

## INSTRUCTIONS SHEET – INBO 2013

The question paper is divided into Section A and Section B.

All answers should be **written in the answer sheet booklet only** which will be collected at the end of the examination.

The question paper need not be submitted to the examiner.

### Section A

- Section A consists of 34 questions carrying 1 point each.
- All 34 questions are of multiple choice type, with only one correct answer for each question.
- Mark the correct answer with '✓' on the answer sheet provided. The correct way of marking is shown below. Use a pen to mark your answer.

Q. No.	a	b	c	d
		✓		

- Each wrong answer will have negative marking as indicated in the scoring key.

### Section B

- Section B consists of 22 questions with a total of 66 points.
- The points for the questions in Part B vary depending on the number of answers and the complexity of the question. These points have been indicated along with the question.
- Contradictory answers will not be considered for marking.

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### SCORING KEY

**NO. OF CORRECT ANSWERS: X**

**NO. OF INCORRECT ANSWERS: Y**

**SCORE INBO (THEORY): SECTION A: 3X – Y**

**SECTION B: 3X**

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**INDIAN NATIONAL BIOLOGY OLYMPIAD – 2013**  
**SECTION A**

**CELL BIOLOGY (5 points)**

1. (1 point) The standard free energy change and standard activation energy for four biochemical reactions are listed in the table below:

Reaction	Standard free energy change (kcal/mol)	Standard activation energy (kcal/mol)
P	- 40	18
Q	-71	18
R	- 40	11
S	-71	11

A few interpretations are given below. Among these, the most appropriate interpretation is:

- a. P, Q, R and S represent the same reaction carried out in the presence of enzyme, high temperature, absence of enzyme and low temperature, respectively.
  - b. Q and S represent the same reaction carried out at high and low temperatures, respectively.
  - c. R and S represent the same reaction carried out in the presence and absence of catalyst, respectively.
  - d. P and R represent the same reaction carried out in the absence and presence of enzyme, respectively.
2. (1 point) For a somatic cell with  $2n = 4$ , which of the following is true?  
(Note: G1- growth phase 1, G2 - growth phase 2, M - metaphase, P - prophase and T - telophase)
- a. (Number of chromatids)<sub>G2</sub> = 4; (Number of chromosomes)<sub>G1</sub> = 4
  - b. (Number of chromatids)<sub>G1</sub> = 8; (Number of sister chromatids)<sub>T</sub> = 8
  - c. (Number of chromatids)<sub>P</sub> = 8; (Number of chromosomes)<sub>G2</sub> = 4
  - d. (Number of chromatids)<sub>G2</sub> = 4; (Number of chromosomes)<sub>M</sub> = 8

3. (1 point) Differential centrifugation separates cellular components based on the differences in their size and / or density. A tissue sample was homogenized and three parts (aliquots) of this homogenate were subjected to differential centrifugation using three different methods as indicated below:

Method I: Aliquot 1 was centrifuged at 200,000g for 2 h.

Method II: Aliquot 2 was centrifuged at different speeds and for variable durations as indicated below:

Step 1: 1,000g for 10 min

Step 2: 20,000g for 20 min

Step 3: 80,000g for 1 h

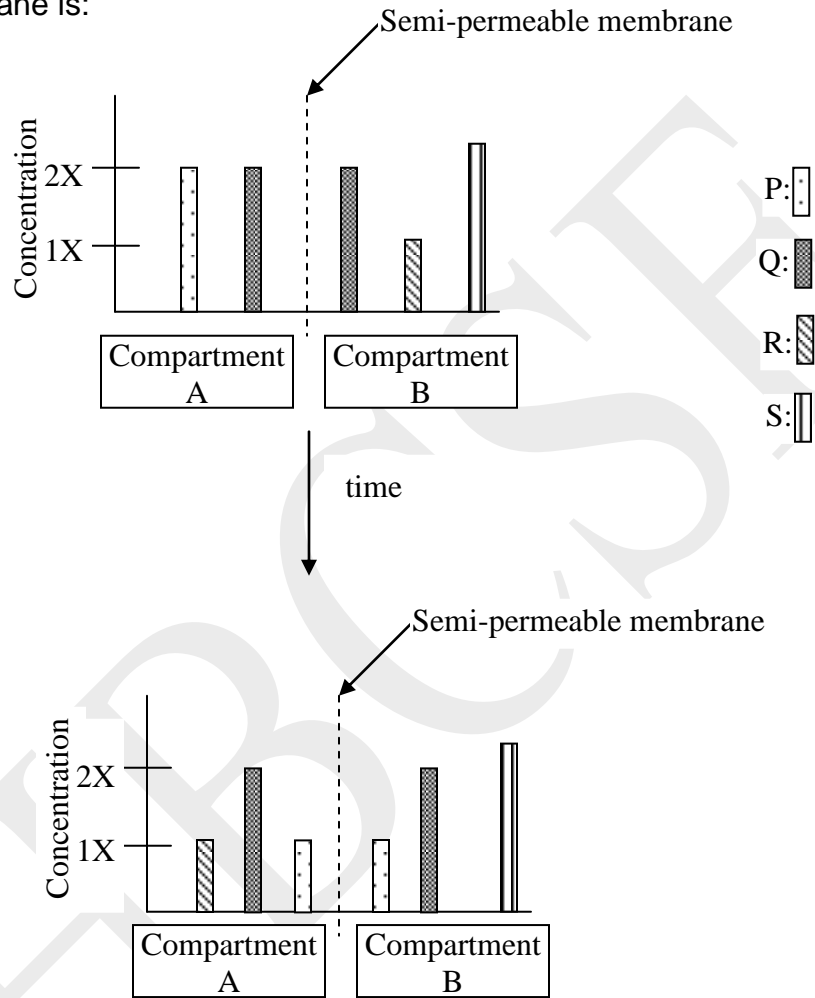
Step 4: 200,000g for 2 h

Method III: Aliquot 3 was processed in the same manner as aliquot 2, except that the sediment and supernatant were separated after each step.

Cellular components can be obtained as separate fractions from which of these methods?

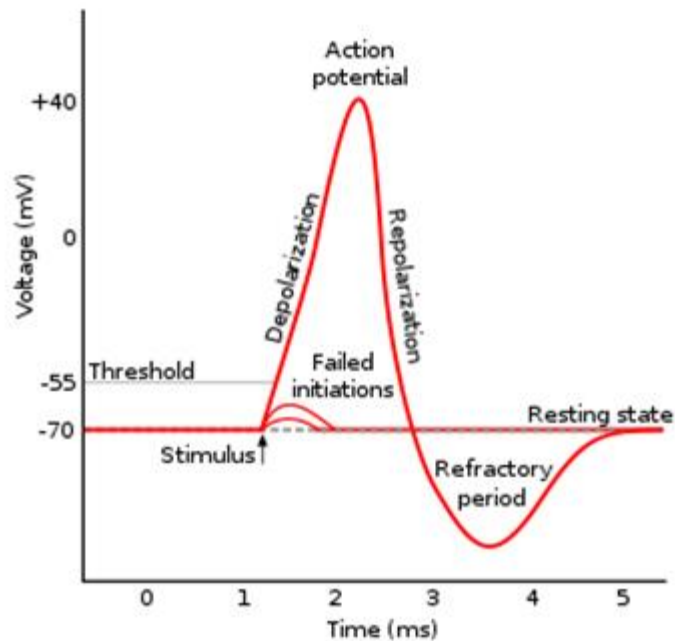
- a. Only method I
- b. Only method II
- c. Only method III
- d. Both methods II and III

4. (1 point) The following figure represents the concentrations of solutes P, Q, R and S in the two compartments A and B which are separated by a semi-permeable membrane. The molecule that is actively transported across the membrane is:



- P
- Q
- R
- S

5. (1 point) Action potentials involve changes in the membrane potential of an axon, as shown in the schematic below.



During the refractory period, sodium channels are inactivated and cannot be opened by depolarization. Such a 'temporary' inactivation mechanism has evolved and ensures:

- the sodium channel has ample time to revert to its 'resting state' conformation.
- the action potential travels unidirectionally.
- $\text{Na}^+, \text{K}^+$ -ATPase has sufficient time to pump  $\text{Na}^+$  out.
- the membrane potential stays below the resting potential of  $\text{Na}^+$ .

