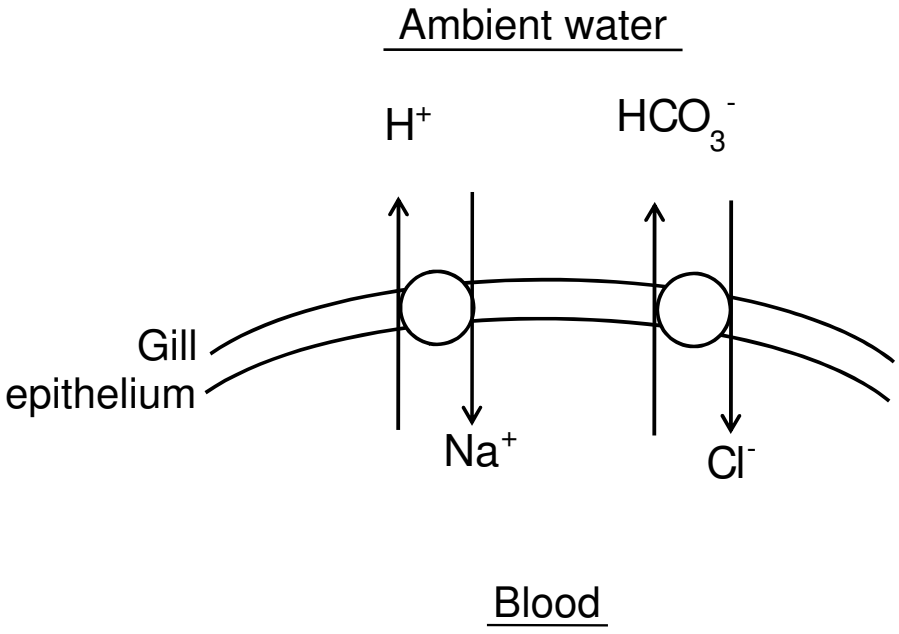


Figure Q.25.

Indicate in the Answer sheet if each of the following statements is True or False.

A. Inhibition of the Cl^- pump leads to an increase in blood pH.

B. An increase in CO_2 produced by catabolism leads to an increase in Na^+ and Cl^- transports across the epithelium cell.

C. A substance blocking the electron transport chain causes a decrease of Na^+ influx, but does not affect HCO_3^- outflux at the gill epitellium.

D. During alkalosis, the epithelial cell increases the synthesis of a key Cl^-/HCO_3^- countertransport protein.

Q.26

Two groups of students separately performed an experiment on kidney function. Thirty minutes before the experiment, each student in one group was instructed to drink 500 mL of water, while each student in the other group was instructed to drink 100 mL of water. At t = 0 minute, each student in both groups was instructed to drink 750 mL of water. Each student was then asked to urinate as he or she would normally do without attempting to manipulate the speed or flow in any way at the different time points shown in Figure Q.26. An electronic uroflowmeter was used to measure the urine flow rate. The Cl^- concentration in each urine sample was measured. Figure Q.26 shows the data of the experiment.

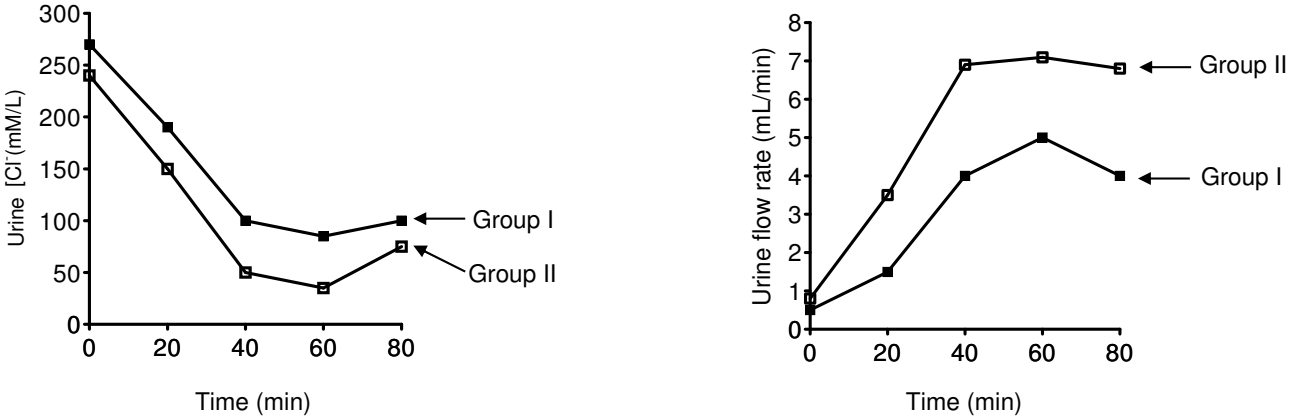


Figure Q.26.

Indicate in the Answer sheet if each of the following statements is True or False.

A. The absolute reabsorption of water by nephrons of the students in Group II at t = 60 min was lower than that of the students in Group I.

B. The plasma aldosterone concentration of the students in Group I was the highest at t = 60 min.

C. The students in Group I drank 500 mL of water 30 minutes before the experiment.

D. The students in Group II produced about 140 mL of urine during the period between t = 40 min and t = 60 min.

Q.27

Figure Q.27 shows the changes in metabolic rates of adult individuals of five animal species in response to temperature changes of the external environment (EM). The individual body weights of the five species were similar (about 30 grams). The data were measured from the animals when they were staying at rest.

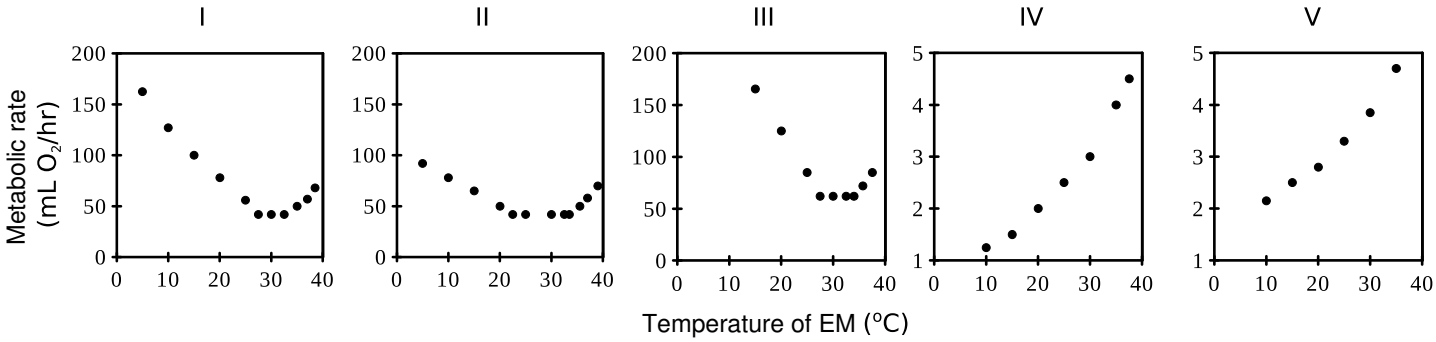


Fig. Q.27

Indicate in the Answer sheet if each of the following statements is True or False.

