Indian National Biology Olympiad (INBO) - 2026

Homi Bhabha Centre for Science Education (HBCSE-TIFR)

Question Paper

Date: 1st February, 2026 Maximum Marks: 300
Duration: 2 hours

ROLL NO. | | | | | – | | | | | – | | | | |

INSTRUCTIONS

The question paper is divided into Sections A and B. All answers should be **written in the answer booklet only** which will be collected at the end of the examination. The question paper need not be submitted to the examiner.
Before starting, ensure that you have received a copy of the question paper containing a total of 32 numbered pages.

Section A

- Section A consists of 22 questions carrying 1 point each.
- All 22 questions are of multiple choice type (MCQ), with only one correct answer for each question.
- Mark the correct answer with '✓' in the answer booklet 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.
- For any MCQ, if you want to change your answer, please strike off your original answer as shown below and tick the new answer. Also, write your newly chosen option (i.e. a or b or c or d) on the side outside the table.

Q. No.	a	b	c	d
		~~✓~~		✓

d

Section B

- Section B consists of 37 questions with a total of 78 points.
- The points for the questions in Section 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.

SCORING KEY

NO. OF CORRECT ANSWERS: X
NO. OF INCORRECT ANSWERS: Y

SCORE: SECTION A: 3X – Y
SECTION B: 3X

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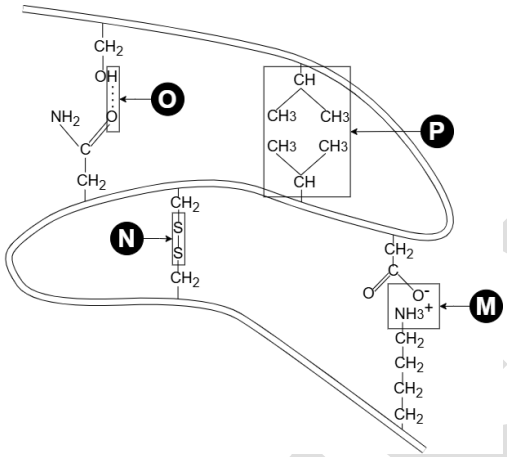
SECTION A

CELL BIOLOGY (5 points)

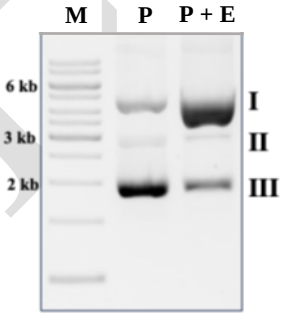
1. (1 point) A portion of the tertiary structure of a protein is represented below.



M, N, O and P respectively represent:

a. ionic bond; disulphide bridge; hydrogen bond and hydrophobic interactions
b. hydrophobic interactions; ionic bonds; disulphide bridge and hydrogen bond
c. hydrogen bond; disulphide bridge; ionic bond and hydrogen bond
d. ionic bond; disulphide bridge; hydrophobic interaction and hydrogen bond

2. (1 point) The following agarose gel image shows the result of an experiment where a purified pUC57 plasmid (P) preparation was incubated with a DNA processing enzyme (E). Lane M is DNA ladder, Lane P is the plasmid-only control, and Lane P+E is Plasmid incubated with the enzyme.



The enzyme E most likely is:

a. blunt-end restriction endonuclease
b. type I topoisomerase
c. sequence-specific exonuclease
d. nicking endonuclease

3. (1 point) The fluidity of a membrane depends primarily on the kinds of lipids it contains. When the temperature of a typical membrane preparation is increased slowly in a calorimetric chamber, a peak of heat absorption marks the gel-to-fluid transition temperature (Tm). Figure 1 depicts the Tm of three kinds of membranes while figure 2 depicts the effect of chain length and number of double bonds on the Tm of fatty acids.

Figure 1:

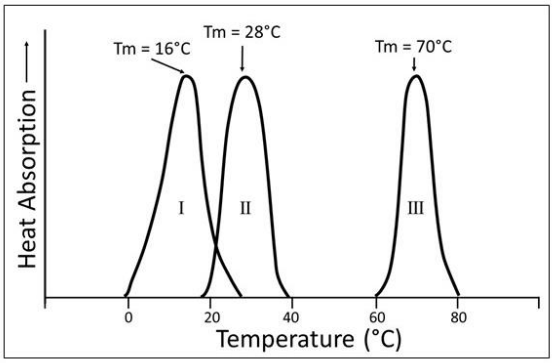
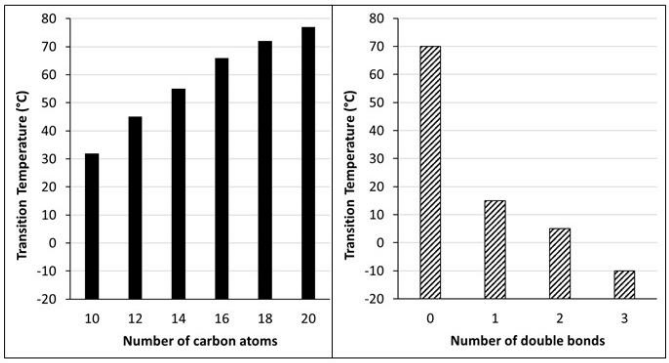


Figure 2:



Mark the correct statement.

a. Animals living in sub-zero habitats most likely have fewer double bonds with a chain length of 10 C atoms or more.
b. Membranes with oleate enriched fatty acids are essential for homeotherms living in tropical climates.
c. Curves I and II represent membranes of terrestrial animals while III represents aquatic animals.
d. Membranes with higher stearate content are likely to be less fluidic than those with higher oleate content.

4. (1 point) Suppose a biomolecule consisting of 100 atoms can exist in two structural states, O and P, at room temperature. The energies of the biomolecule are identical in both of these structural states. Suppose structural state O consists of 2000 conformations and structural state P consists of 5000 conformations (where a conformation refers to unique arrangement of atoms of the biomolecule in 3 dimensional spaces) at room temperature. Which of the following statement is correct regarding this biomolecule?

a. State O will have lower free energy than State P.
b. State O will have lower entropy than State P.
c. State P will have lower entropy than State O.
d. Both State P and State O will have the same entropy.

5. (1 point) A synthetic mRNA sequence 5′-AUG UUA GGU UGG UAA-3′ was translated *in vitro* using wild-type *E. coli* ribosomes and yielded a peptide Met-Leu-Gly-Trp. When the same mRNA was translated in a mutant *E. coli* strain, the product peptide was: Met-Leu-Gly-Trp-Tyr. All known tRNAs and aminoacyl-tRNA synthetases were the same as wild-type,

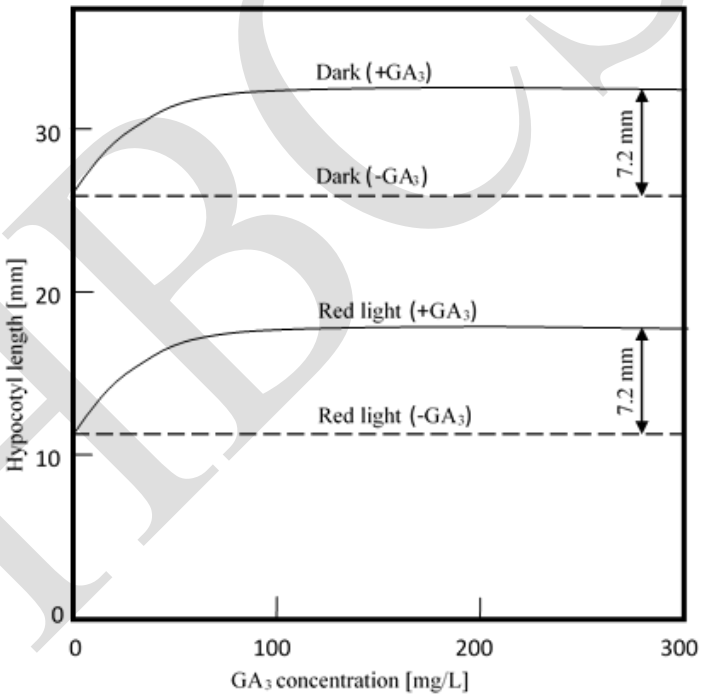
except one species of tRNA in the mutant carried tyrosine but had the anticodon AUU. Which interpretation/s best explain/s the altered translation outcome?

i. The mutant tRNA reads the UAA stop codon, inserting tyrosine instead of terminating translation.
ii. The mutant ribosome fails to recognize start codons, extending translation downstream.
iii. A frameshift occurred at the glycine codon, producing an altered peptide tail with tyrosine near the C-terminus.

a. i only
b. iii only
c. i and iii only
d. i, ii and iii

PLANT SCIENCES (4 points)

6. (1 point) Light as well as plant hormones play an important role at various stages of plant development right from the emergence of seedling from soil to the growth of a photosynthetically active plant. In an experiment, when effect of gibberellic acid (GA_3) and light was studied to measure hypocotyl growth of mustard seedlings, following graph was obtained.



Mark the correct statement.

a. GA_3 and light have a synergistic effect on hypocotyl length elongation.
b. GA_3 alone is an essential factor for elongation of hypocotyl to occur.
c. GA_3 cannot override the effects of light and lead to hypocotyl length stimulation.
d. Results are indicative of numerical additive inhibitory effect of Pfr and stimulating effect of GA_3.

7. (1 point) In a heavily shaded forest, many auxiliary buds remain dormant. This helps to:

a. prevent loss of water by excessive transpiration over a wider area.
b. prevent exchange of volatile signals from neighboring plants.
c. redirect resources to enhance vertical growth.
d. have better capillary pull of water to reach the ends of branches.