### **PLANT SCIENCES (10 points)**

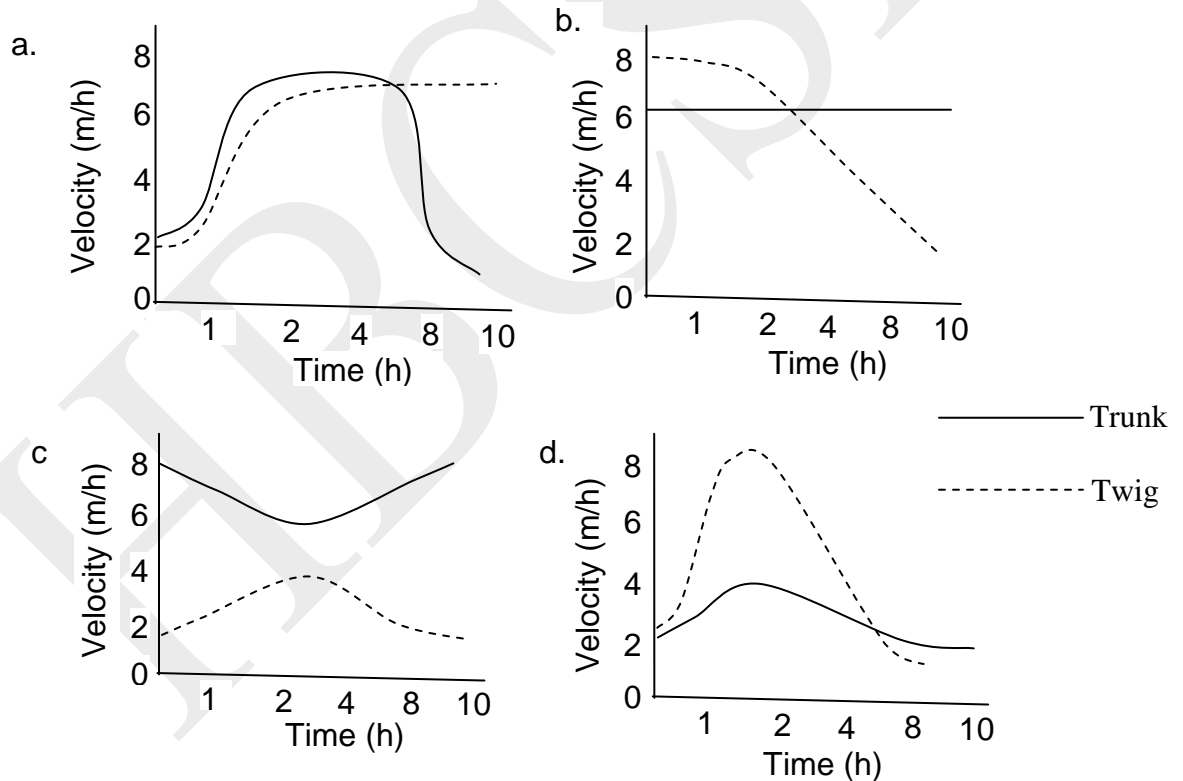
6. (1 point) In an experiment, isolated chloroplast thylakoids were incubated at pH 4.0 with ADP and inorganic phosphate ( $\text{P}_i$ ) added to the medium and then transferred to a medium having pH 8.0. After sometime, an agent 'X' that makes membrane permeable to protons is added to it. What would happen?
- On transferring to medium with pH 8.0, ATP formation would occur only on addition of X.

- b. There will be ATP formation in the medium at pH 8.0 and X will have no effect.
- c. At pH 8.0, ATP would be formed, but if X is added, ATP formation will stop.
- d. There will be ATP formation in the medium at pH 8.0 and addition of X will enhance it.
7. (1 point) A student while studying the anatomy of leaves of four specimens (P - S), observed the following characters:
- P. Reticulate venation and no bundle sheath.
- Q. Parallel venation and bundle sheath containing chloroplasts.
- R. Reticulate venation and bundle sheath containing chloroplasts.
- S. Parallel venation and bundle sheath without chloroplasts.
- Identify the type of plants.
- a. P and R are  $C_4$  dicots, while Q and S are  $C_4$  monocots.
- b. P and R are  $C_3$  dicots, while Q and S are  $C_3$  monocots.
- c. P and S are  $C_3$  dicot and monocot, respectively, while Q and R are  $C_4$  monocot and dicot, respectively.
- d. P and S are  $C_4$  dicot and monocot, respectively, while Q and R are  $C_3$  monocot and dicot, respectively.
8. (1 point) One can determine the age of an oak tree by counting the annual rings of \_\_\_\_\_ formed by the \_\_\_\_\_.
- a. primary xylem, apical meristem
- b. secondary phloem, vascular cambium
- c. dermal tissue, cork cambium
- d. secondary xylem, vascular cambium
9. (1 point) For measuring the rate of transpiration of a twig using Ganong's potometer, student A cuts the twig and fits it in the broad end of the water-filled potometer. Student B cuts the twig under water and fits in the broad end of the potometer. Both the students introduce an air bubble in the stem of the

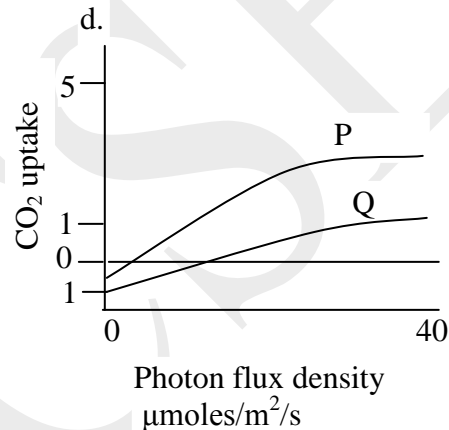
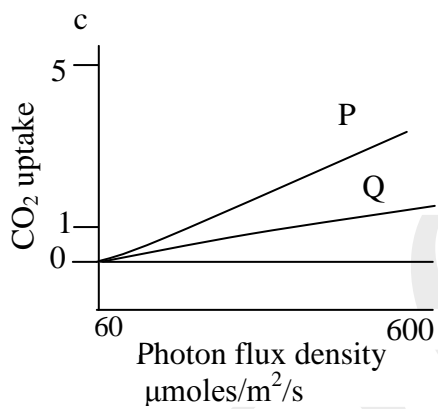
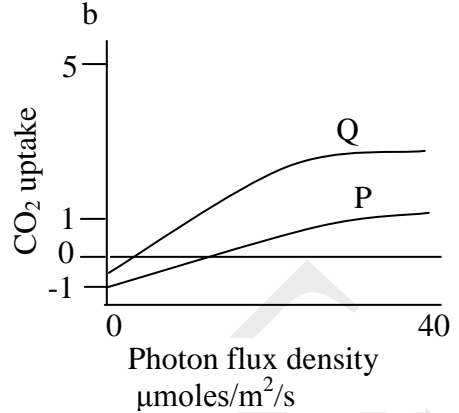
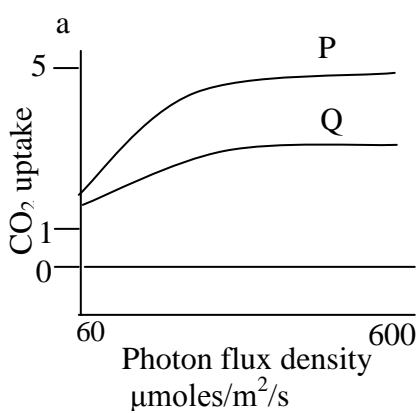
potometer, make the apparatus air-tight and start taking readings. What would they observe?

- Both A and B observe air bubble moving towards the twig.
- Both A and B observe no movement of air bubble.
- A observes no movement and B observes movement of air bubble towards the twig.
- A observes movement, while B observes no movement of air bubble towards the twig.

10. (1 point) In an experiment, velocity of xylem sap is measured in both small twig as well as main trunk of the same tree over a day. Which one of the following could be the correct graph describing it?



11. (1 point) Which of the following graphs correctly depicts the rate of photosynthesis of sun plant (P) and shade plant (Q)?



12. (1 point) Read the following description:

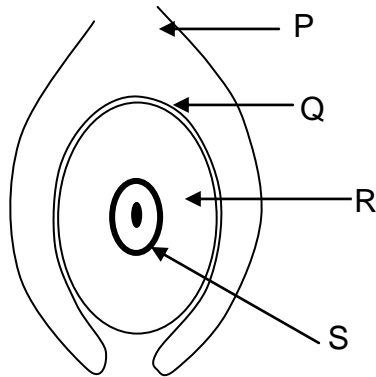
“In these autotrophs, sporophyte is the dominant generation. Gametophyte is also photosynthetic and not dependent on sporophyte for nutrition.”

These autotrophs are:

- a. Bryophytes.
- b. Pteridophytes.
- c. Gymnosperms.
- d. Angiosperms.