A. Species IV was an ectothermic animal.

B. Species II had the highest thermo-insulating ability among the five species.

C. Species III possessed the highest basal metabolic rate among the five species.

D. Increase in body temperature in species V was mainly dependent on metabolism.

Q.28

BDNF, a brain protein, is crucial for neuron activities. BDNF is activated during the activation of neurons of the limbic system. An important function of BDNF in mammals is shown in Figure Q.28. The signal via the catecholamine receptor (β-AR) has a specific positive effect on the browning process and thermogenesis.

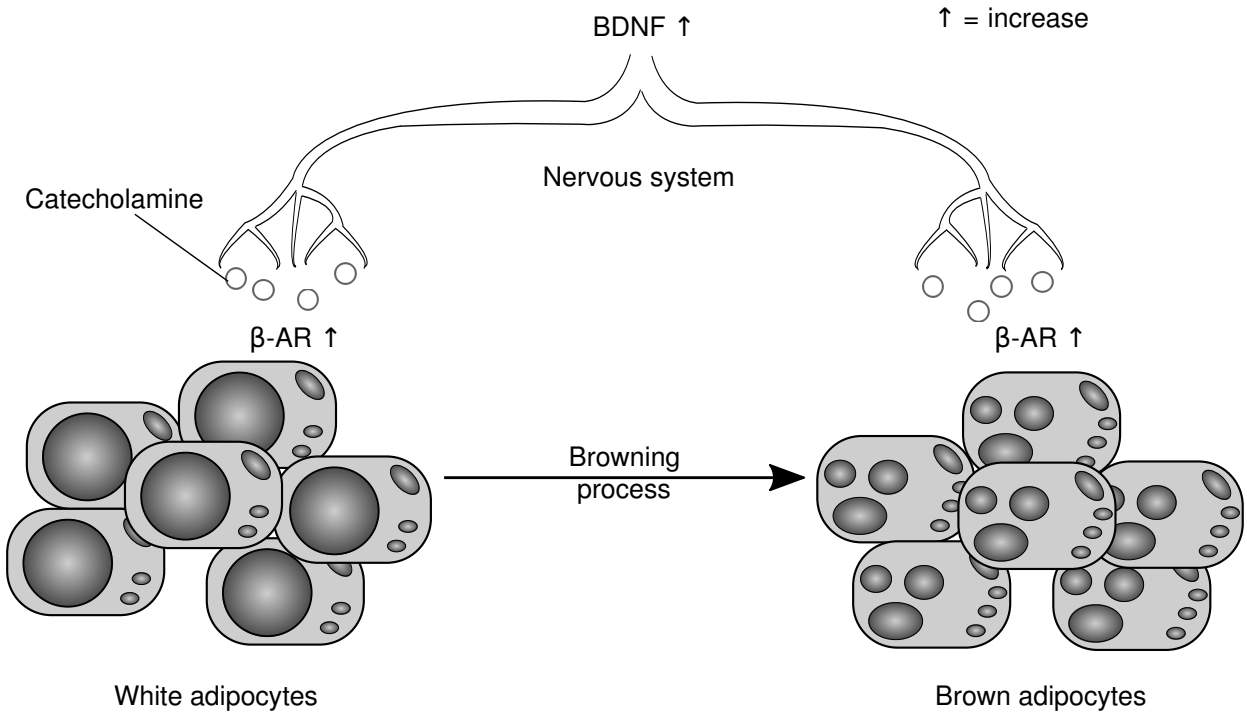


Fig. Q.28

Indicate in the Answer sheet if each of the following statements is True or False.

A. Regularly learning and memorizing activities help to increase the number of brown fat cells.

B. Inhibition of BDNF expression reduces the size of white adipose tissue.

C. Psychological anxiety increases the manifestation of the β-AR.

D. β-AR gene-deleted mice will show higher sensitivity to cold

Q.29

The skeletal muscle fibers are divided into three types depending on the speed and energy sources of muscle contraction:
Type I: Slow twitch, oxidative muscle fibers.
Type IIa: Fast twitch, oxidative muscle fibers.
Type IIb: Fast twitch, glycolytic muscle fibers.
Figure Q.29 shows the correlation of mRNA expression levels of the genes *Myh7*, *Myh2*, and *Myh1* specific for muscle fiber types I, IIa, and IIb, respectively, in human skeletal muscles of legs: quadriceps, gastrocnemius, and soleus muscles.

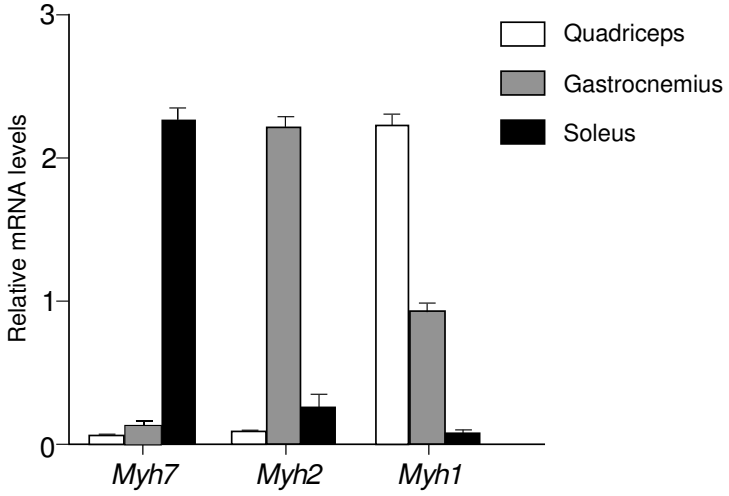


Figure Q.29.

Indicate in the Answer sheet if each of the following statements is True or False.

A. The soleus muscles of the sprinter athletes are prone to be more developed than those in the marathon athletes.

B. The ratio of mitochondria number per muscle mass in the quadriceps muscle is less than that in the gastrocnemius muscle.

C. The soleus muscle contains less sarcoplasmic reticulum than the gastrocnemius muscle does.

D. Regularly doing the endurance exercise for a long period of time can increase the number of glycolytic muscle fibers in the gastrocnemius muscles.