8. (1 point) Consider two types of plant cells X and Y.
The water potential data:
Cells X: Solute potential: 0 MPa
Net water potential: -0.2 MPa

Cells Y: Solute potential: -0.7 MPa
Net water potential: 0 MPa

When cells Y were subjected to a certain condition (M), the new net water potential becomes -0.7 MPa.

Which of the following are consistent with the above data?

i. Cells X likely represents xylem cells while Y represents phloem cells.
ii. Condition M to which cells Y were subjected to is likely to be the addition of abscisic acid.
iii. Cells Y are likely to be expanding leaf cells and the condition M is immersing the cells in hypotonic solution.
iv. Cells X are likely to be turgid cells and cells Y are likely to be flaccid cells.

Options:

a. i and iii
b. iv only
c. ii and iv
d. iii only

9. (1 point) Sap exudation from an aphid stylet continues even if the stylet is severed from the aphid head. This phenomenon can be used to measure phloem transport rate. It has been observed that phloem sap exudation rate decreases if the plant is kept in dark. The correct order of underlying processes that lead to this effect is:

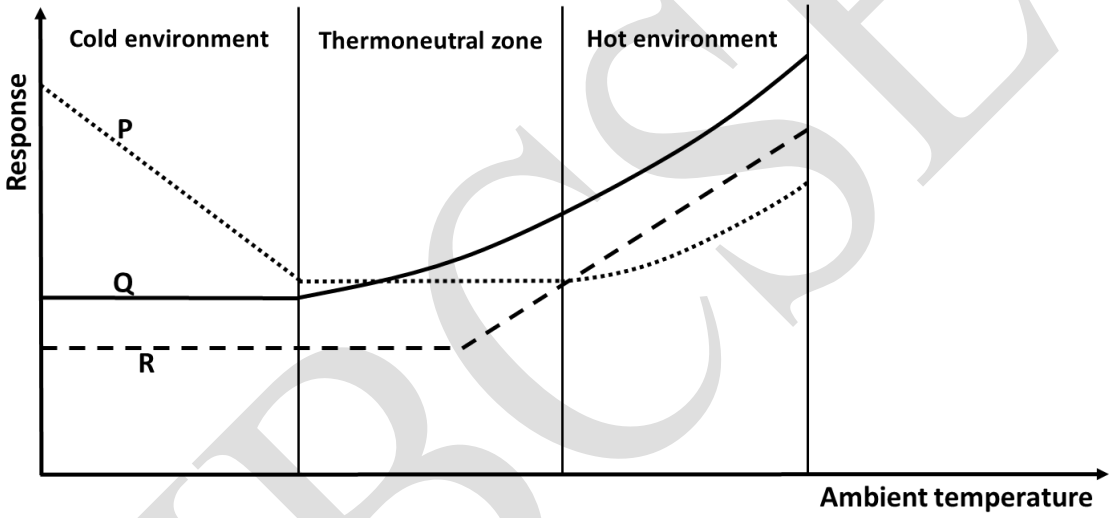
a. reduced water entry into sieve tubes → less sucrose loaded into phloem → osmotic potential less negative → slower sap exudation →lower turgor pressure.
b. less sucrose loaded into phloem → osmotic potential more negative → reduced water entry into sieve tubes → slower sap exudation.
c. osmotic potential less negative → reduced water entry into sieve tubes → lower turgor pressure → slower sap exudation.
d. less sucrose loaded into phloem →water potential less negative → increased turgor pressure → slower sap exudation.

ANIMAL SCIENCES (3 points)

10. (1 point) Approximately four hours after death, the body stiffens (known as Rigor mortis). The reason behind this phenomenon is:

a. Severe calcium deficiency in the skeletal muscles following death, leading to continuous contractile stimuli, as seen in the case of tetanus.
b. Progressive muscle fibrosis (a condition where extracellular matrix molecules, like collagen, deposits in muscles), which causes hardening of muscles.
c. Unavailability of ATP, which keeps the myosin head in 'lock' position with actin filaments.
d. Rapid degeneration of ligaments and tendons, which limits bone and muscle movement.

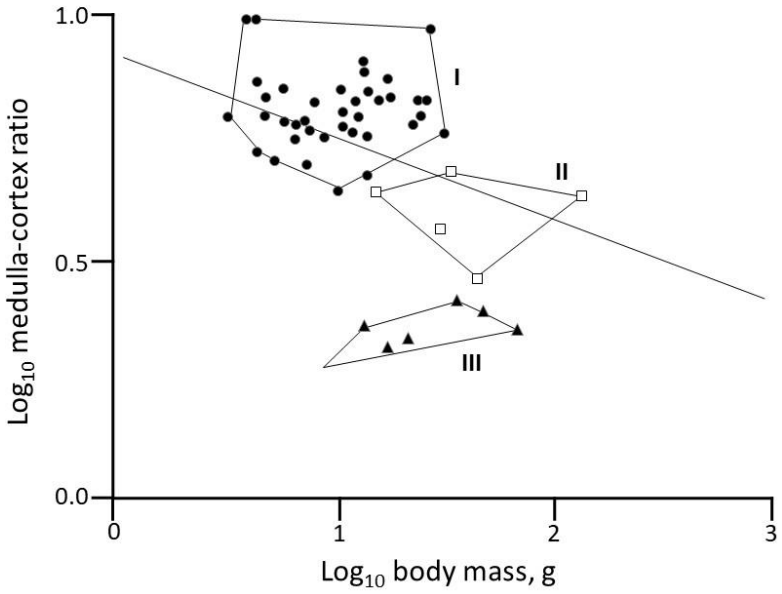
11. (1 point) Relationship between heat production and heat loss as a function of ambient temperature for a homeotherm is shown below:



P, Q, and R respectively indicate:

a. Evaporative water loss, Peripheral blood flow, Oxygen consumption
b. Oxygen consumption, Peripheral blood flow, Evaporative water loss
c. Oxygen consumption, Evaporative water loss, Metabolic heat production
d. Peripheral blood flow, Evaporative water loss, Oxygen consumption

12. (1 point) Food habits of mammals place differential demands on the renal system of these animals. This impact has been shown best in an examination of kidney morphology and function in bats having different diets. The renal indices of three such groups of bats are indicated in the scatter plots given below. The cortex region of the kidney is involved in the initial filtration while the medulla is responsible for the production of concentrated urine.



Group I, II and III most likely, respectively, represent:

a. Omnivores; Insectivores; Frugivores
b. Frugivores; Omnivores; Carnivores
c. Insectivores; Frugivores; Omnivores
d. Insectivores; Omnivores; Nectarivores

GENETICS & EVOLUTION (2 points)

13. (1 point) An *E. coli* culture was grown under four nutrient conditions, and β-galactosidase activity was measured as an indicator of lac operon transcription:

Condition	Glucose	Lactose	Observed β-galactosidase activity
A	+	–	Very low
B	+	+	Low
C	–	–	Very low
D	–	+	High

Which of the following statements most accurately explains the molecular basis for the observed results?

a. The presence of glucose prevents formation of CAP-cAMP complex limiting operon induction even when lactose is available.
b. Absence of glucose permits efficient uptake of lactose, but allolactose cannot inactivate the repressor unless cAMP is degraded, hence transcription remains low.
c. When both lactose and glucose are absent, the lac operon is repressed solely because CAP–cAMP complex binds strongly to the promoter, preventing RNA polymerase attachment.
d. Glucose enhances adenylate cyclase activity, producing high cAMP that represses lac operon transcription until lactose concentration falls below threshold.

14. (1 point) Two individuals, P and Q, were analyzed cytogenetically:

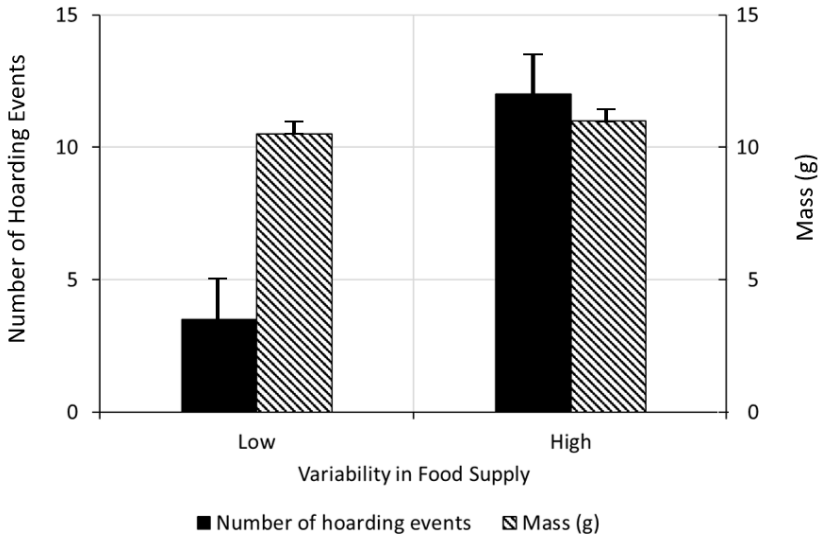
Parameter	Individual P	Individual Q
Total chromosome count	45	47
Number of Barr bodies	0	1
Y-specific (SRY) probe	Absent	Present
Gonadal development	Rudimentary	Small testes
Secondary sexual characteristics	Poorly developed	Partial masculinization with gynecomastia

Which of the following interpretations best explains the chromosomal and molecular basis of these findings?

a. P: Loss of one X chromosome after fertilization (post-zygotic nondisjunction) → mosaic with defective ovarian development
   Q: Gain of one Y chromosome → abnormal testicular development due to Y-linked gene overexpression
b. P: 45, XY complement with mutation in SRY → defective testis differentiation
   Q: 47, XYY complement → enhanced spermatogenesis and masculinity
c. P: Loss of one sex chromosome during gametogenesis → monosomy leading to female phenotype due to absence of SRY
   Q: Gain of one sex chromosome during gametogenesis → presence of Y initiates male development but extra X causes partial feminization due to dosage imbalance
d. P: Duplication of X chromosome → overexpression of X-linked genes
   Q: Loss of one X chromosome → male phenotype by default

ECOLOGY (4 points)

15. (1 point) In animals, food, once acquired can either be transported to another location for subsequent processing or storage, or consumed immediately. In an experiment done with active marsh tit birds, ecologist Hurley measured seed hoarding and body mass (indicative of adipose tissue content) changes in captive birds by using infrared detectors and computer-controlled balances. He used automatic feeders to feed the birds at uniform times versus highly unpredictable times. The results obtained are shown.