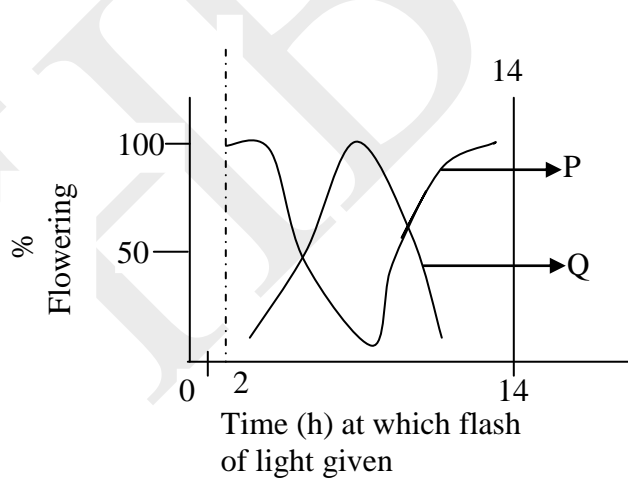
13. (1 point) A vertical section of an ovule is shown below. The correct ploidy levels of the four structures P, Q, R and S respectively are:





- a.  $n, 2n, n, n$
- b.  $2n, n, n, n$
- c.  $2n, 2n, 2n, n$
- d.  $n, 2n, 2n, 2n$

14. (1 point) Plants P and Q were studied for the effect of flashes of light on the flowering. For both P and Q, during 14 h dark period, flashes of light were given at different time intervals. The results are shown in the graph. Mark the correct interpretation:



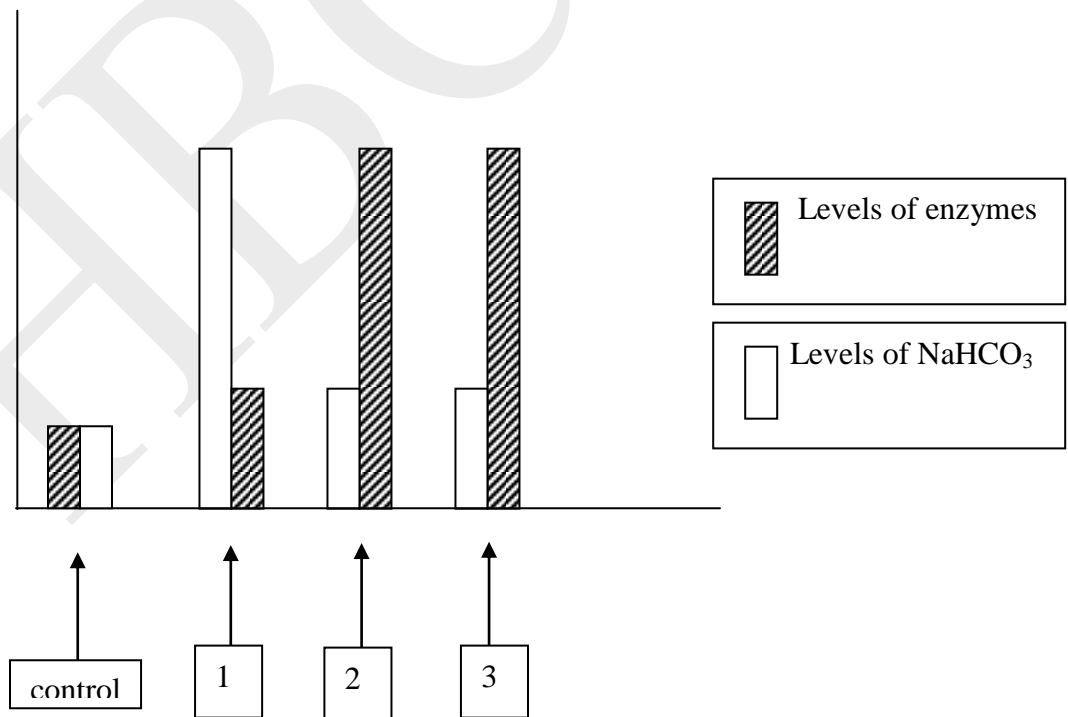
- a. P: Short day plant, sufficient Pfr (in the middle of the dark period) → florigen
- b. Q: Short day plant, sufficient Pr (in the middle of the dark period) → florigen
- c. P: Long day plant, sufficient Pr (in the middle of the dark period) → florigen
- d. Q: Long day plant, sufficient Pfr (in the middle of the dark period) → florigen

15.(1 point) Arrange the following processes sequentially to explain the translocation of food through sieve tubes.

- i. Unloading of sugar in sink cells (or cells of root).
  - ii. Uptake of water from xylem vessels.
  - iii. Transfer of water from sieve cells to xylem vessels.
  - iv. Sugars loaded from leaf cells to sieve cells.
- a. ii → iv → iii → i
  - b. iv → iii → ii → i
  - c. iv → ii → i → iii
  - d. i → iii → iv → ii

**ANIMAL SCIENCES (2 points)**

16.(1 point) Effect of some compounds (present in partially digested food) on pancreatic secretion is depicted in the bar graph. Compounds 1, 2 and 3 represent:



- a. 1. Acid      2. Fat      3. Salt

- b. 1. Salt      2. Peptone    3. Fat  
c. 1. Acid      2. Fat          3. Peptone  
d. 1. Pepsin    2. Acid        3. Fat

17.(1 point) An osteoclast is a type of bone cell that absorbs bone tissue by removing its mineralized matrix and breaking up the organic bone. This process is known as *bone resorption*. These osteoclasts are derived from:

- a. Monocytes-macrophage cells.  
b. Mesenchymal cells.  
c. Osteogenic cells.  
d. Fibroblast cells.

### **GENETICS & EVOLUTION (6 points)**

18.(1 point) In a particular DNA sample, nucleotide pairs are distributed uniformly. It has 50% GC content. The restriction enzyme *HpaII* recognizes the sequence 5'-GGCC-3'. What will be the average length of the DNA fragment, if digested by *HpaII*?

- a. 128  
b. 512  
c. 1024  
d. 256

19.(1 point) A cross between wild-type fruitfly *Drosophila melanogaster* [normal bristles and grey body ( $s^+s$ ,  $e^+e$ )] with a mutant fly [short bristles and ebony body ( $ss ee$ )] produces following progeny:

- Normal bristles with grey body – 537 flies
- Short bristles with ebony body – 542 flies
- Normal bristles with ebony body – 76 flies
- Short bristles with grey body – 75 flies

The map distance between 's' and 'e' genes will be:

- a. 87.7 map units
- b. 50.2 map units
- c. 12.3 map units
- d. 49.8 map units

20.(1 point) In a plant, genes *A*, *B* and *C* control the flower colour, height and position of the flowers, respectively. Study the following genotypes and corresponding phenotypes:

*AA* → red flower,

*aa* → white flower,

*Aa* → pink flower,

*B\_* → tall plant,

*bb* → dwarf plant

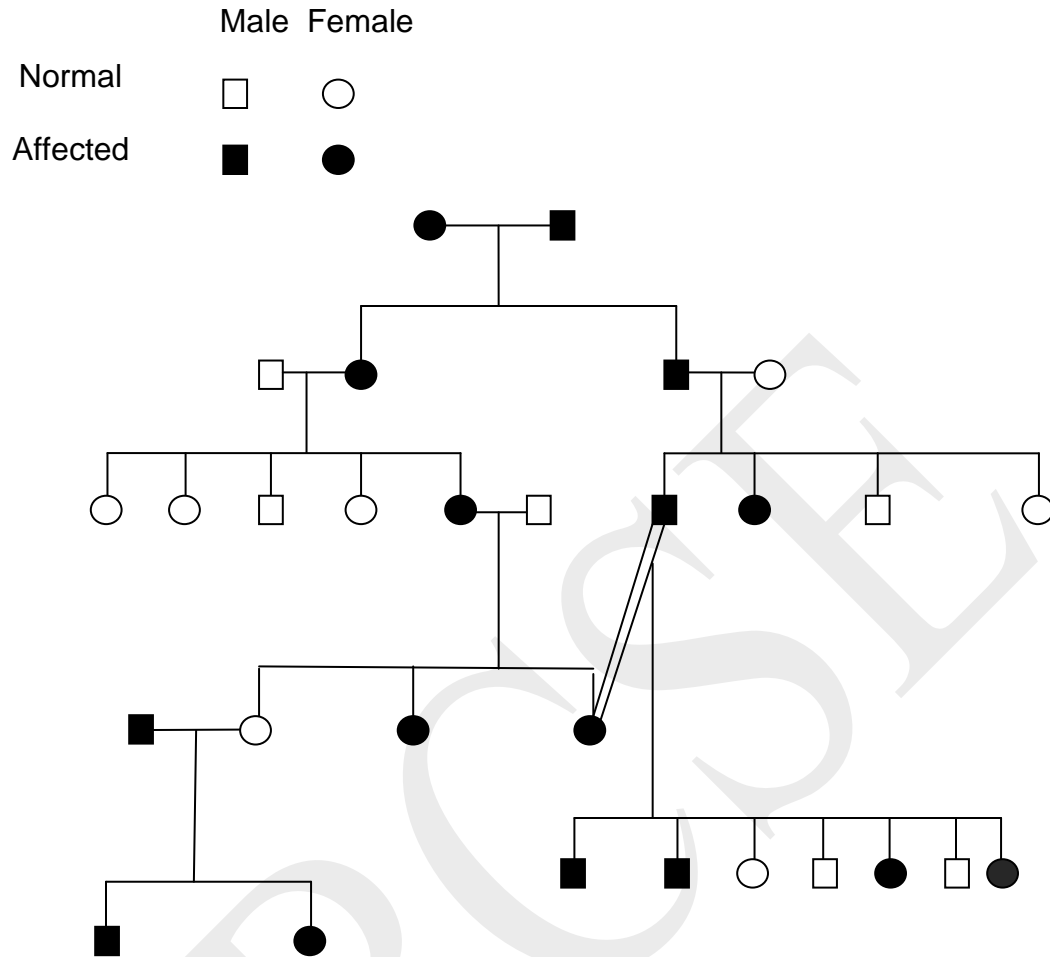
*C\_* → axillary flower and

*cc* → terminal flower,

If *AabbCC* and *aaBbCc* are crossed, what proportion of plants would be tall, have pink and axillary flowers in the progeny?