Q.30

Figure Q.30A shows an insulin secretion and the mechanism by which insulin stimulates glucose absorption into cell. The mechanism includes four steps depicted by the four circled digits 1 to 4.
Four patients (E, F, G and H) had a defect each in a single step of the above mechanism. Patients E, F, G and H had defect in steps 1, 2, 3 and 4, respectively. These patients were given two tests:
- Test 1: Muscle cells from each patient were isolated and the percentage of insulin binding cells at different concentrations of insulin was determined (Figure Q.30B).
- Test 2: Each patient was injected with same insulin quantity related to their body mass and their plasma glucose concentrations were then measured at various times after injection (Figure Q.30C).

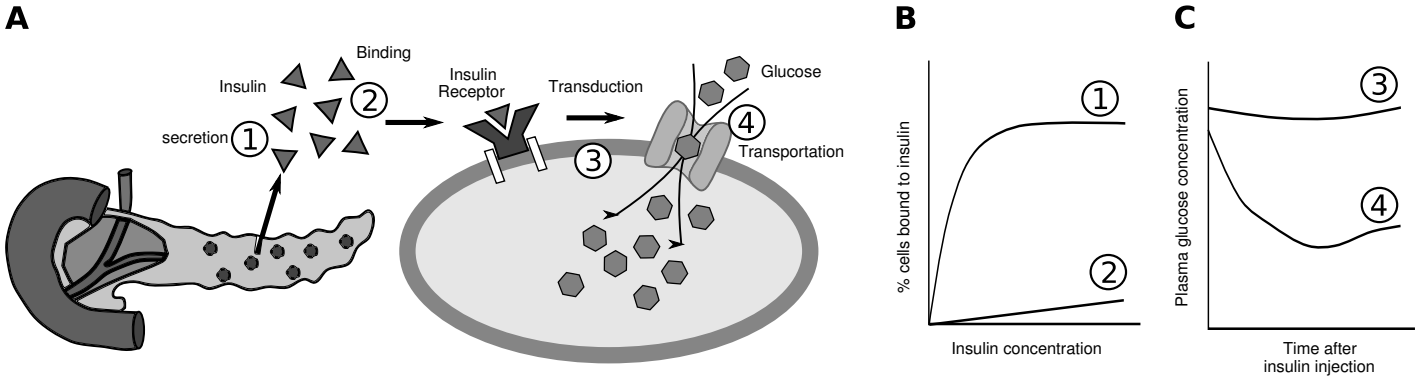


Figure Q.30

Indicate in the Answer sheet if each of the following statements is True or False.

A. The result of Test 1 of Patient G could be shown in Line 1.

B. Lines 2 and 3 show the results of Tests 1 and 2, respectively, of Patient F.

C. Line 3 shows the tested result of Patient E.

D. Lines 1 and 4 show the results of Tests 1 and 2, respectively, of Patient H.

ETHOLOGY

Q.31

The territorial behavior of the red-whiskered bulbul (*Pycnonotus jocosus*) was studied during pre-nesting and nesting periods. Songs of decoys were played from ten different locations around a farmhouse, where the test birds lived, and the time taken to start displaying territorial behavior by the resident male measured at the different locations (Table Q.31). The resident bird defended the territory with aggressive calls, threat display and tried to attack the decoy.
Table Q.31

Station	C	I	K	G	H	B	F	J	D	E
Distance (m)	20	50	110	30	50	19	46	72	29	38
Direction	N	N	N	S	S	E	E	E	W	W
Pre-nesting										
Territory defense	+	+	-	+	-	+	+	-	+	-
Response time	1	3	>10	5	>10	1	3	>10	4	>10
Nesting										
Territory defense	+	+	-	+	-	+	+	-	+	-
Response time	0.2	1	>10	0.7	>10	0.3	2.5	>10	1	>10

Table Q.31. Mean response time = time taken to start displaying territorial behavior (minute). (+) signifies territory defense whereas (-) stands for “no territory defense”. N= north, S= south, E= east and W = west.

Based on this information, indicate in the answer sheet if each of the following statements about the behavior of the birds is true or false.

A. The territory size during the pre-nesting period was smaller than that during the nesting period.

B. The quadrangle made by stations G, D, I and F marks the territory size of the bird.

C. The male responded more rapidly to the decoy within its territory during the nesting period.

D. The intensity of territorial behavior displayed is a dependent on seasonal fluctuation of hormones.

Q.32

Female vampire bats live in colonies made up of unrelated females and their offsprings, and they feed exclusively on blood of herbivores. The fully-fed bats often share some of the blood that they collected with bats that are starving, and are more likely to receive blood from these individuals when they themselves starve.

Indicate in the answer sheet if each of the following statements about this behavior of bats is mostly true or false.

A. Kin selection plays an important role in evolution of the sharing behavior in vampire bats.

B. Vampire bats are likely to live in colonies only for short periods of time.

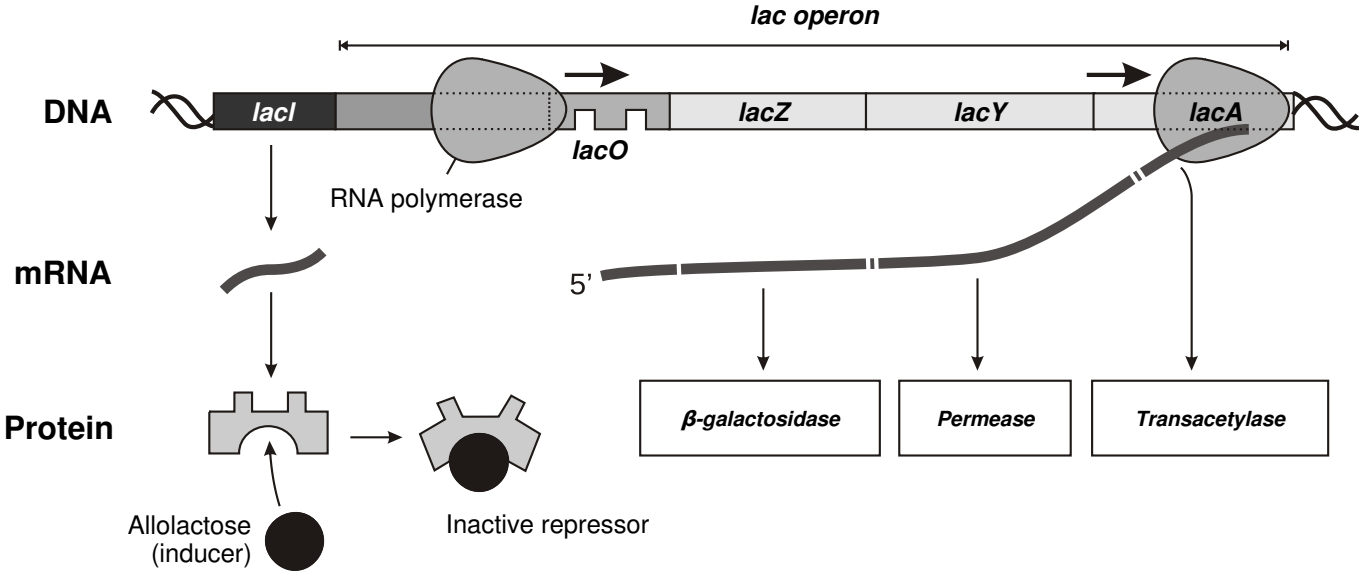
C. The bats showing this behavior have higher indirect fitness than if they would not do so.