Based on the findings, mark the correct statement.

a. Hoarding is directly and fat storage is inversely proportional to variability in food supply.
b. Birds prefer to store the extra energetic buffer as fat when there is scarcity of food.
c. It is likely that the storage of food as fat is energetically more demanding than hoarding.
d. The birds may be adopting a strategy of reduction in energy requirements through prolonged fat-storing torpor during times of reduced food resource availability.

16. (1 point) Several animals migrate long distances at specific times of the year, with monarch butterflies and green sea turtles being classic examples. Which among the following is extensively used by migratory insects / birds / animals for navigation?

i. Foliage density of forests along the route.
ii. Ultraviolet polarized rays of the sun.
iii. Earth's magnetic field.
iv. Humidity and air density.

Choose the correct option.

a. i and ii only
b. ii, iii and iv
c. ii and iii only
d. iii and iv only

17. (1 point) The global hydrological cycle represents the dynamic movement of water among different reservoirs such as lakes, rivers, oceans, ice and the atmosphere. Turnover time is the time required for the entire volume of a particular reservoir to be renewed. Consider the statements below.

I. The turnover time of water in the atmosphere is shorter than that of the largest lakes on earth like Lake Victoria.
II. The flux of evapotranspiration from terrestrial areas is greater than the flux of evaporated water moving from the ocean to land.
III. Water in the form of ice is a larger reservoir on earth than ground water.
IV. The size of the atmospheric reservoir is larger than that of ground water.

Which of the following combinations represents true statements?

a. I, II and III only
b. I, III and IV only
c. I and III only
d. II and IV only

18. (1 point) Which of the following represents the correct combination of the carbon to nitrogen (C:N) and carbon to phosphorus (C:P) ratio between plants and insects feeding on them?

a. Higher C:N ratio and higher C:P ratio in plants as compared to insects.
b. Higher C:N ratio and lower C:P ratio in plants as compared to insects.
c. Lower C:N ratio and higher C:P ratio in plants as compared to insects.
d. Lower C:N ratio and lower C:P ratio in plants as compared to insects.

ETHOLOGY (2 points)

19. (1 point) An animal is generally known to adopt one of the two strategies – namely the Hawk or the Dove strategy, when in conflict. In speckled wood butterflies *Parage aegenia*, males compete for patches of sunlight on the ground layer of woods. Females are attracted to these spots and it is here that nearly all the courtship occurs.

In a study by the ecologist Davies, only about 60% of the males held these temporary territories at any one time, the remainder patrolled for females up in the canopy top. Such patrolling males continually flew down from the canopy and rapidly took over vacant spots. If, however, the sunspot was already occupied, the intruder (P) and territory owner (Q) went into a short spiral flight (of few seconds), at the end of which, in every case, the intruder retreated, even if he was in prime condition and the territory owner had tatty wings.

In another experiment, a male (R) was released into a territory occupied by another male (S), without either butterfly initially noticing the other's presence.

The strategy adopted by each male P, Q, R and S respectively is likely to be:

a. Dove, Hawk, Hawk, Hawk
b. Hawk, Hawk, Hawk, Dove
c. Dove, Hawk, Dove, Dove
d. Hawk, Dove, Hawk, Dove

20. (1 point) Which of the following strategies will **NOT** always minimize cost in migratory organisms?

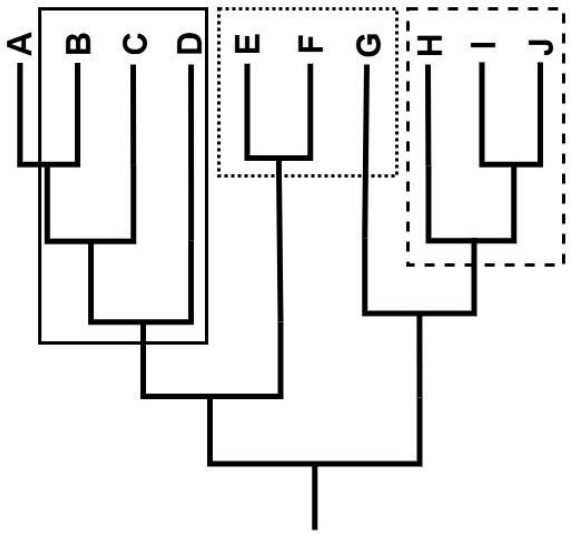
a. Increasing body weight prior to migration
b. Formation of a V in migrating flocks
c. Butterflies flying on less windy days.
d. Taking the shortest route

BIOSYSTEMATICS (2 points)

21. (1 point) Desert environments brought evolutionary adaptations in two different categories of plant species such as Cacti and Euphorbias. Cacti spines are modified leaves whereas Euphorbias spines are modified shoots. This is an example of:

a. Convergent evolution
b. Divergent evolution
c. Adaptive radiation
d. Disruptive selection

22. (1 point) A cladogram representing plant specimens A – J is shown below.



Boxes indicated by solid line, dotted line, and dashed line, respectively indicate:

a. Monophyletic group; paraphyletic group; polyphyletic group
b. Paraphyletic group; polyphyletic group; monophyletic group
c. Polyphyletic group; paraphyletic group; monophyletic group
d. Monophyletic group; polyphyletic group; paraphyletic group

****** END OF PART A********

SECTION B

CELL BIOLOGY (13.5 points)

23. (2 points) A few genes from human DNA were analysed and results obtained are given in the table below.

	Gene	Gene size (kbp)	Number of introns	mRNA size (kbp)
1.	Collagen	38.0	50	5.0
2.	Insulin	1.7	2	0.4
3.	Dystrophin	2000.0	50	17.0
4.	Albumin	25.0	14	2.1
5.	Phenylalanine hydroxylase	90.0	12	2.4

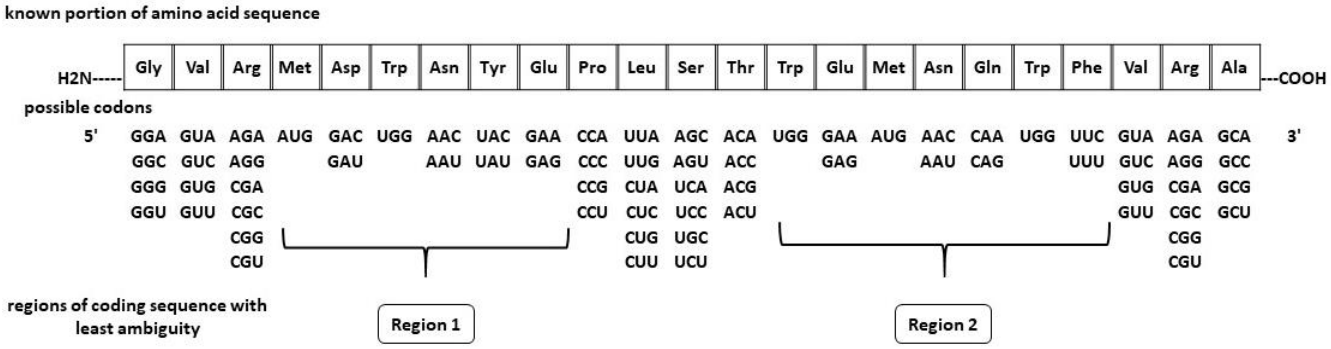
Based on the data given, mark each of the following statements as true or false by putting tick marks (✓) in the appropriate boxes.

a. The average size of introns is directly proportional to the size of the gene.
b. The dystrophin gene has the longest introns with an average size of about 40kb.
c. On translation, the albumin gene produces about 100 amino acids less than the phenylalanine hydroxylase gene.
d. The average intron size of collagen is about 25 times smaller than that of insulin.

24. (2 points) A transcription factor has two subunits, X and Y. Subunit 'X' has the DNA binding domain, and the 'Y' has the transactivation domain. The X-Y heterodimers are sequestered in the cytosol when it binds to another subunit 'I'. The transcription factor is activated by an effector 'E', which causes the phosphorylation of I and Y. Phosphorylated I, further is ubiquitinylated and degraded. Phosphorylated Y along with X is translocated to the nucleus for transactivation. Acetylation of 'Y' augments gene activation.
Based on the given information, mark whether each of the following statements is true or false by putting tick marks (✓) in the appropriate boxes.

a. When the cells are treated with the effector (E) and inhibitor of phosphatase, the transcription factor will be translocated into the nucleus, and there will be activation of genes regulated by the transcription factor.
b. When the cells are treated with the effector (E) and inhibitor of ubiquitinylation, the transcription factor will be translocated into the nucleus, but there will be no activation of genes regulated by the transcription factor.
c. When the cells are treated with the effector (E) and inhibitor of deacetylase, the transcription factor will be translocated into the nucleus and there will be enhanced activation of genes regulated by the transcription factor.
d. When the cells are treated with the effector (E) only, the transcription factor will not be translocated into the nucleus and there will be no activation of genes.