- a. 25%
- b. 50%
- c. 75%
- d. 100%

21.(1 point) Follow the pedigree chart given below and determine the type of inheritance that it indicates.



- Autosomal dominant.
- Autosomal recessive.
- X-linked recessive.
- X-linked dominant.

22. (1 point) A few statements about the mechanism of evolution are made. Mark the correct statements.

- Evolution occurs at the individual level as well as population level.
- As changes in the gene pool occur, a population evolves.
- Mutation is the driving force of evolution and it leads to change in a gene pool of population.
- Genetic drift is the change in the gene pool that occurs in a small population due to adaptation.

(v) Assortative mating can cause an increase in homozygous individuals and changes the allele frequencies in the population.

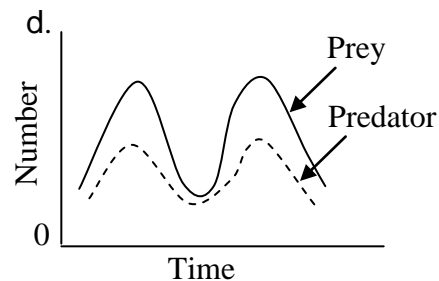
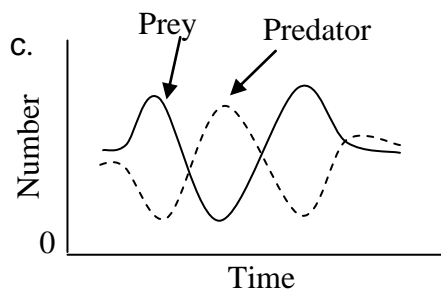
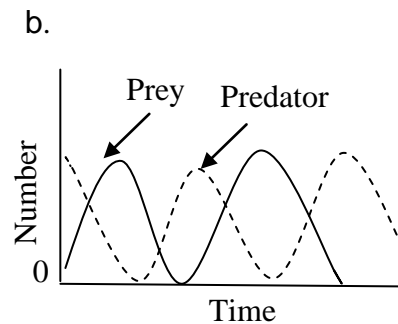
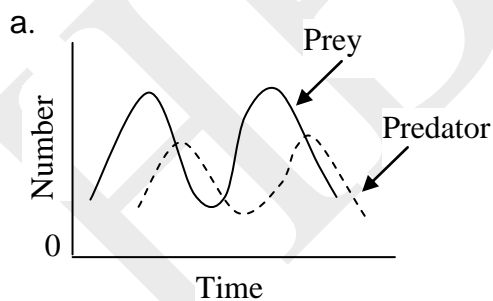
- a. (i) and (ii)
- b. (ii) and (iii)
- c. (i), (iv) and (v)
- d. (i), (ii), (iii) and (v)

23. (1 point) A few individuals from a herd of deer are forced to migrate to a new herd. This is an example of \_\_\_\_ resulting in \_\_\_\_.

- a. Gene flow ; increase in similarities between populations.
- b. Genetic drift ; increase in dissimilarities between populations.
- c. Bottleneck effect ; survival of the fittest.
- d. Sympatric isolation ; speciation.

**ECOLOGY (8 points)**

24. (1 point) Which of the following graphs correctly depicts the prey – predator relationship?



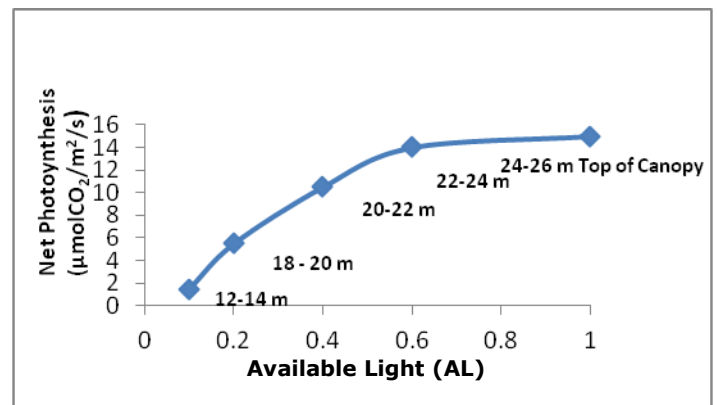
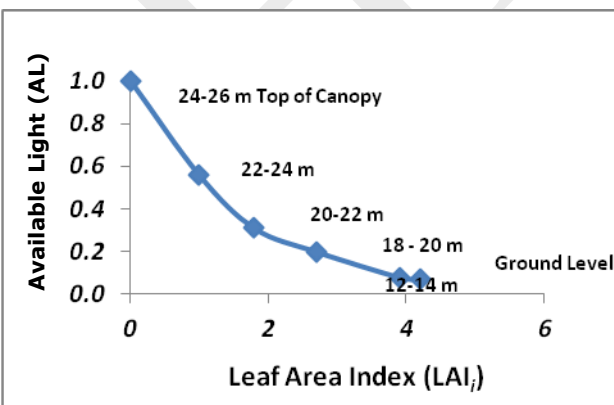
25. (1 point) Consider an ecosystem consisting of a prey and a predator. If  $H$  is the density of prey,  $P$  is the density of predator,  $r$  is the intrinsic rate of prey population increase and  $q$  is the predation rate coefficient, which of the following correctly represents change in prey population density with time?

- a.  $dH/dT = rH + qP$
- b.  $dH/dT = rH - qHP$
- c.  $dH/dT = qH - rHP$
- d.  $dH/dT = qH + rHP$

26. (1 point) Which of the following correctly depicts a reaction involved in the nitrogen cycle?

- a.  $N_2 + H^+ + e^- + ATP \longrightarrow NH_3 + ADP + Pi$
- b.  $N_2 + H^+ + e^- + ADP + Pi \longrightarrow NH_3 + ATP$
- c.  $NO_2 + e^- + ADP + Pi \longrightarrow NH_3^+ + ATP$
- d.  $NO_3^- + H^+ + e^- + ADP + Pi \longrightarrow NH_3^+ + NO_2 + ATP$

27. (1 point) The following figures show the relationship between the available light as a proportion of photosynthetically active radiation (PAR) at the top of the canopy and leaf area index (LAI). They also show the relationship between net photosynthesis and available light. Which of the following statements would be true for these figures?



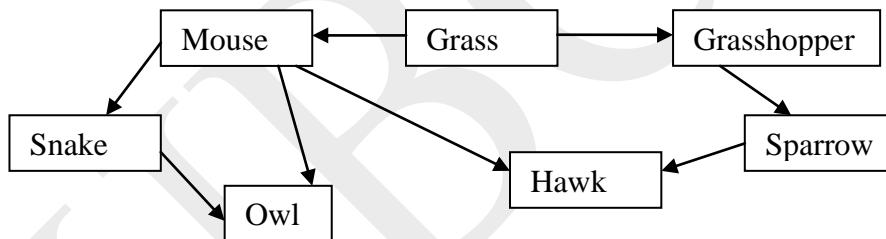
- a. The quantity of PAR is highest at the top of the canopy.

- b. A major fraction of total photosynthesis occurs at the top of the canopy.
- c. There is a linear positive correlation between LAI and net photosynthesis.
- d. The decrease in the intensity of light in the lower part of the canopy is fully compensated by larger leaves.

28. (1 point) A body which has a temperature above absolute zero emits radiation based on its temperature (Stephan-Boltzman's law). The predominant wavelength of this radiation is determined by the energy level of the body (Wein's law). Which of the bodies will emit light with the longest wavelength?

- a. A man in Kashmir during winter.
- b. A frozen pond in Himachal Pradesh in winter.
- c. A black rock lying in the open at noon in the Thar desert.
- d. A Sarus crane sitting on it's nest on a November morning in Gujarat.

29. Based on the food web of a natural habitat depicted below, answer questions 29 – 31:



(1 point) Under optimal environmental conditions, which of the following would have the total highest biomass per year?