D. Vampire bats are able to recognize and remember other individual bats.

GENETICS AND EVOLUTION

Q.33

Mr. Long had ten strains of *Escherichia coli* with different mutations in their *lac* operon. Analyzing their DNA, he found that each strain is one of five mutation types: *lacZ*$^-$, *lacY*$^-$, *lacI*$^-$, *lacI*^{S} (the repressor LacI^S can bind to the operator but cannot bind to the inducer), or *lacO*^{c} (the mutated operator *lacO*^{c} cannot be bound by the repressor). Mr. Long also knew that strain number 6 is a *lacZ*$^-$ mutant. Operon *lac* is shown below.



Mr. Long isolated DNA containing the *lac* operon from each strain (donor) and transformed it into other strains, thus making the strain merodiploid (recipient). Thereafter recipient strains were cultured on minimal medium that contained lactose as the only carbon source. Growth of the strains was recorded in the table below (+ means that the strain is growing, - means that the strain is not growing).

Recipient strains	Donor strains 1	2	3	4	5	6	7	8	9
2	-								
3	-	+							
4	-	+	+						
5	+	+	+	+					
6	-	+	+	+	+				
7	-	+	+	+	+	-			
8	-	-	-	-	+	-	-		
9	+	+	+	+	+	+	+	+	
10	-	+	-	+	+	+	+	-	+

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

A. Strain number 7 is a *lac Z*$^-$ mutant.

B. Strain number 3 is a *lac Y*$^-$ mutant.

C. Strains number 2 and 4 are of the same mutation type.

D. If strain number 5 receives DNA from itself, the transformed bacteria cannot grow.

Q.34

Mr. Long analyzed DNA samples from three families using six loci of short tandem repeat (STR) on six different autosomal chromosomes. Each STR locus usually has many different alleles that are labeled by numbers, e.g. 3 and 5 for locus 1 of Huong sample, in the table. In the first family, the father is Hung, the mother is Huong and their son is Dung. In the second family, the father is Nhan and his two sons are Tin and Nghia. In the third family the father is Phu, and his son is Quy. Mr. Long also included a DNA sample from Dat who is unrelated to any of the three families. Samples were randomly encoded with numbers but the key was lost except for Huong's sample.

DNA samples	STR loci					
	Locus 1	Locus 2	Locus 3	Locus 4	Locus 5	Locus 6
Huong	3/5	2/2	5/6	3/3	1/2	2/6
669	3/5	2/7	4/9	5/8	3/7	4/5
297	1/5	3/3	3/3	6/9	2/7	4/8
653	1/5	2/2	6/6	3/7	2/9	4/5
735	5/7	2/4	5/5	3/4	2/2	1/2
130	5/7	7/7	5/9	3/8	2/7	4/5
860	1/6	2/3	3/5	6/7	1/7	2/8
938	3/7	4/5	5/6	4/4	2/3	1/2
264	3/7	7/7	1/4	5/9	7/9	3/4

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

A. Sample 735 is Dat's DNA.

B. Sample 669 is Nhan's DNA.

C. Sample 938 is Hung's DNA.

D. Sample 297 can be Phu's DNA.

Q.35

Centromere position can be mapped using linear tetrads in some fungi. If there is no cross-over between gene E and the centromere, four spores are arranged in sequence of eeEE or EEee (Fig.Q.35A). If there is a cross-over between gene E and the centromere, four spores are arranged in sequence of eEeE or EeEe (Fig.Q.35B). There are many types of crossovers involving 2, 3 and 4 strands of chromatids as illustrated in Fig.Q.35C.

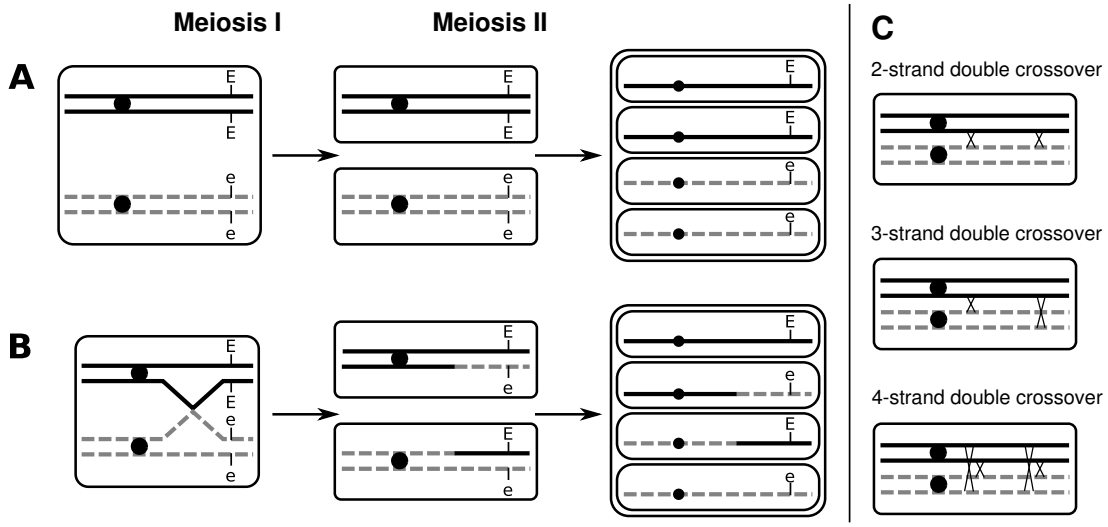


Figure Q.35

Strain ab was crossed to strain a+ b+ and 100 linear tetrads were isolated. Those tetrads were divided into six classes as shown in the following table:

Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
ab	ab	ab	ab	ab^+	ab
a^+b	ab^+	ab	a^+b^+	a^+b	a^+b^+
ab^+	a^+b	a^+b^+	ab	ab^+	ab^+
a^+b^+	a^+b^+	a^+b^+	a^+b^+	a^+b	a^+b
15	29	47	2	2	5

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

A. Locus a and b are located on the same arm of chromosome.

B. Class 4 involves a 4-strand double crossover.

C. Class 6 involves a 3-strand double crossover, with one between gene a and the centromere and between the centromere and gene b.