25. (2 points) A molecular biologist was trying to make synthetic nucleic acid probes against the transcript of the given peptide. Although only one nucleotide sequence will actually code for the protein, the degeneracy of the genetic code could result in several different nucleotide sequences that will give the same amino acid sequence, and it is impossible to tell in advance which is the correct one. Because it is desirable to have as large a fraction of the correct nucleotide sequence as possible in the mixture of oligonucleotides to be used as a probe, those regions with the fewest possibilities are chosen, as shown by regions 1 and 2.



If probes have to be designed separately for each region, how many total possible oligonucleotide probes would have to be synthesized?
Note that the final answer for this part of the question will be given marks only if calculations are shown in the box given and the final answer is filled in the blank.

26. (2 points) Calculate the number of protein molecules in a typical eukaryotic hepatocyte in a situation where total proteins account for 20 percent of the weight of the cell. Assume the hepatocyte to be a cube with a side measuring 15 µm and having a cell density of 1.03 g/ml. Also, assume the average eukaryotic protein of molecular weight to be 52,700 g/mol and Avogadro's number to be 6.02×10^{23}.
Note that the final answer for this part of the question will be given marks only if calculations are shown in the box given and the final answer is filled in the blank.

27. (2 points) In a restriction digestion experiment, a sample of a synthetic linear DNA molecule 21 kbp in length was treated with an enzyme 'P. Another sample of the same DNA was treated with another restriction enzyme 'Q'. The fragments (in kbp) obtained after gel electrophoresis profiling are as follows:

Reaction 1: Treatment with enzyme P: 9, 7.2 and 4.8
Reaction 2: Treatment with enzyme Q: 10.4, 7.6 and 3

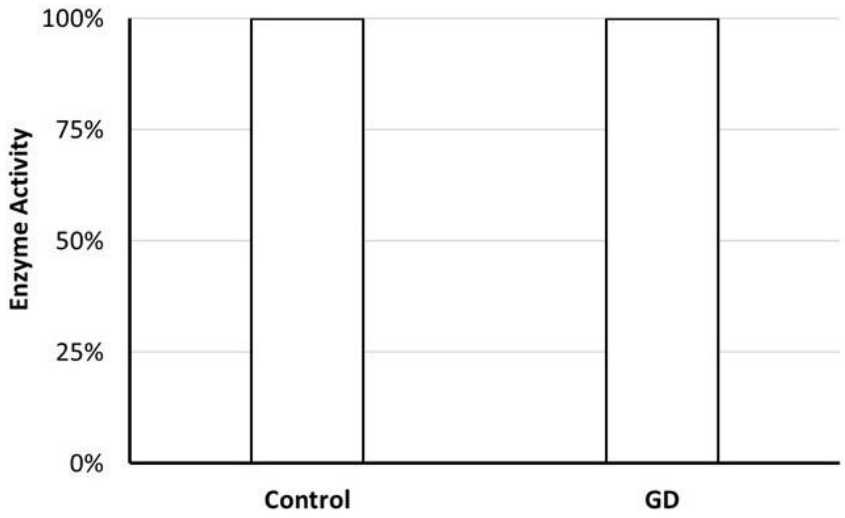
The fragment mixture obtained in reaction 1 was then treated with enzyme Q. Similarly, the fragment mixture obtained in reaction 2 was treated with enzyme P. The fragments (in kbp) obtained from these treatments are given below.

Reaction 3: Reaction mixture from reaction 1 treated with enzyme Q: 9, 4.2, 3.4, 3,1.4
Reaction 4: Reaction mixture from reaction 2 treated with enzyme P: 9, 1.4, 4.2, 3.4, 3

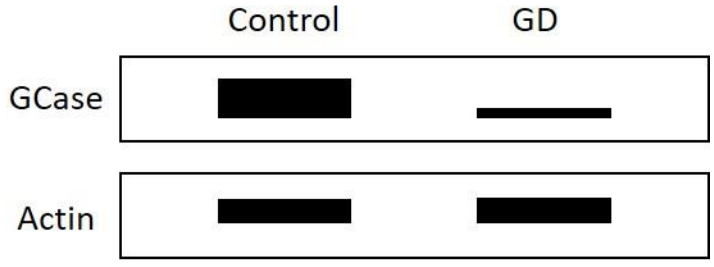
Based on the fragments obtained, draw the restriction map indicating the positions of the restriction sites of the enzymes P and Q. Also, indicate the fragment lengths between the sites. *Note: Draw the restriction map in the given box. Only a completely correct answer will be given points.*

28. (1.5 points) Gaucher disease (GD), the most common lysosomal storage disease in humans is caused by mutations in the gene encoding glucocerebrosidase (GCase). Symptoms include bone pain, enlarged liver, excessive fatigue, and cognitive disabilities. In order to understand the disease, researchers undertook a series of experiments to characterize the nature of defects in the enzyme.

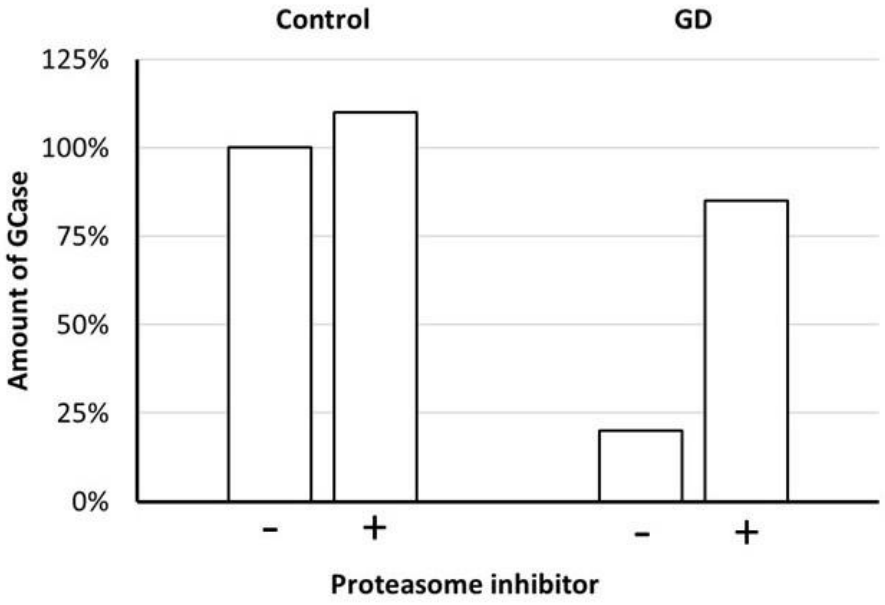
A. Cells were obtained from a person without the disease (control) and patients with GD. GCase was isolated and enzyme activity of 10µg of protein was measured.



B. In the next experiment, proteins were extracted from equal number of cells from control and GD individuals, and subjected to Western blotting using antibodies against GCase and actin proteins.



C. Next, cells from control and GD individuals were grown in the presence and absence of a potent proteasome inhibitor. The amount of GCase was determined using Western blotting.



Based on the above experimental results, indicate whether the following statements are true, false or inconclusive by putting tick marks (✓) in the appropriate boxes.

a. The mutation in GCase was not in the active site of the enzyme.
b. The mutation affected the transcription and hence the translation of GCase gene.
c. The mutation occurred at a site that enhanced proteasomal degradation of the GCase protein.

29. (2 points) Catalysis of the cleavage of peptide bonds in a small peptide by a proteolytic enzyme is described in the following table (the arrow indicates site of cleavage):

Sr. no	Substrate	Km (mM)	Kcat (s^{-1})
1.	Glu-Met-Thr-Ala↓Gly	4.0	24
2.	Glu-Met-Thr-Ala↓Ala	1.5	30
3.	Glu-Met-Thr-Ala↓Phe	0.5	18
4.	Glu-Met-Thr-Ile↓Phe	9.0	18
5.	Glu-Met-Thr-Gly↓Tyr	1.0	20

Mark whether each of the following statements is true or false or cannot be deduced by putting tick marks (✓) in the appropriate boxes.

a. Substrate 3 is cleaved most efficiently.
b. Alanine is the most preferred amino acid on either side of the cleavage site.
c. The enzyme most efficiently cleaves the peptide bond between a small hydrophobic amino acid residue and a large, aromatic hydrophobic amino acid residue.
d. A new substrate with a Km value of 0.3 would be more efficiently cleaved compared to the given substrates.

PLANT SCIENCES (13 points)

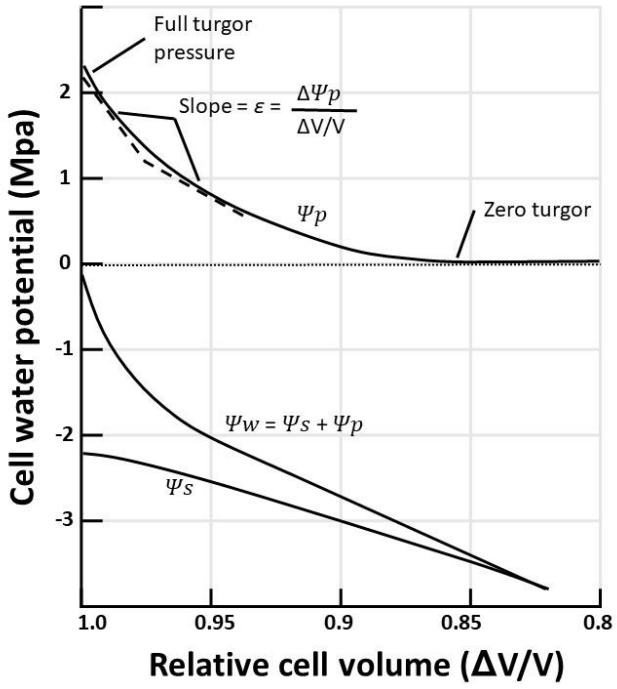
30. (2 points) Biomolecular composition of four plant samples is shown in the table.