- a. Snake
- b. Grass
- c. Hawk
- d. Grasshopper



30. (1 point) Which of the following is NOT true?

- a. The food web depicts two trophic levels.
- b. Mouse and grasshopper occupy the same trophic level.
- c. All organisms except grass are consumers.
- d. The predators prefer multiple prey species.

31. (1 point) The depicted food web is not complete, mainly because:

- a. the number of producers is less than the number of consumers.
- b. there are no decomposers.
- c. only secondary consumers are shown with multiple prey species.
- d. the source of energy is assumed as sun.

**ETHOLOGY (1 point)**

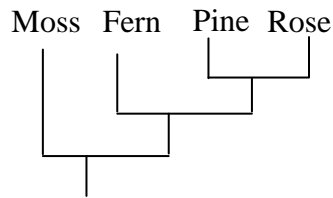
32. (1 point) Aid-giving behaviour among genetically related individuals in animal groups is often observed in nature. This aid-giving behaviour can evolve when the benefits of helping relatives are greater than losses the aid-giver incurs in terms of not having its own offspring. This rule is known as Hamilton's rule and is given as  $rB > C$ , where  $r$  is genetic relatedness of the aid-giver and aid-receiver,  $B$  is benefit and  $C$  is cost.

If an individual is faced with an alternative of rearing its own offspring or rearing its cousin's offspring, what is the minimum number of offspring its cousin should produce so that helping will be favoured?

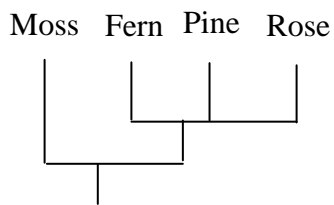
- a. 2
- b. 3
- c. 4
- d. 5

**BIOSYSTEMATICS (2 points)**

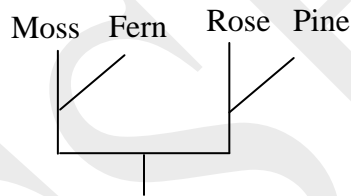
33. (1 point) Which of the following phylogenies are equivalent to the one given below?



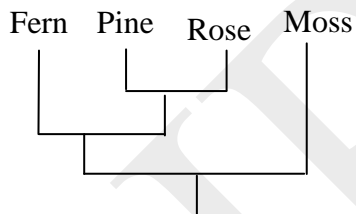
a



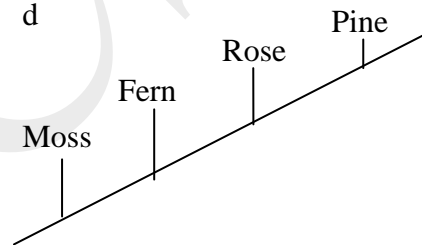
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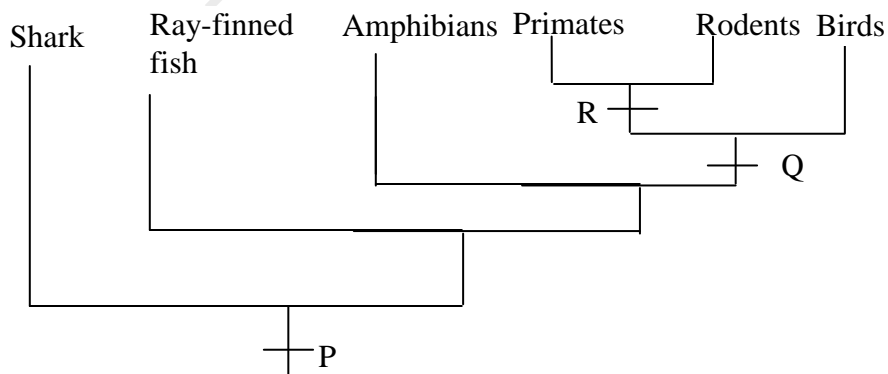
c



d



34. (1 point) Evolutionary relationship between various animal groups is depicted in the cladogram given below. P, Q and R respectively represent:



- a. Vertebrae, hair and four limbs.
- b. Bony skeleton, hair and amniotic eggs.
- c. Vertebrae, amniotic eggs and hair.
- d. Respiration by skin, lungs and poikilothermy.

**\*\*\*\*\* END OF SECTION A \*\*\*\*\***

HB CSE

**INDIAN NATIONAL BIOLOGY OLYMPIAD – 2013**

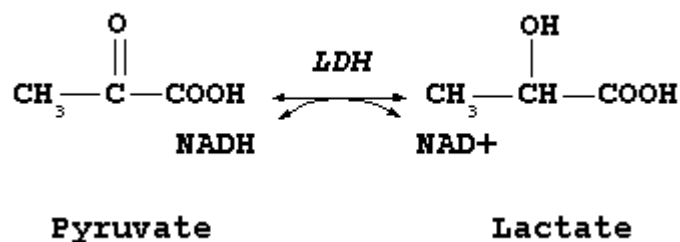
**SECTION B**

**NOTE:**

- Write all answers in the **ANSWERSHEET ONLY**.
- Only the answer sheets will be collected at the end of the examination.

**CELL BIOLOGY (16 points)**

35. (2 points) Lactate dehydrogenase (LDH) is one of the important enzymes in glycolysis which catalyzes the interconversion of pyruvate and lactate as follows:

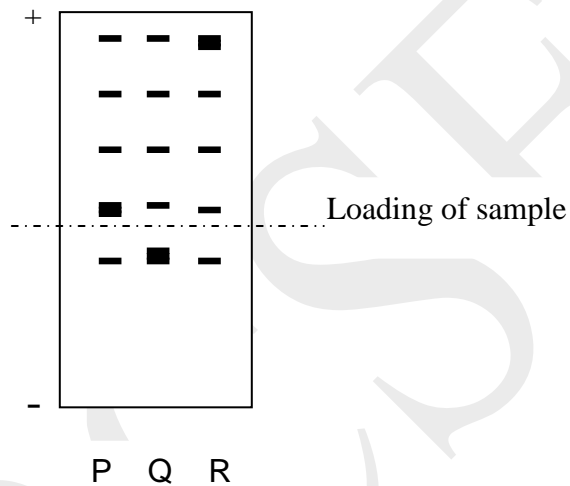


Functional lactate dehydrogenases are tetramers composed of both M and H type subunits. M type subunits are predominantly found in muscle tissue and H type subunits are predominantly found in heart tissue.

(A) How many isozymes (types of functional lactate dehydrogenase molecules) of LDH can be found in the body fluids?

Answer: \_\_\_\_\_

(B) The net surface charge on a H<sub>4</sub> isozyme is - 6 while that of M type homotetramer is +1. Blood samples of three individuals were subjected to electrophoresis. Study the LDH profile of these samples shown below to determine the condition. Put tick marks (✓) in the appropriate places in the table.



Sample	Muscular dysfunction	Cardiac dysfunction	Normal profile
P			
Q			
R			

36. (5 points) The complementary strands of nucleic acids, under appropriate conditions, re-associate to form base-paired duplex molecules. DNA was melted to separate into individual strands and under five conditions allowed to re-associate. Indicate against each condition the final outcome with a tick mark (✓). Also indicate the correct reason by choosing from the options provided and filling the number in the table.

No.	Condition	Final outcome			Reason
		Favour re-association	Not favour re-association	No effect on re-association	
1.	Solution with high ionic strength				
2.	Temperature just below the melting temperature				
3.	Temperature much below the melting temperature				
4.	Low concentration of DNA				
5.	Small size of fragments				

Options:

- I. Reduce intra-strand pairing
- II. Reduce intermolecular repulsion
- III. Reduce intermolecular collisions per unit time
- IV. Increase rate of movement of molecules in solution.
- V. Favour intra-molecular pairing.

37. (4 points) Glycolysis, Krebs's cycle and oxidative phosphorylation are three important processes of cellular respiration while photosynthesis is an important biosynthetic process. Complete the table by putting tick marks (✓) to indicate

the features that are observed and crosses (X) to indicate the features that are not observed for each of these processes.

**Only an entirely correct column will carry 1 point.**

Features	Processes			
	Glycolysis	Kreb's cycle	Oxidative phosphorylation	Photosynthesis
Evolution of CO <sub>2</sub>				
Synthesis of ATP				
Utilization of ATP				
Utilization of O <sub>2</sub>				
Formation of NADH				

38. (5 points) Michael Brown and Joseph Goldstein received Nobel Prize in 1985 for their discovery of receptor-mediated endocytosis. They used cultures of fibroblasts from patients suffering from familial hypercholesterolemia (FH) and low-density lipoprotein (LDL) preparations. LDLs are taken up by cells using a receptor that is specific to an apolipoprotein present in LDL.

Suppose, you are given the following, along with all the other equipment / chemicals:

- (a) Fibroblasts from a normal and an affected individual and
- (b) LDL from a normal and an affected individual.