D. Class 5 involves a 2-strand double crossover.

Q.36

Heritability in broad sense (H^2) is the ratio of total genetic variance (V_g) to total phenotypic variance (V_p): $\mathbf{H^2 = V_g/V_p}$. The phenotypic variance is often divided into three components: the genetic variance (V_g), environmental variance (V_e) and the interaction variance (V_i), $V_p = V_g + V_e + V_i$. The genetic variance is divided into three components: the additive genetic variance (V_a, cumulative effects of individual loci), the dominant genetic variance (V_d), and the genetic interaction variance (V_{gi}), $V_g = V_a + V_d + V_{gi}$. Heritability in narrow sense $\mathbf{(h^2) = V_a/V_p}$.

Indicate in the answer sheet if each of the following statements about heritability is true or false

A. A low H^2 value of a trait always indicates that the trait is determined mainly by the environment.

B. Genetic variance depends on the environment to which the population is exposed.

C. The artificial selection for a trait with higher h^2 is more successful than that for a trait with lower h^2.

D. Two pure strains of bean that produce seeds with different weights were crossed. The variances of seeds (V_p) from F_1 and F_2 plants are 2.0 and 4.1, respectively. If we ignore interaction effects, H^2 of seeds is 0.51.

Q.37

F.D. Enfield selected for increased body size in the flour beetle *Tribolium castaneum*. He started with a population of beetles that had a mean weight of 2.4 g and variance of 4.0 g^2. For each generation, the selection differential (the difference between the mean of a generation subset selected for further breeding and the overall mean of that generation) was 0.022g. The initial value of h^2 (heritability in narrow sense- h^2 is the ratio of the additive variance to the total phenotypic variance) for body size in the original population was 0.3. For the first 50 generations, the mean weight of the selected population increased steadily. After 125 generations of selection, the mean weight had increased to 5.8g, more than twice the original mean, and additional selection did not result in a further increase in size. The lightest individuals in the selected population were heavier than the heaviest individuals in the original population. Enfield determined h^2 for the selected population after 125 generations and discovered that it was only slightly less than for the original population.

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

A. The failure of the population to respond to further selection was because the population genetic variation is exhausted.

B. The reason why the mean of the population could be shifted to a value outside the original range of the population is that the selection for the increased the body size is a selection favoring heterozygotes.

C. After 125 generations of selection, additional selection can result in a further increase in size if we increase the selection differential (higher than 0.022g).

D. If selection was stopped after 125 generations of selection then the body size would decrease.

Q.38

A mutated male mouse that is phenotypically normal shows reproductive anomalies when compared with a normal male in terms of mean number of embryos as shown in Table Q.38. The anomaly manifests itself after fertilization.

Mean number of embryos

Mating	Implanted in uterine wall	Degeneration after implantation	Normal	Degeneration (%)
mutated ♂ X normal ♀	8.7	5.0	3.7	57.5
normal ♂ X normal ♀	9.5	0.6	8.9	6.5

Study carefully data given in the table and indicate in the answer sheet if each of the following statements is true or false.

A. The mutated male mouse can have a chromosome deletion.

B. The mutated male mouse can be a chromosomal translocation heterozygote.

C. The mutated male mouse can be a chromosomal inversion heterozygote.

D. The genetic defect in mutated male could be verified by cytological observation of meiotic cells in the mouse.

Q.39

Speciation rates are variable in different lineages of organisms. Some lineages have many species; others have only a few.

Indicate in the answer sheet if each of the following statements about the factors influencing speciation rates is true or false.

A. The larger the number of species in some lineages, the larger number of opportunities for new species to form.

B. Animal-pollinated plant families have, on average, more species than closely related families pollinated by wind.

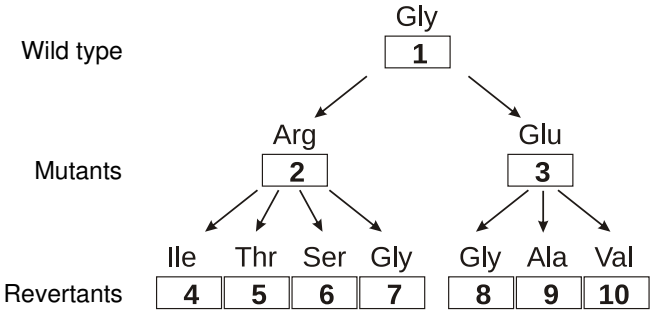
C. Animals with complex mating behavior are likely to form new species at a low rate.

D. Oscillations of climates may increase the speciation rate.

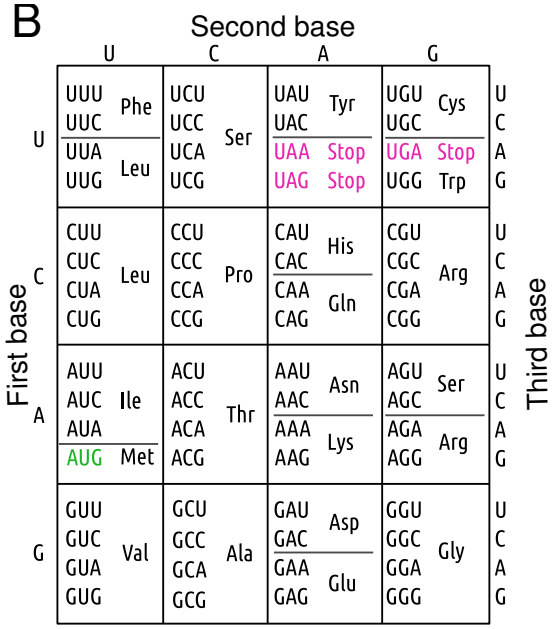
Q.40

About 50 years ago, Charles Yanofsky studied the sequence of the tryptophan synthetase of *E. coli*. The wild type protein (*1*) has a glycine in position 38. Yanofsky isolated two inactive *trp* mutants: *2* and *3*. Mutant *2* had Arg instead of Gly at position 38, and mutant *3* had Glu at position 38. Mutants *2* and *3* were plated on minimal medium (without tryptophan). Colonies appearing correspond to spontaneous mutations that restored tryptophan synthetase function. The amino acid at position 38 was identified as described in figure A. Assume that each amino acid replacement results from a single base-pair change.

A



B



Indicate in the answer sheet if each of following statements about codon 38 of tryptophan synthetase is true or false.

A. Mutant *2* results from a base substitution at the first position of the codon.

B. Strains *7* and *8* likely have the same sequence as the wild type strain.

C. The codon in strain *10* is 5'GUA3'

D. The codon in strain *6* is 5'AGC3'.

Q.41

Frequencies of the human AB0 blood group alleles in a population are p(I^A) = 40%, p(I^B)=40% and p(i)=20%.

Assuming that the population is in Hardy-Weinberg equilibrium, indicate in the answer sheet if each of the following statements is true or false.