	Cellulose	Hemi-cellulose	Lignin	Pectin	Water
P	50%	30%	15%	1%	20%
Q	15%	10%	1%	10%	70%
R	20%	9%	55%	0.7%	10%
S	20%	15%	15%	2%	60%

Match them against appropriate sample by choosing from the options for samples (I – IV). *Fill in the blanks with the corresponding option number.*

Options:
I. Fresh wood
II. Decaying wood
III. Fresh leaves
IV. Fresh non-fibrous fruit

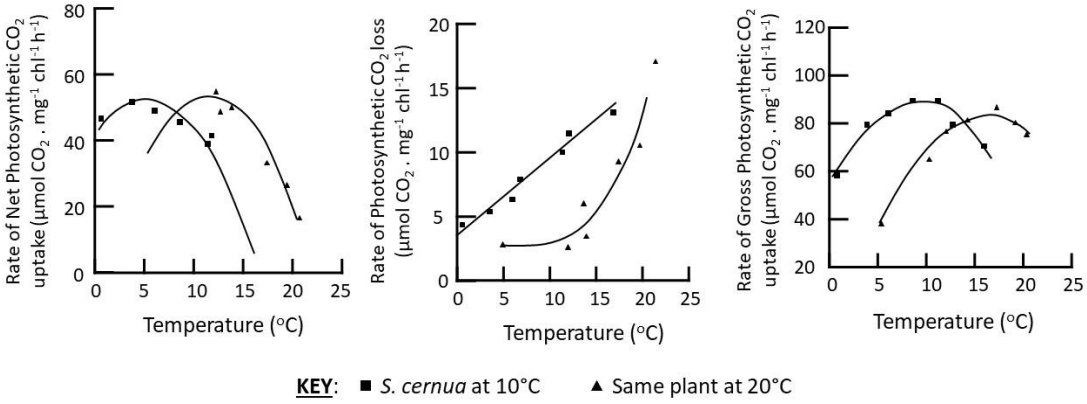
31. (2 points) The relationship of plant cell water potential (Ψ_w) and its components (Ψ_p and Ψ_s) as well as relative cell volume ($\Delta V/V$) are shown in the graph below.



Mark the following statements as true or false by putting tick marks (✓) in the appropriate boxes.

a. Turgor pressure changes with an initial 5% change in cell volume is comparable with the changes observed in the osmotic potential.
b. With a fall in cell volume from 90 to 80%, most of the change in the water potential is due to a drop in turgor pressure and not as much due to osmotic pressure.
c. The elastic modulus (Є) of the cell is not constant but decreases as the cell loses turgor.
d. For leaf mesophyll cells of palm trees having relatively rigid cell walls, the volume change associated with turgor loss will be smaller than cells with extremely elastic walls.

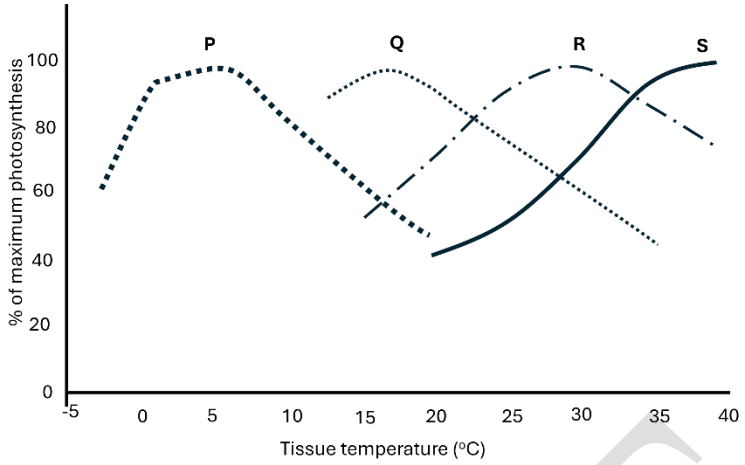
32. (2 points) A group of researchers was studying effect of thermal acclimation on photosynthesis. They were working on a perennial herb, *Saxifraga cernua* which is widely distributed in Canadian Arctic region. A set of *S. cernua* plants was initially grown at 10° C for 5 to 7 weeks under controlled conditions. The rate of net photosynthesis, dark respiration and gross photosynthesis was measured with varying temperature. The same set was subjected to acclimation at 20° C for 10 days and the same parameters were measured. The results are shown in the graphs below.



Mark whether each of the following statements is true or false by putting tick marks (✓) in the appropriate boxes.

a. Acclimation to higher temperature resulted in higher rate of net photosynthesis.
b. There is a linear increase in rate of dark respiration only above 10°C in *S. cernua* grown at lower temperature.
c. Optimum temperature of gross photosynthesis increased to 12°C post acclimation.
d. The difference between temperature optima of net and gross photosynthesis is due to dark respiration.

33. (2 points) The photosynthetic temperature response curves for four terrestrial plant species (P, Q, R and S) are shown below. The difference in optimum temperature requirement for maximum photosynthesis indicates variations in their respective habitats. Match each plant name with the correct type of representative curve.



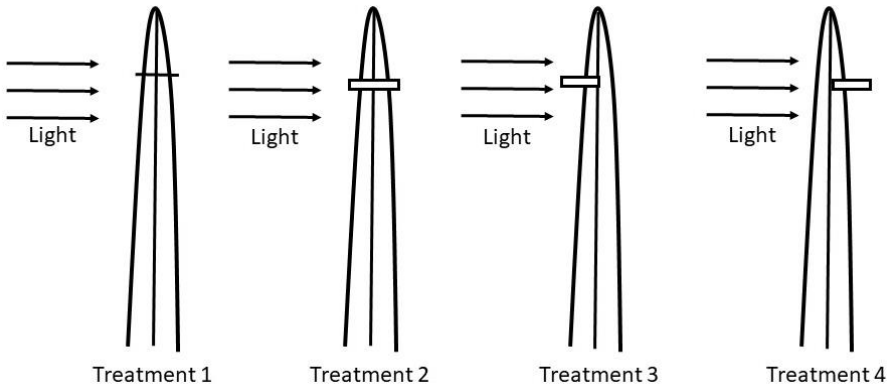
Choose from the following and indicate the answers by filling the corresponding option number in the blanks.

i. *Atriplex hymenelytra*: C4 desert shrub growing on steep slopes or gravel deposited at the base of hill slope.
ii. *Tidestromia oblongifolia*: C4 desert perennial growing in open spaces having scanty vegetation cover.
iii. *Neuropogon acromelanus*: A lichen growing in arctic region.
iv. *Abrosia chamissonis*: A herb found in cooler coastal environment.

34. (2 points) In a study on the effect of light on the bending of shoots, the following four treatments were given to growing shoots:

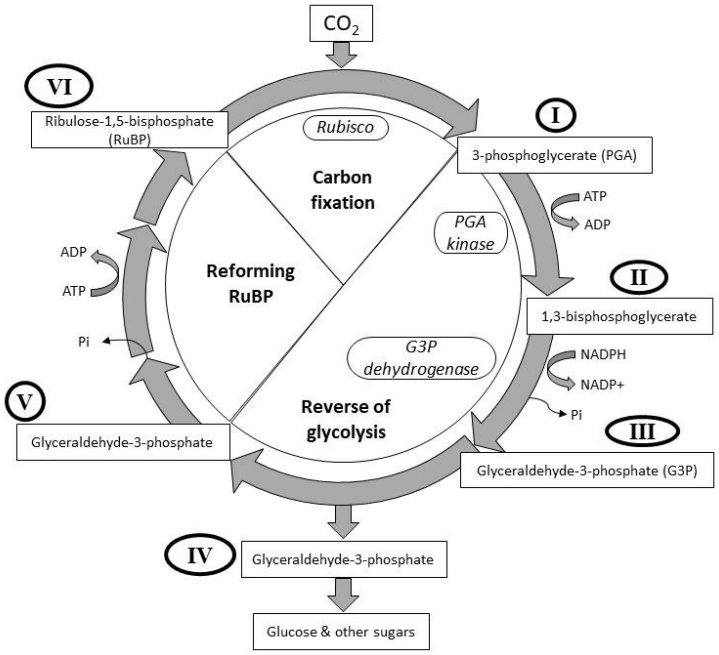
Treatment 1: Decapitated tip is replaced back.
Treatment 2: Decapitated tip is replaced on a gelatin block.
Treatment 3: Plastic strip inserted on illuminated side.
Treatment 4: Plastic strip inserted on the dark side.

Figures indicating the treatments are shown below.



Indicate whether each treatment would lead to bending of the shoot tip towards light; away from light or no bending would occur by putting tick marks (✓) in the appropriate boxes.

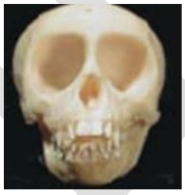
35. (3 points) The reactions of the Calvin cycle are represented below. The intermediates in the cycle are labeled as I – VI. Fill in the blanks against each intermediate with the number of molecules of each intermediate when 6 molecules of CO_2 are fixed.