The affected individual is hypothesized to have either a mutant receptor or a mutant apolipoprotein because of which the receptor-mediated endocytosis is not taking place. Design of an experiment to test this hypothesis is given

below. Choose the appropriate expected outcomes/interpretations from the options and fill in the table with the corresponding numbers.

Source of fibroblasts	Source of LDL	Expected outcome / interpretation
Normal individual	Normal individual	LDL is internalized by receptor-mediated endocytosis
Normal individual	Affected individual	
Affected individual	Normal individual	
Affected individual	Affected individual	

Options:

- I. If endocytosis occurs, the apolipoprotein of the affected person is mutated.
- II. If endocytosis does not occur, the receptor of the affected person is mutated.
- III. If endocytosis occurs, the receptor of the affected person is likely to be mutated.
- IV. If endocytosis does not occur, the apolipoprotein of the affected person is mutated.
- V. If endocytosis does not occur, the affected person has apolipoprotein or receptor or both mutated.



**PLANT SCIENCES (7 points)**

39. (4 points) Major types of photo-autotrophs are listed in the table along with some features. Indicate for each group, the presence (✓) or absence (X) of these features and fill in the table.

**Only an entirely correct row will carry 1 point.**

<b>Features</b>	<b>Red algae</b>	<b>Green algae</b>	<b>Mosses</b>	<b>Gymnosperms</b>	<b>Angiosperms</b>
Apical meristem					
Alternation of generation					
Double fertilization					
Presence of chlorophyll a and b					

40. (3 points) Leaf samples from three plants were collected and their stomatal frequency was measured. The following data was obtained.

<b>Sample</b>	<b>Stomata on upper epidermis (per sq mm)</b>	<b>Stomata on lower epidermis (per sq mm)</b>
X	28	269
Y	0	0
Z	363	0

From the options given below, choose the appropriate description for each of the three samples and fill in the corresponding numbers.

Options:

- I. Monocot
- II. Dicot
- III. Floating hydrophyte

- IV. Submerged hydrophyte
- V. Xerophyte
- VI. Halophyte
- VII. Mesophyte

Answers:

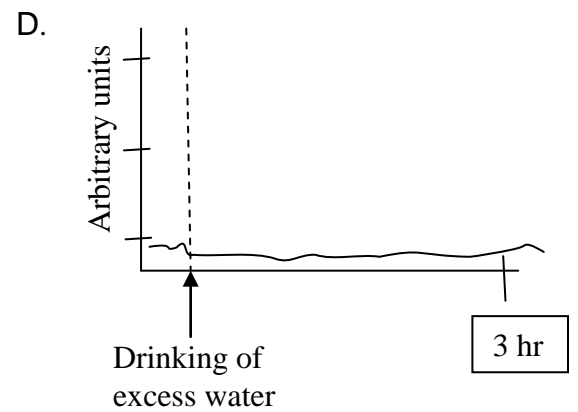
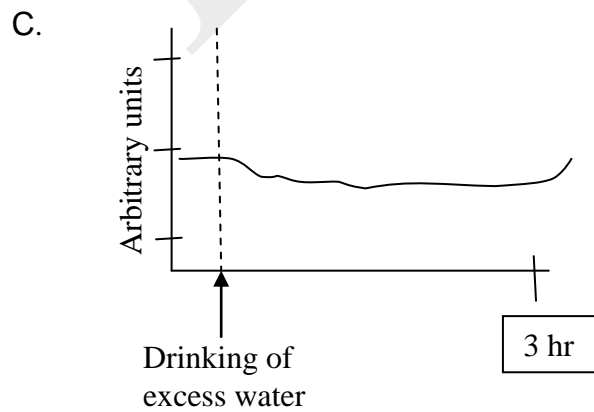
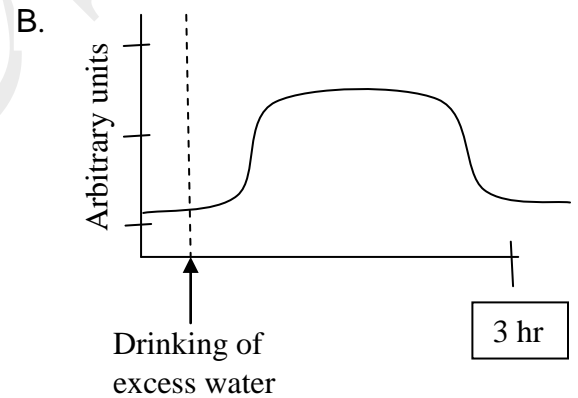
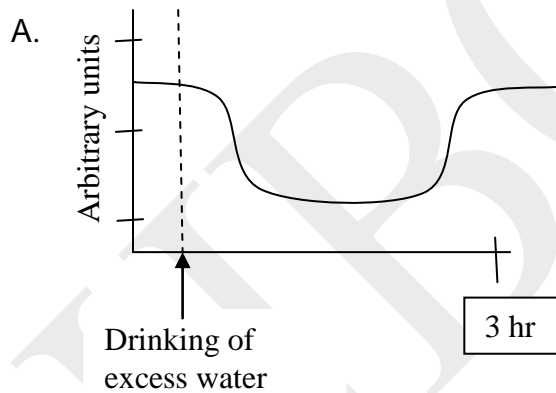
X: \_\_\_\_\_

Y: \_\_\_\_\_

Z: \_\_\_\_\_

**ANIMAL SCIENCES (12.5 points)**

41. (2 points) When a person drinks excess quantity of water, it affects various parameters. The effects are depicted in four graphs (A – D). Assign the correct parameter to each graph by choosing from the options below.



Options:

- I. Plasma osmolarity
- II. Osmolarity of urine
- III. Urine flow rate
- IV. Plasma anti-diuretic hormone level

Answers:

Graph A: \_\_\_\_\_

Graph B: \_\_\_\_\_

Graph C: \_\_\_\_\_

Graph D: \_\_\_\_\_

42. (2 points) High levels of blood glucose can cause several physiological changes in the body. Which of the following will occur as a result of this condition? Fill in the table with tick marks (✓) in the appropriate places.

	<b>Description</b>	<b>Yes</b>	<b>No</b>
a.	Cellular dehydration		
b.	Decreased extracellular osmotic pressure		
c.	Increased renal glucose reabsorption		
d.	Polyuria (excessive urine output)		

43. (2 points) Congenital Adrenal Hyperplasia (CAH) is a genetic disorder in which one or more enzymes needed for the synthesis of cortisol are absent. For an individual affected with this disorder, indicate whether each statement given in the table is true or false. Fill in the table with tick marks (✓) in the appropriate places.

Statements	True	False
1. Secretion of ACTH from anterior pituitary gland will be high.		
2. Adrenal glands will be enlarged.		
3. Secretion of Corticotropin Releasing Hormone from hypothalamus will be low.		
4. Precursors for Cortical hormone synthesis will accumulate and may be secreted from adrenal gland.		

44. (4 points) In some organisms, the cells are in direct contact with the surroundings. However in several multicellular organisms, cells are not in direct contact with surroundings and hence require some medium for the exchange of nutrients, metabolic waste and respiratory gases. A few animals are listed below. Choose the appropriate medium of circulation and transport and fill the number against each animal.

- a. Sponge
- b. Hydra
- c. Octopus
- d. Planarian
- e. Round worm
- f. Bony fish
- g. Prawn
- h. Earthworm

Options:

- 1. Water surrounding the body

2. Body fluids without respiratory pigments
3. Haemolymph
4. Blood

45. (2.5 points) A few types of locomotory actions are listed in column A. Choose from the options and fill in the table with the number of the appropriate animal.

No.	A	B
1.	Ciliary locomotion	
2.	Looping movements	
3.	Alternate movements of multiple limbs	
4.	Alternate contraction circular and longitudinal muscles in the body	

Options:

- I. Earthworm
- II. Nereis
- III. Crab
- IV. Planarian
- V. Amoeba
- VI. Leech

**GENETICS & EVOLUTION (11.5 points)**

46. (2 points) In humans, attached earlobes are a dominant feature over free earlobes while hypertrichosis of the ear is a holandric (Y-linked) feature. A person with attached earlobes and extensive hair on pinna married another person having free earlobes. The couple had one son with attached earlobes and hairy pinna, another son with free earlobes and hairy pinna and two daughters with attached earlobes. One of the daughters married a person with

free earlobes and sparse hair on pinna. They had two sons. What would be the characteristics of their pinnae?

- a. They would have sparse hair on pinna and there would be 1 in 4 chance that both will have attached earlobes.
- b. Both will have attached earlobes and sparse hair on pinna.
- c. There would be equal chances for both having free or attached earlobes and sparse hair on pinnae.
- d. They would have hairy pinnae and there would be 1 in 8 chance that both will have attached earlobes.
- e. There is an equal chance for the two to have either hairy pinnae or sparse hair on pinnae.
- f. Both will have free earlobes and extensive hair on pinnae.