A. In this population, the number of persons with the blood groups A and B should be equal.

B. In this population, the number of persons with the blood groups A and AB should be equal.

C. In this population the frequency of persons with anti-B antibodies is 64%.

D. Locus AB0 is localized on an autosomal chromosome because the blood group frequencies are the same for men and women.

Q.42

Frequency-dependent selection is an evolutionary process where the fitness of a phenotype depends on its frequency relative to other phenotypes in a given population. In **positive** frequency-dependent selection, the fitness of a phenotype increases as it becomes more common. And in **negative** frequency-dependent selection, the fitness of a phenotype decreases as it becomes more common.

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

A. Plant self-incompatibility alleles are an example of negative frequency-dependent selection.

B. Spreading of a newly emerged virus in a human population is controlled by negative frequency-dependent selection.

C. Prevalence of *Papilio memnon* whose females resemble distasteful *Papilio coon* is an example of positive frequency-dependent selection.

D. Spread of genes responsible for warning coloration in toxic organisms in population is controlled by positive frequency-dependent selection.

ECOLOGY

Q.43

A population of dragonfly larvae (*Leucorrhinia intacta*) is separated into two groups. In both groups, larvae populations are put inside a cage with no food limitation. The first group is exposed to a fish predator that can swim freely, but cannot enter the cage. The second group is a control with no fish. The proportion of larvae surviving and the proportion of live larvae failing to metamorphose in the two groups are shown below:

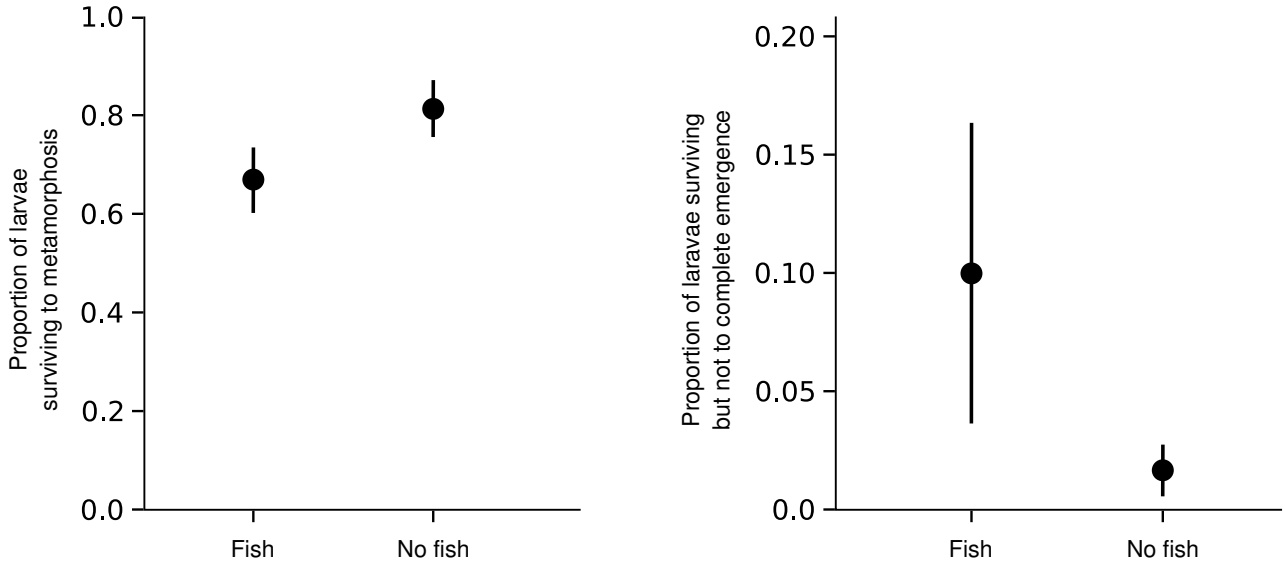


Figure Q.43

Indicate in the **Answer sheet** if each of the following statements is True or False.

A. One of the causes of high failure rate of metamorphosis of the larvae upon exposure to a non-lethal predator is cannibalism.

B. The high mortality of larvae in the first group is due to predator-induced stress.

C. In the predator treatment, the percentage of individuals that survived the larval stage completed emergence to the adult stage is lower than the percentage of those in the fishless treatment.

D. The survival of dragonfly before metamorphosis is dependent on the predator while those during metamorphosis is not.

Q.44

Laboratory experiments were conducted to examine the effects of temperature on interspecific competition between two stream salmonid fishes, *Salvelinus malma* and *S. leucomaenis*, with largely allopatric altitudinal distribution. Three combinations of species population, including allopatric populations of *S. malma* and *S. leucomaenis*, and sympatric populations of both species, were treated with low temperature (6°C) and high temperature (12°C), in which thriving allopatric populations of *S. malma* (6°C) and *S. leucomaenis* (12°C) are commonly found.

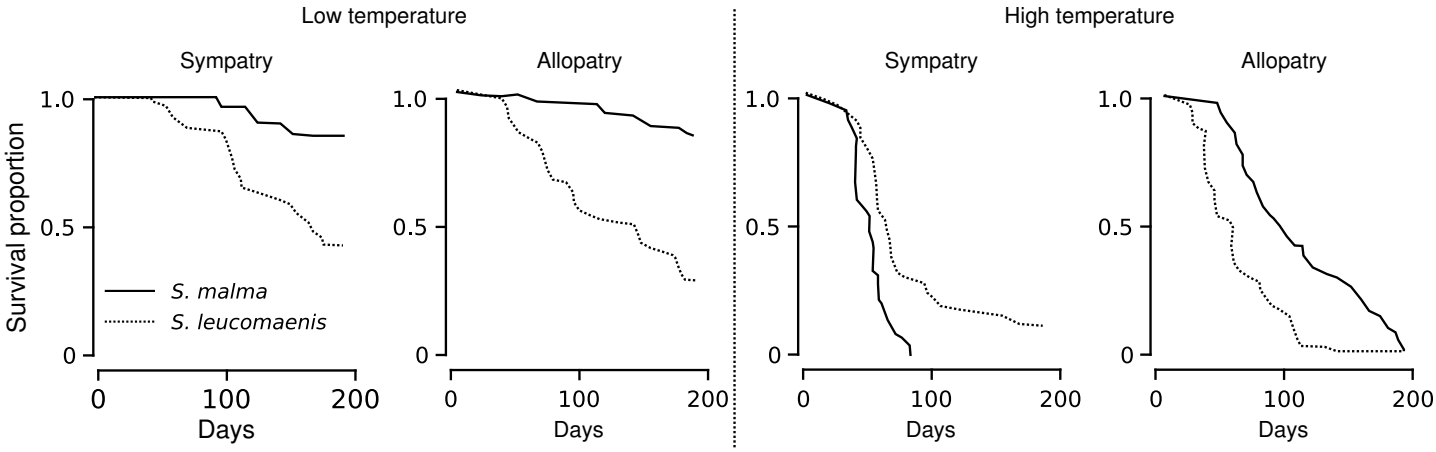


Figure Q.44

Indicate in the **Answer sheet** if each of the following statements is True or False.