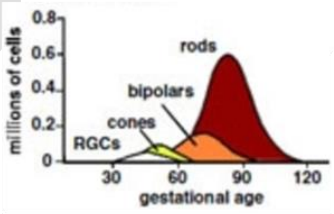


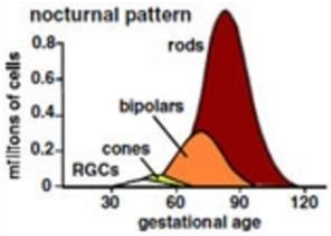
ANIMAL SCIENCES (14 points)

36. (2 points) P and Q are the pictures of two mammalian skulls while R and S represent the composition of different types of retinal cells. RGCs in the plots indicate retinal ganglion cells.

P 

Q 

R 

S 

Mark whether each of the following statements is correct or incorrect by putting tick marks (✓) in the appropriate boxes.

a. P and R most likely represent a diurnal mammal.
b. Retina of a mammal with composition as shown in S is less likely to have fovea in the retina.
c. P and S most likely represent a mammal that is better adapted to nocturnal vision.
d. Contrast sensitivity in both mammals is high giving them the ability to perceive finer details of objects.

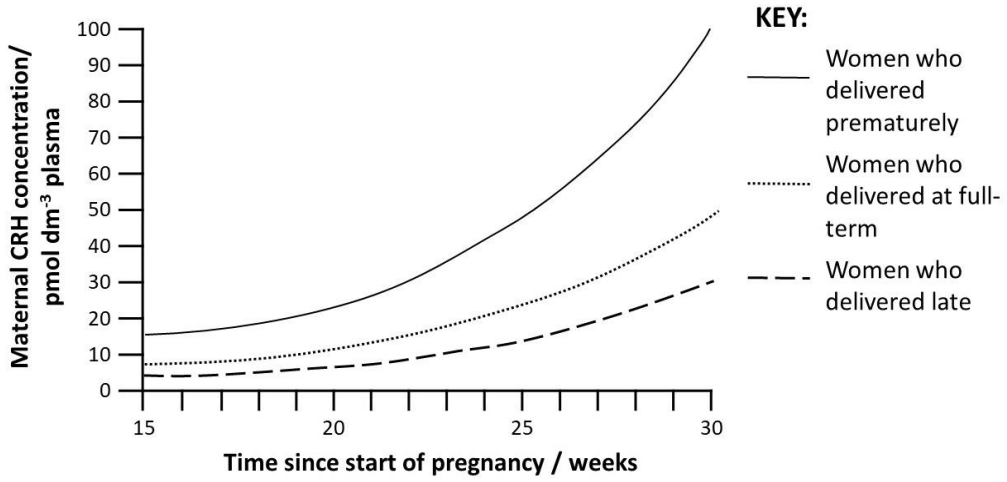
37. (2 points) The membrane potential (Vm) of a typical cell due to the diffusion of Na^+ or K^+ ions can be calculated using the simplified Nernst equation as follows:

$Vm = 61.5 \log_{10} [ion]_{outside}/[ion]_{inside}$

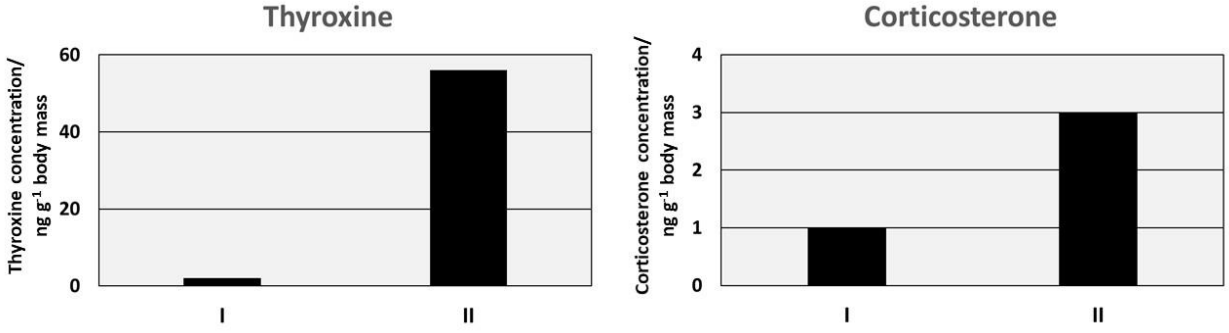
A combination of concentrations of these ions (represented as M and N) outside and inside of a cell are given below:
$M_{(outside)}$: 5 mEq/L
$M_{(inside)}$: 140 mEq/L
$N_{(outside)}$: 142 mEq/L
$N_{(inside)}$: 14 mEq/L

For a given cell, calculate the membrane potential due to potassium ions alone.
Note that the final answer for this part of the question will be given marks only if calculations are shown in the box given and the final answer is filled in the blank.

38. (2 points) The results of a study on the placental secretion of a hormone Corticotropin Releasing Hormone (CRH) and its correlation with delivery of babies in a group of women during their pregnancy is represented in the graph below.



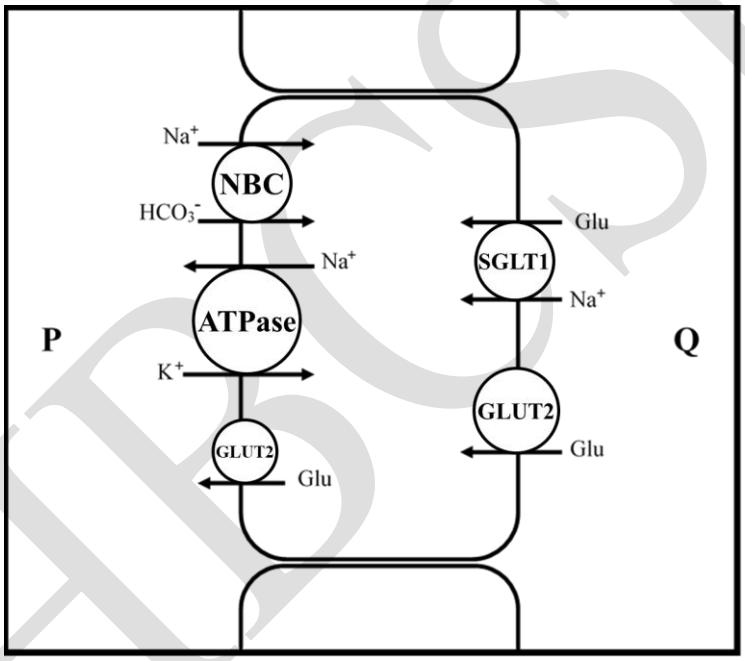
Studies have shown that control of development by CRH might have evolved in amphibians long before mammals appeared. An increase in CRH concentration leads directly to an increase in the level of the hormone thyroxine and indirectly to an increase in corticosterone levels. The results of an experiment with tadpoles raised in two different environmental conditions (I and II) are shown.



Mark each of the following statements as true or false by putting tick marks (✓) in the appropriate boxes.

a. In women who deliver prematurely, CRH levels show a steep rise towards the third trimester.
b. High concentration of CRH at 30 weeks of pregnancy could indicate the need to induce labour.
c. CRH concentration of about 20 pmol dm^{-3} at mid-pregnancy may require provision of special incubator for likely premature birth.
d. Condition II most likely represents the physiology of tadpoles in a pond that is shrinking due to lack of rain.

39. (2 points) Schematic of an enterocyte showing transporters for various ions/solutes is depicted. These transporters play an important role in absorption of nutrients as well as cell homeostasis under different conditions.



Based on the given information, mark each of the following statements as true or false by putting tick marks (✓) in the appropriate boxes.

a. The region marked as P represents interstitial fluid.
b. In case of severe diarrhoea, drinking solution containing Na^+, K^+ and HCO^{3-} ions will help restore cellular functions.
c. In case of severe dehydration, drinking saline glucose solution will restore cellular osmolarity.
d. In case of severe diarrhoea and vomiting, drinking hypertonic glucose solution will help restore cellular osmolarity.

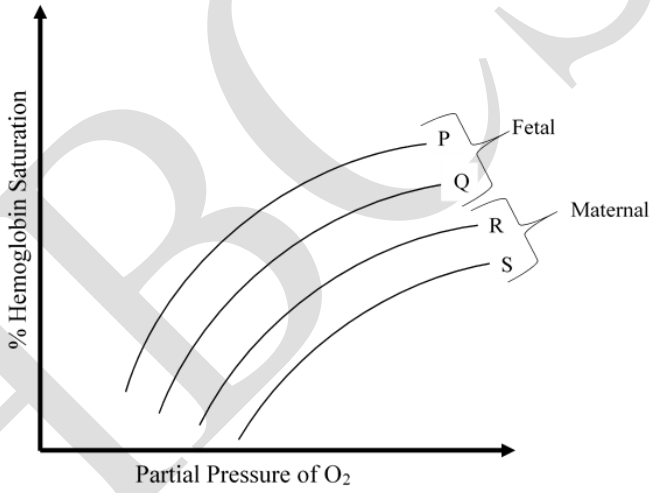
40. (2 points) Consider 4 organs (P-S) of human body. Some values related to their weights and basal metabolic rate (BMR) considering an adult human of 80 Kg body weight are given in the table.

Organ	Weight (kg)	Absolute BMR	% of total BMR
P	12	54	3
Q	0.37	163	9
R	1.5	300	17
S	32	416	23

Mark the following interpretations as true or false by putting tick marks (✓) in the appropriate boxes.

a. Weight specific BMR is highest in Q and is likely to represent heart.
b. R likely represents skeletal muscles as its contribution to total BMR is much higher than its contribution is to total body mass.
c. Weight specific BMR is least in P and it likely represents adipose tissues.
d. Since both absolute BMR and % of total BMR are largest in S, it is likely to represent brain.