Choose from the options and put a tick mark (✓) in the appropriate box.

a.	b.	c.	d.	e.	f.

47. (2 points) If 4% of a population is born with a severe form of sickle cell anemia, what percent of population will be resistant to malaria in spite of carrying an allele for sickle cell anemia?

Answer: \_\_\_\_\_%

48. (2 points) The frequency of an autosomal recessive disease in a population is 1 in a million. An unaffected person who had a sibling affected with this disease marries a lady from the population. What is the probability that their child will have the disease?

Answer: \_\_\_\_\_

49. (1+2+1+2 = 6 points) A true-breeding petunia plant with red petals was crossed with another true-breeding petunia plant with white petals. The plants of the  $F_1$  progeny had blue petals. When these  $F_1$  plants were selfed, the resulting progeny consisted of 243 plants with blue petals, 81 plants with red petals and 108 plants with white petals.

(A) Which of the following can be deduced from the above data?

- a. The formation of blue petals requires activity of two genes.
- b. The formation of red petals requires activity of three genes.
- c. The formation of white petals requires activity of a single gene.
- d. The two true-breeding strains are mutated in the same locus.

Choose from the options and put a tick mark (✓) in the appropriate box.

a.	b.	c.	d.

(B) The  $F_1$  plants obtained were then crossed with fully homozygous recessive plants.

(B.1) What phenotypic ratio would you expect from such a cross?

Note: Indicate the phenotypes with the ratio.

Answer: \_\_\_\_\_

(B.2.) What fraction of the  $F_2$  would you expect to be true-breeding?

Answer: \_\_\_\_\_

(C) The correct pathway for the synthesis of pigments is:

Note: Use only required length of pathway.

White precursor → \_\_\_\_\_ → \_\_\_\_\_ → \_\_\_\_\_ → \_\_\_\_\_.

50. (0.5+0.5+1+0.5+1 = 3.5 points) MN blood group in humans is under the control of two co-dominant alleles *M* and *N*. Blood typing results of a population consisting of 1349 individuals showed that:

- 363 persons had *MM* genotype.
- 352 persons had *NN* genotype.
- 634 persons had *MN* genotype.

(A) You need to check if this population is in Hardy Weinberg Equilibrium. For this, you first have to formulate null hypothesis. Which of the following is the correct null hypothesis?

- The population is not in Hardy Weinberg equilibrium.
- The population does not deviate from Hardy Weinberg equilibrium.
- The population does not show random mating.
- The population does not show any preponderance of heterozygotes.

Choose from the options and put a tick mark (✓) in the appropriate box.

a.	b.	c.	d.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

(B) Now to test the null hypothesis, which statistical test will you apply?

- t-test
- Chi-square test
- both a and b



d. variance

Choose from the options and put a tick mark (✓) in the appropriate box.

a.	b.	c.	d.

(C) Value of the statistic: \_\_\_\_\_

(D) Degrees of freedom: \_\_\_\_\_

(E) Determine the probability (p) at which the data will be significant. (Refer to the tables given at the end of the paper.)

Answer: \_\_\_\_\_

### **ETHOLOGY (4.5 points)**

51. (4.5 points) When we observe animals in the wild, most often we see them foraging for food. The foraging behavior of animals has been a focus of behavioral studies for several decades. Natural selection shapes this behavior so as to maximize net energy gain as a function of time.

*Corvus caurinus*, a species of crow, forages mainly on the bivalves found in the inter-tidal zones. After searching and locating the prey, the crow picks up the bivalve. To break open the bivalve, it flies to a certain height and then drops the bivalve on a rock. Profitability of a prey is the most important consideration in any such behavior and is defined as the net energy gained per unit of prey handling time.

(A) A few statements about the profitability of the prey are listed in the table. Fill in the table with tick marks (✓) in the appropriate places to indicate whether each statement is true or false:

Statements	True	False
a. Larger the bivalve size, greater will be the effort to carry it to a height and hence profitability of the prey will always decrease.		
b. Smaller the size of the bivalve, easier it is to capture. Also carrying it to a height is energetically less demanding. Hence profitability of such a prey is always greater than the larger bivalve.		
c. Camouflaged bivalves will show greater profitability as compared to the non-camouflaged ones.		
d. Harder the shells of the bivalve, more will be the energy content and thus more will be the profitability.		
e. Larger bivalves will always show greater profitability provided they do not require extra efforts to break and open the shells.		

(B) In a realistic situation, the profitability of a bivalve will depend on its energy content ( $E$ ), probability of its opening ( $P$ ), handling time for opened bivalves ( $H$ ) and wasted time ( $W$ ) for unopened bivalves. Then the correct expression for the profitability of the bivalve will be:

a. 
$$\frac{(E)}{(H+W)(P-1)}$$

b. 
$$\frac{(E \times P)}{H+W(P-1)}$$

c.  $\frac{(E \times P)}{(H \times P) + W \times (1 - P)}$

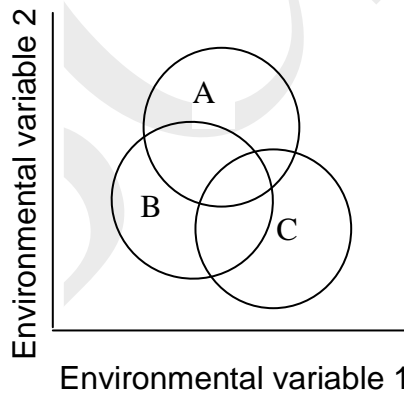
d.  $\frac{(E \times P)(P - 1)}{(H \times P) + W}$

Choose from the options and put a tick mark (✓) in the appropriate box.

a.	b.	c.	d.

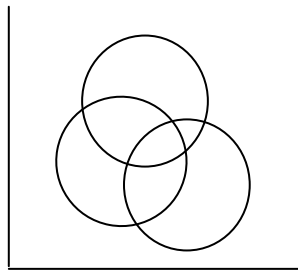
**ECOLOGY (9 points)**

52. (3 points) Fundamental niches of three species A, B and C are shown below.

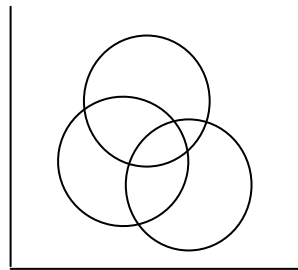


Relationships between these species are: (i) B commensal for A, (ii) B obligate mutualist for C and (iii) C host for A.

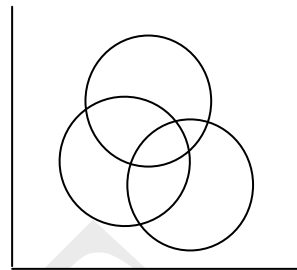
Based on this information, indicate the realised niche of these species by shading regions in the respective figures:



Realised niche of A



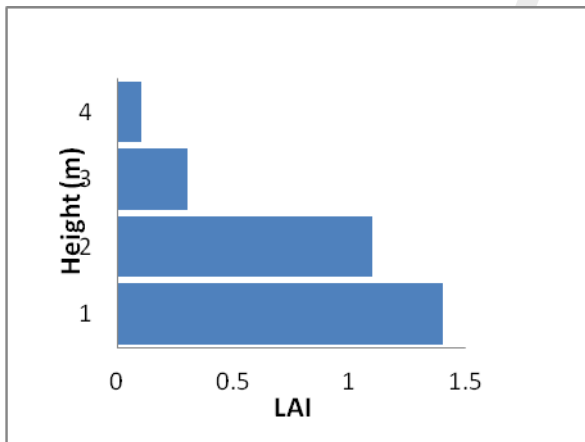
Realised niche of B



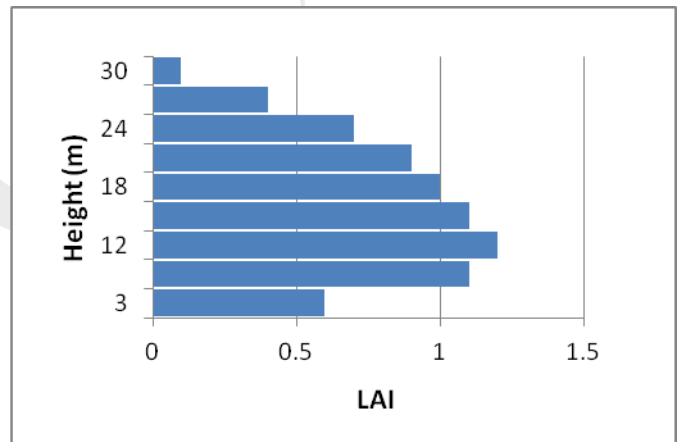
Realised niche of C

53. (2 points) The leaf area index (LAI) is a quantitative character which calculates the area of leaves per unit ground area. LAI values for different vertical strata of vegetation in different biomes were calculated. The following graphs depict the results obtained.