A. Competition of these two species is likely to have been affected by temperature and altitude

B. *S. malma* may be distributed at higher altitudinal ranges than is *S. leucomaenis*

C. *S. leucomaenis* is likely to be more low-temperature stress-resistant than S. *malma*

D. *S. malma* has a narrower fundamental niche than does *S. leucomaenis*

Q.45

Male guppies (*Poecilia reticulata*) show a complex color pattern polymorphism that varies with predation pressure, reflecting a balance between selection for crypsis by predators and selection for conspicuousness by sexual selection. Three experimental ponds were used to study this phenomenon, mimicking the real condition on the native habitat of the guppies and its predators, *Rivulus hartii* and *Crenicichla alta*. One pond has the control group while the other two ponds were added with one of the two predators. In the field, *C. alta* was observed to be more dangerous than *R. hartii*.

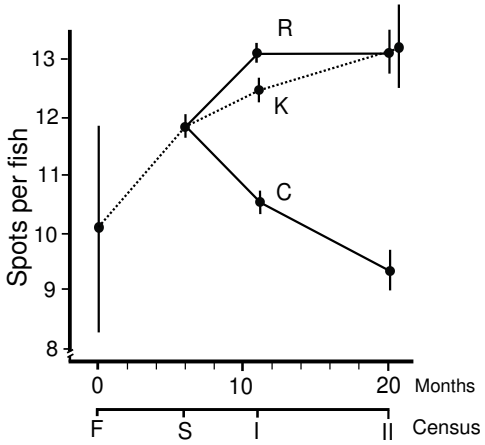


Figure Q.45. Changes in the number of spots per fish during the course of the experiment. Line 'K' stands for pond without predator, 'R' for pond with *R. hartii*, and 'C' for pond with *C. alta*. In the X-axis, 'F' stands for the time when the foundation population was started, 'S' stands for the time when the predators were added, then 'I' and 'II' stands for the numbering of the following censuses.

Indicate in the **Answer sheet** if each of the following statements is True or False.

A. The color pattern is responsible for the reduced fitness of *P. reticulata*.

B. Sexual selection for color pattern of the *P. reticulata* cannot be inferred from the data.

C. The color pattern of the *P. reticulata* may be advantagous in escaping *R. hartii*.

D. The two predators possibly use two different mechanisms to detect *P. reticulata*.

Q.46

The dioecious perennial *Poa* grass coexists with *Stipa* grass in the steppes. The former is highly preferred by domestic and wild herbivores, while the latter is relatively unpalatable. Scientists grew *Poa* plants in different distances to *Stipa* plants, with or without root barrier, in different grazing levels, and then recorded the growth of *Poa* plants.

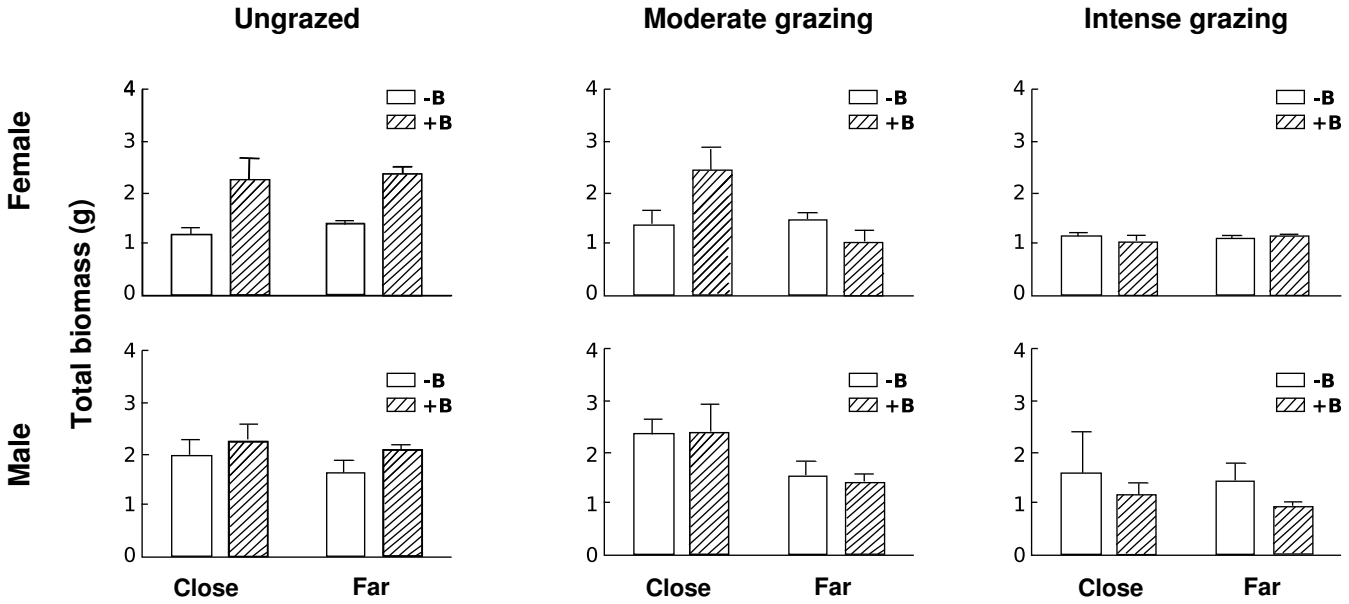


Figure Q.46-1. Effects of distance (close and far) and barrier (without barrier (-B) and with the barrier present (+B)) to root competition manipulations on *Poa* female (top panels) and male plants (bottom panels) total biomass, at each grazing intensity level.

In another experiment, they recorded the density of *Poa* male and female plants under differenet grazing levels.

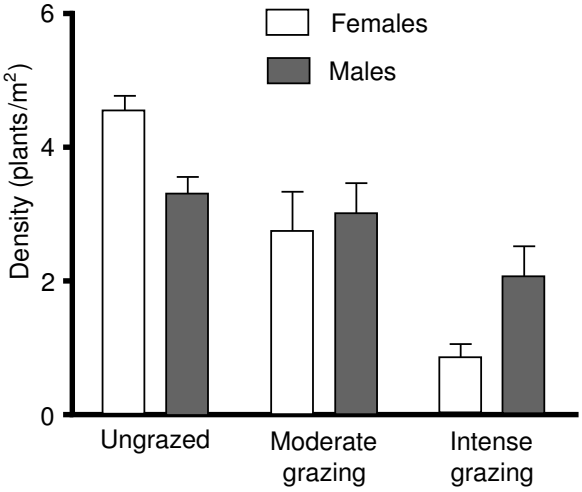


Fig.Q.46-2

Indicate in the **Answer sheet** if each of the following statements is True or False.