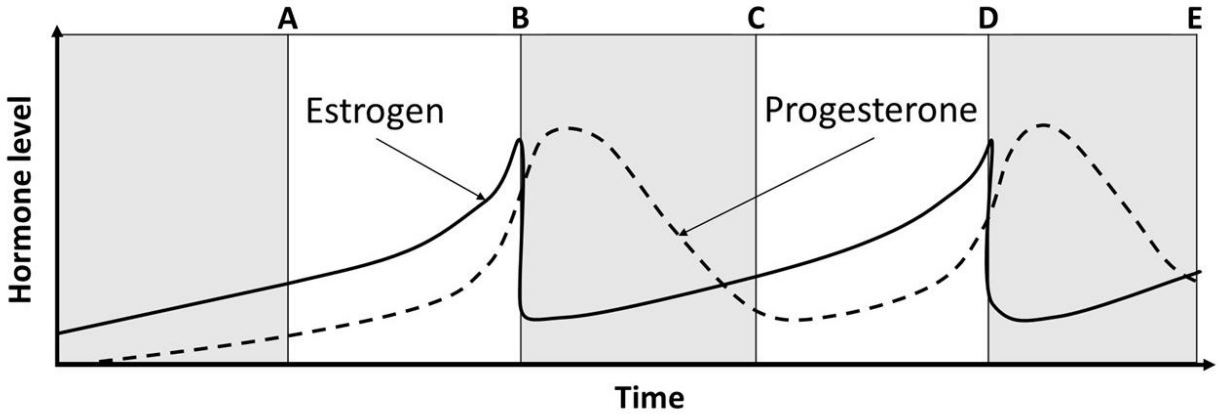
41. (2 points) Bohr effect is the phenomenon where increase in CO_2 level or acidity reduces hemoglobin affinity for oxygen while Haldane effect is a physiological process where increasing O_2 level reduces hemoglobin affinity for CO_2. The haemoglobin saturation curves of maternal and fetal hemoglobin are shown. Gaseous exchange between the hemoglobin molecules of maternal and fetal blood can shift the position of the curves.



Mark the following statements as true or false by putting tick marks (✓) in the appropriate boxes.

a. As the blood of fetal and maternal circulation juxtapose (come in close vicinity) in placenta, the curve R shifts to S and is called Bohr effect.
b. As the blood of fetal circulation comes in close vicinity of maternal blood, the curve P shifts to Q and it is Haldane effect.
c. Curve P represents umbilical vein and Q represents umbilical artery.
d. Curve R represents maternal arterial blood and S represents maternal venous blood.

42. (2 points) A certain species of whiptail lizards reproduce only asexually by parthenogenesis. This species has no males but females can act as males engaging in all aspects of mating behavior. The presence and variation in the levels of two hormones estrogen and progesterone in this species is depicted in the graph.



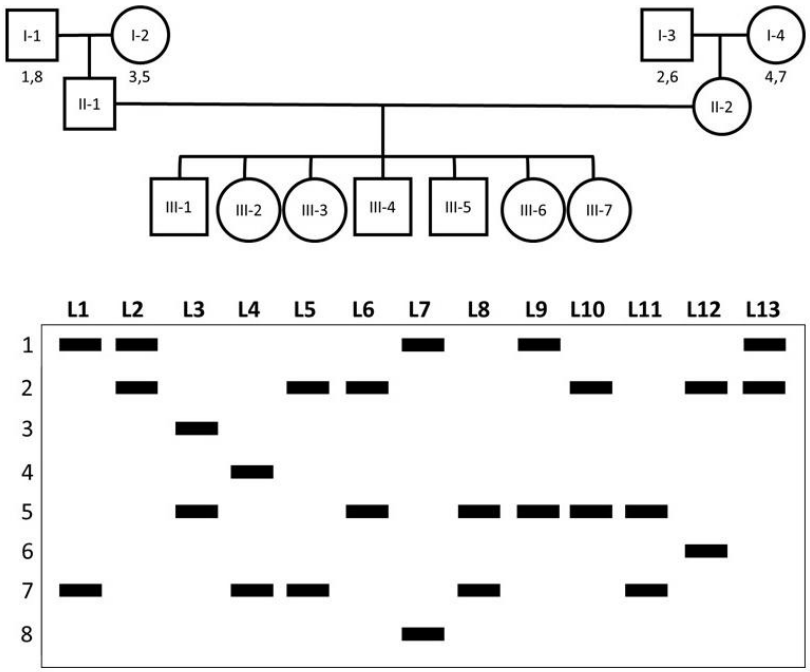
Indicate if each of the following statements is true or false by putting tick marks (✓) in the appropriate boxes.

a. Ovulation is most likely to occur in mid A - B period of the ovarian cycle.
b. A given individual behaves as a male during D – E and as a female during A – B period in the cycle.
c. The act of copulation will trigger the release of eggs from the ovaries of the lizards.
d. As compared to sexually reproducing species, the mode of reproduction adopted by this species of lizards is favoured when availability of resources is not a constraint.

<u>GENETICS & EVOLUTION</u> (16 points)

43. (2 points) Consider a plant species, wherein the height is determined by four independently assorting genes M, N, O and P. The contribution of the alleles of each of these genes to the basal height of the plant is additive and indicated as the superscript with '0' denoting no increment; '1' denoting an additional growth of 1 cm and so on. If 45 cm is the basic height of this plant and a gardener carries out selfing of plants with the genotype $M^0M^1N^0N^2O^0O^3P^0P^4$, then what proportion of plants would be 65 cm tall?
Note that the final answer for this part of the question will be given marks only if calculations are shown in the box given and the final answer is filled in the blank.

44. (3 points) A pedigree representing three generations is shown. The inheritance of a RFLP marker through three generations in a single family is monitored and the gel profile obtained for the 13 members of this family is shown. A total of 8 alleles (numbered to the left of the blots) are present in the family.



The alleles present in the grandparents (Generation I) are shown in the pedigree. Based on the pedigree and the RFLP profile, answer the following.

(A) Indicate the lanes that represent the RFLP pattern of individuals II-1 and II-2 (Parents). *Fill in the blanks with the respective lane numbers. Only a completely correct answer will be given points.*

(B) Indicate the number of individual/s with the respective alleles for the progeny in generation III. (E. g. 1 individual with 1, 8 alleles.)

45. (2 points) An example of multiple alleles is seen at a locus that determines the feather pattern of mallard ducks. One allele, *M,* produces the wild-type *mallard* pattern. A second allele, M^R, produces a different pattern called *restricted,* and a third allele, m^d, produces a pattern termed *dusky*. In this allelic series, restricted is dominant over mallard and dusky, and mallard is dominant over dusky. In a given cross, if the F1 progeny yield 50% restricted; 25% mallard and 25% dusky ducks, then the genotype of the parents would be:
(Note: Only a completely correct answer will be given points.)

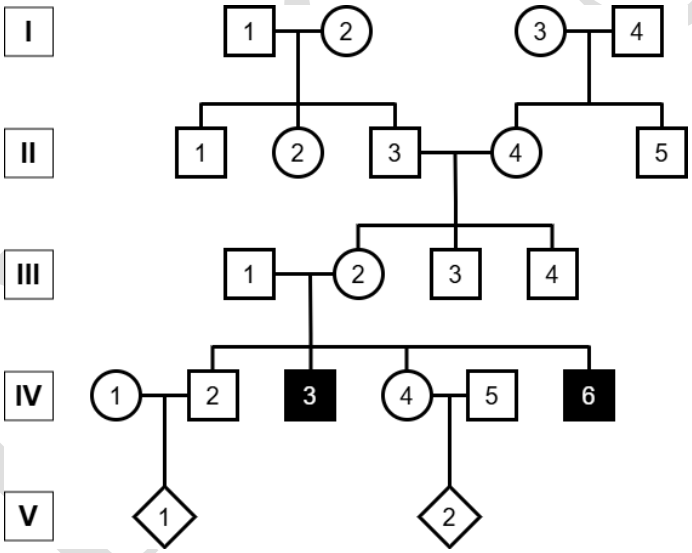
46. (3.5 points) Coat color in a certain rodent species is governed by the '*S*' allele. Pigment production occurs only in the presence of this allele. Thus a rodent with the genotype '*ss*' will produce no pigment (pale coat colour). When the pigment is produced, alleles *B* and b determine the color with *B* being the dominant allele resulting in brown phenotype. Homozygous recessive rodents have black coats.

(A) If a true breeding brown rodent is crossed with a rodent having completely recessive genotype, then the resulting phenotypic ratio in the F2 generation would be:
(Only a completely correct answer mentioning the values in the ratio with coat colour will be given points. E. g. 1 brown: 2: black: 1 pale)

(B) Three separate crosses were carried out between brown females (genotypes unknown) and males with completely recessive genotype for the two genes. The phenotypic ratios obtained in progeny of each cross is given. Determine the maternal genotype for each of the cross and fill in the blanks.

(i) 7 brown: 7 pale
(ii) 8 brown: 9 black
(iii) 5 brown: 6 black : 12 pale

47. (2 points) The Lesch-Nyhan syndrome, which is a very rare trait in the general population, is an X-linked trait. The abnormality of the enzyme hypoxanthine phosphoribosyltransferase (HPRT) results in the accumulation of purines in the joints and nervous tissues of affected individuals. A pedigree for the transmission of the trait is shown below.