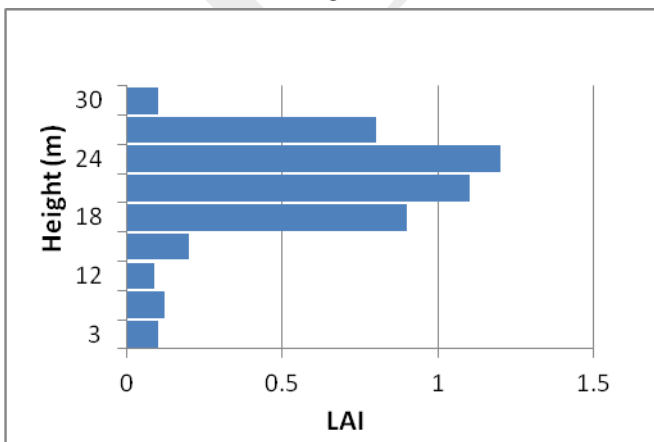
1.



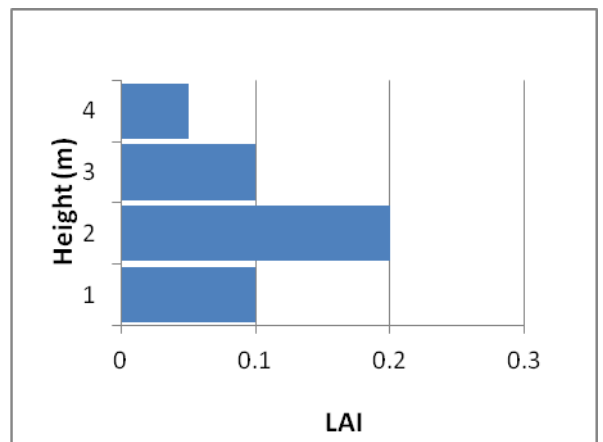
2.



3.



4.



Four biomes are listed below. Match the appropriate biome with each graph.

- A. Coniferous Forest
- B. Tropical Forest
- C. Desert
- D. Grassland

Answers:

1: \_\_\_\_

2: \_\_\_\_

3: \_\_\_\_

4: \_\_\_\_

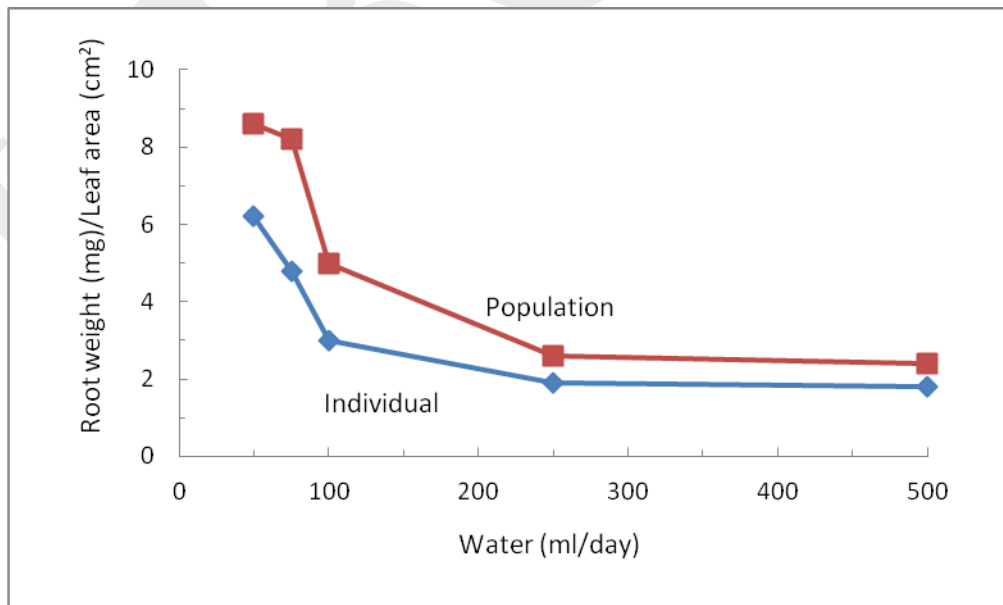
54. (2 points) The following table shows the characteristics of four populations of different species. Analyze the characters and place the populations in boxes on a continuum from r-selected species to k-selected species.

<b>Character</b>	<b>Species A</b>	<b>Species B</b>	<b>Species C</b>	<b>Species D</b>
Population size	150 - 550	100 - 800	100 - 700	400 - 450
Mortality	Density dependent	Not density dependent	Not density dependent	Density dependent
Survivorship curve	Diagonal	Concave	Concave	Convex
Competitor	Average competitor	Poor competitor	Average competitor	Good competitor
Life span	Short	Short	Short	Long

r  $\longrightarrow$  k

Answer:

55. (2 points) To determine the effect of intra-specific competition on the growth of saplings of *Eucalyptus dives*, an experiment was designed in which two sets of pots were used. In the first set only 1 sapling was planted per pot and in the other set 16 saplings were planted per pot. To check for the effect of intra-specific competition on allocation of resources, a decreasing amount of water was added to each set. The results have been graphically indicated below. Which of the following conclusions can be drawn from the study? Indicate correct conclusions using tick marks (✓) and incorrect or no conclusions with a cross (X).



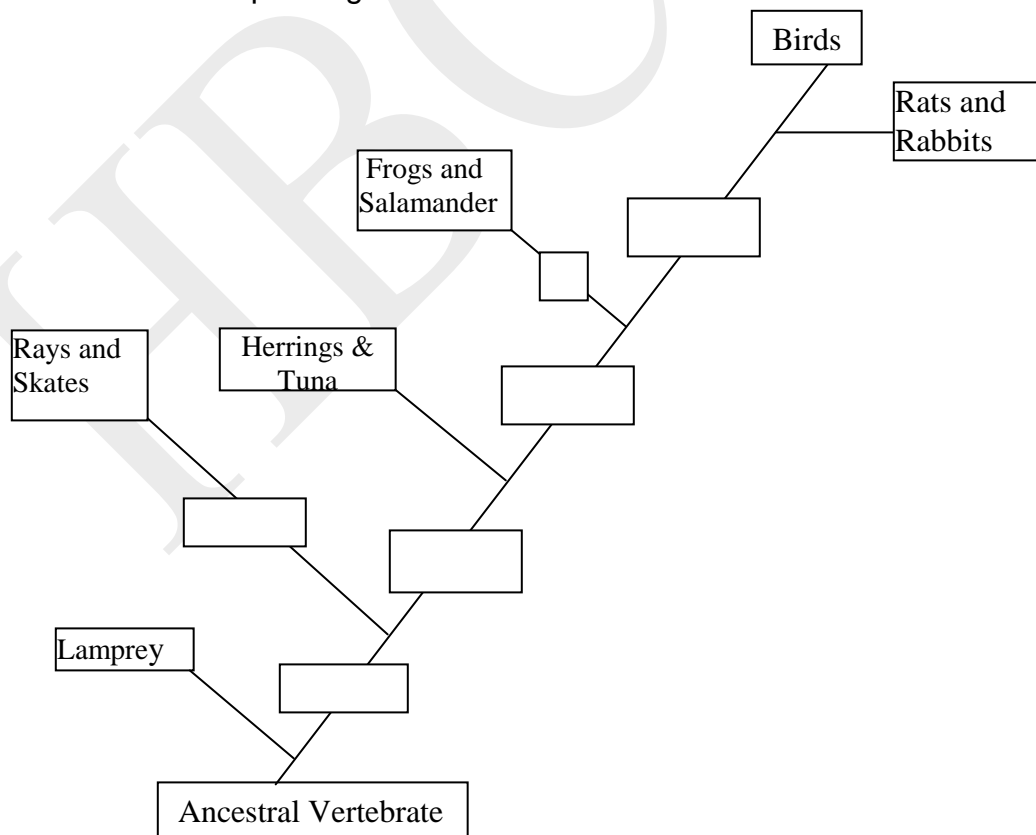
1. More resources are allocated to the root during low water conditions.

2. Competition for water among individuals of a population causes more root growth compared to individuals who are growing alone.
3. Lesser leaves are formed under low water conditions.
4. Root growth is higher in individuals grown singly compared to individuals in populations.

Statement	1	2	3	4
Conclusion				

**BIOSYSTEMATICS (3.5 points)**

56. (3.5 points) A cladogram of various animal groups is shown below. The boxes in the cladogram indicate the development of specific structures in the course of evolution. Fill these boxes with numbers indicating the correct structures. Choose from the options given.



Options:

1. Paired appendages
2. Bony endoskeleton
3. Jaws
4. Three-chambered heart
5. Clawed digits
6. Cartilaginous endoskeleton
7. Four-chambered heart
8. Operculum

\*\*\*\*\* END OF SECTION B \*\*\*\*\*