A. Distance to the less palatable *Stipa* neighbours affects the *Poa* biomass of females and males at the ungrazed site.

B. Plants at the moderate grazing site, whether male or female, generally perform better near *Stipa* tussocks than far from them, demonstrating a positive effect of *Stipa* canopies on both genders.

C. There is a strong below-ground competition between *Poa* females and *Stipa* neighbours at the ungrazed site.

D. Population sex ratio drift between female and male bias is influenced by domestic grazing intensity.

Q.47

Goats are fed with alfalfa and corn stubble. At time 0, they were also fed with *Mimosa* seeds. The presence of viable *Mimosa* seeds in goat faeces was recorded with a germination experiment with egested and control seeds.

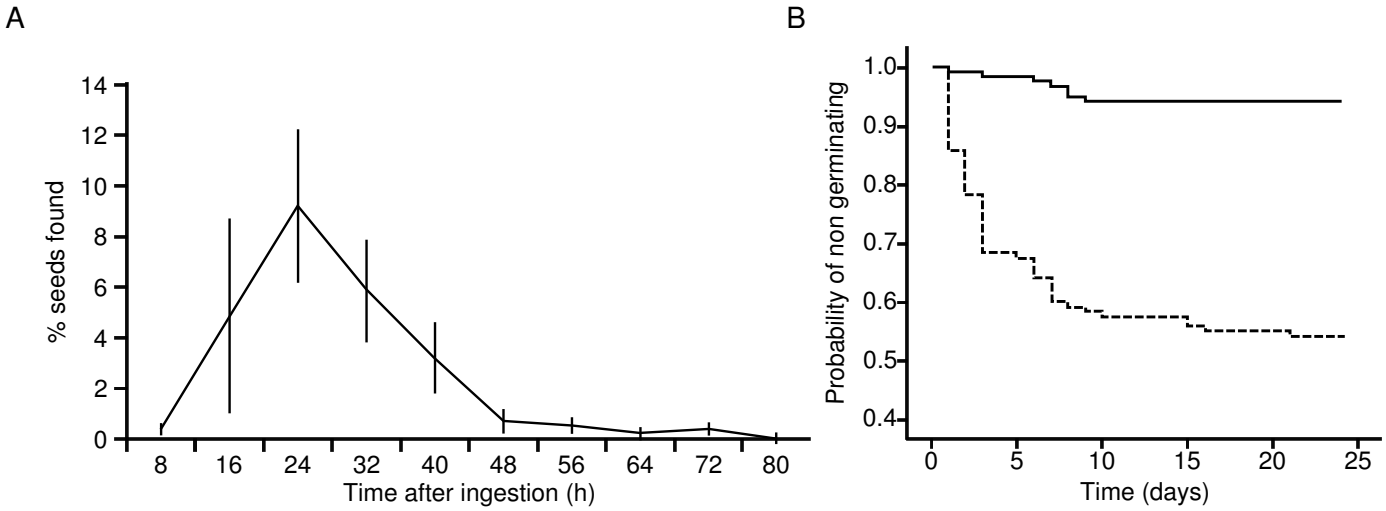


Figure Q.47 A: *Percent of Mimosa seeds found in goat faeces as a function of time after ingestion. Goat pellets were collected every 8 hours over a period of 80 hours after ingestion.* **B***: Probability of non germinating of egested (stippled line) and control (solid line) Mimosa seeds.*

Indicate in the **Answer sheet** if each of the following statements is True or False.

A. *Mimosa* seed can survive up to 3 days in the goat digestive system.

B. The passage through the goat digestive system decreases seed germination.

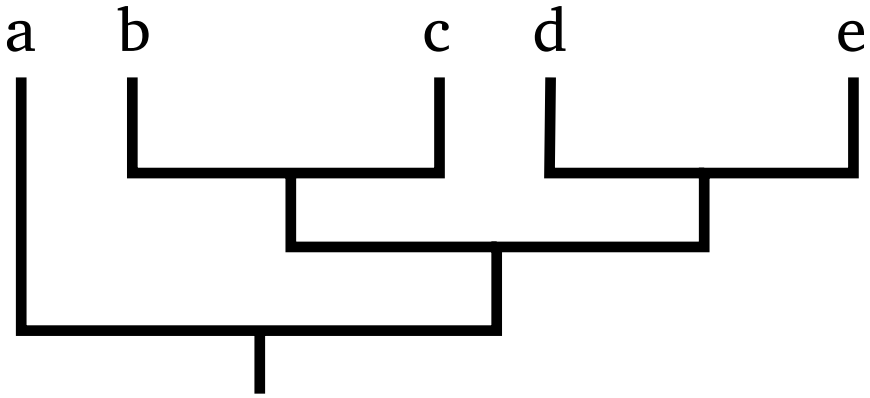
C. Number of seeds egested after ingestion is highest after 24 hours.

D. Goats could act as legitimate disperser of *Mimosa* seeds.

BIOSYSTEMATICS

Q.48

Study the cladogram given below and indicate if each of the following statements is true or false.



Indicate in the **Answer sheet** if each of the following statements is True or False.

A. The clade containing (d) and (e) is a sister group to the taxon consisting of (a), (b) and (c).

B. The last common ancestor of (b) and (c) descended from the last common ancestor of (c) and (d).

C. Taxon (b) is more closely related to taxon (a) than to taxon (e).

D. The lineage leading to taxon (a) was the first to diverge from the other lineages.

Q.49

Most taxonomists today believe that biological classification systems should reflect the evolutionary relationships of organisms and taxonomic groups should be monophyletic. However, the classification used today still contains many polyphyletic and paraphyletic taxonomic groups.

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

A. Polyphyletic taxa can arise when taxa that are not directly related share similar character states due to convergence

B. If a classification is based on phenotypic similarity, paraphyletic taxonomic groups may result

C. Some taxa in a paraphyletic taxonomic group have phenotypically evolved at different rates compared to closely related taxa that are not included in the group.

D. All molecular data support gymnosperms as a monophyletic taxon.

Q.50

Using sequence differences to establish phylogenies has some advantages and possible dangers. An inappropriate choice of molecule could result in molecular trees that greatly distort true phylogenetic relationships. Hence, care must be taken in using this approach.

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

A. Polypeptide sequences of cytochrome c are very useful for establishing evolutionary relationships between closely related species.

B. For phylogenetic analysis, comparing partial sequences from many different genes is better than comparing full-length sequences of several genes.

C. Rates of nucleotide substitution per unit of time are faster in organisms with short generation times than in organisms with long generation times.

D. The Neutral Theory requires that all polypeptide and DNA sequences evolve at the same rate.

END OF THEORY PART A