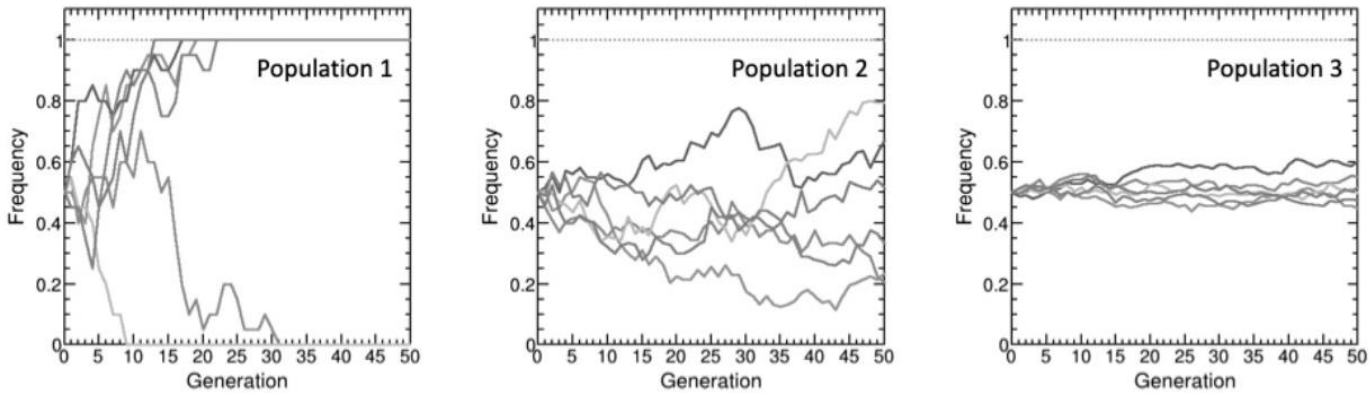
Answer the following questions related to the syndrome. *(Fill in your answers in the blanks given.)*

(A) The probability that V-1 is a son affected with the disease is:

(B) The probability that V-2 is a daughter and who is not a carrier for the trait is:

48. (2 points) To study the role of genetic drift, a simulation was performed using a simple model on three different populations, namely, population 1, population 2, and population 3. A gene with two alleles was considered for modelling. The following assumptions were applied; (1) the population size does not change from generation to generation, (2) each allele

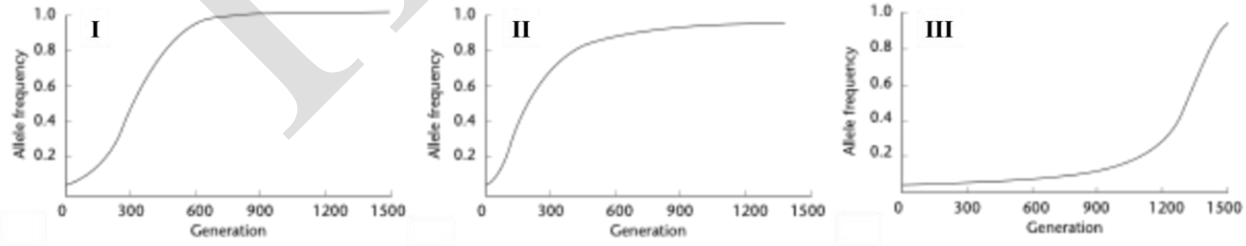
has the same expectation of offsprings in the next generation (selection not acting), and (3) no new mutations would arise. In the starting (or the zeroth) generation, that is before any reproduction, both alleles are assumed to be in the same frequency. The following figures show the result of 6 independent simulation experiments on populations 1, 2, and 3. *Y axis*- frequency of the dominant allele is shown.



Mark whether the following statements are true or false by putting tick marks (✓) in the appropriate boxes.

a. Population 1 has the largest number of individuals.
b. The effect of drift is seen only in population 1 and 2, but not in population 3.
c. Data from population 1 show that genetic drift does not distinguish between a recessive allele and a dominant allele.
d. The effect of random fluctuations in allele frequency tends to cancel each other in large population sizes.

49. (1.5 points) Change in allele frequency of an advantageous allele A2 is shown in the three panels, I, II, and III below under various types of selection given in the table. Match them with the appropriate type of selection and fill in the table with the respective correct graph number.



Type of selection:

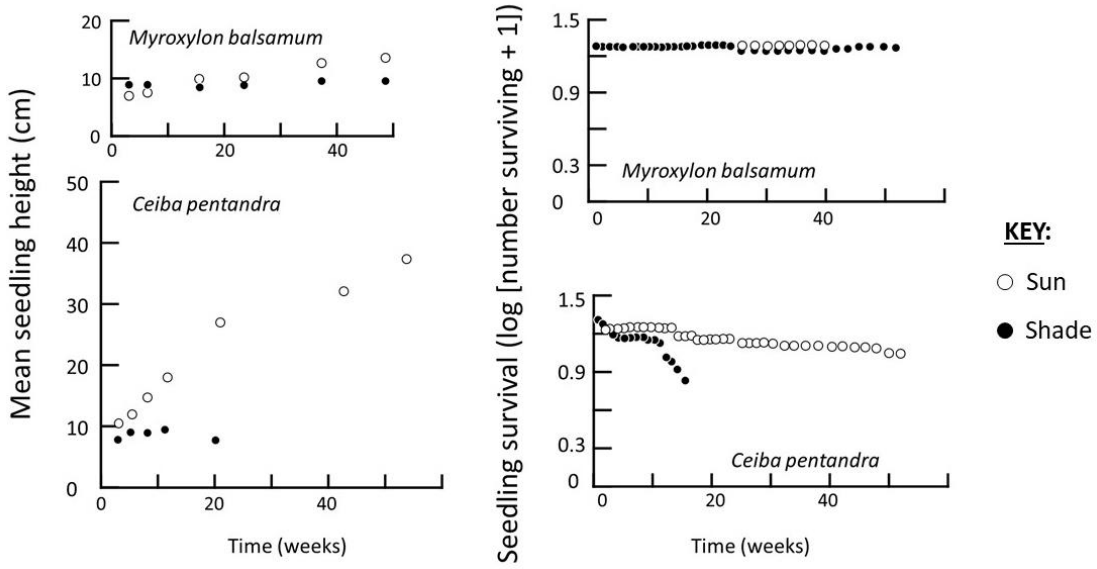
a. Dominant selection where A2 is dominant over A1
b. Dominant selection where A1 is dominant over A2
c. Codominant selection

ECOLOGY (10 points)

50. (2 points) Caroline Augspurger studied the effect of light conditions on seedling survival and growth. She worked on tree species growing in tropical rain forest. In a series of experiments, she grew tree seedlings of two species, *Myroxylon balsamum* and *Ceiba pentandra* under two different light conditions.

Condition 1: Shaded environment as found under continuous forest canopy.
Condition 2: High sunlight exposure found in openings or large gaps formed by falling of large trees.

After one year of monitoring the seedlings, the results were as shown below:



Indicate whether each of the following statements is true or false by putting tick marks (✓) in the appropriate boxes.

a. Shaded condition drastically reduces the *M. balsamum growth.*
b. Seedlings of *M. balsamum* are tolerant to high sunlight.
c. *M. balsamum and C. pentandra* are both shade intolerant species.
d. *M. balsamum* is shade tolerant while *C. pentandra* is better suited for higher sunlight.

51. (2 points) Foraging birds often face complex trade-offs between energy gain, predation risk, and the energy costs of travel. Decisions are made depending on food density, energy reserves and risks associated with behaviour.
Consider that a house sparrow has two food patches available as given below:
Food Patch 1 - high food density but unpredictable food availability
Food Patch 2 - low food density but stable food availability.
If the sparrow's current energy reserves are marginally above the survival threshold and if the risk of predation increases non-linearly with travel frequency, which of the following

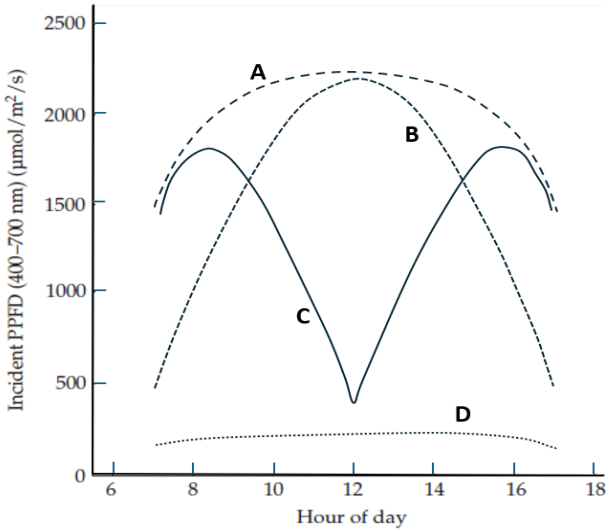
statements is correct? *Choose the correct option and put a tick mark (✓) in the appropriate box.*

a. Choose Patch 1, because high expected gain minimizes risks of long-term energy deficits despite higher risks during travel.
b. Choose Patch 2, because stable returns reduce the probability of short-term energy shortfall with lower risk of multiple travels.
c. Alternate rapidly between Patches 1 and 2 to overcome uncertainty, because increasing travel frequency reduces predation risk by unpredictable movement.
d. Avoid both patches until reserves increase further, decreasing predation risk and prevents the energy–risk trade-off.

52. (2 points) The amount of light received by a leaf depends on its orientation with respect to the sun. Different species of desert plants orient their leaves in different ways to control the amount of solar radiation falling on them. Given below are four different orientation of leaves and the figure below depicts the amount of useful solar radiation (measured as photosynthetic photon flux density-PPFD) falling on it.

i. Paraheliotropic solar tracking leaf (parallel to sun rays)
ii. Diheliotropic solar tracking leaf (perpendicular to sun rays)
iii. Horizontally placed leaf
iv. East-West facing vertically oriented leaf

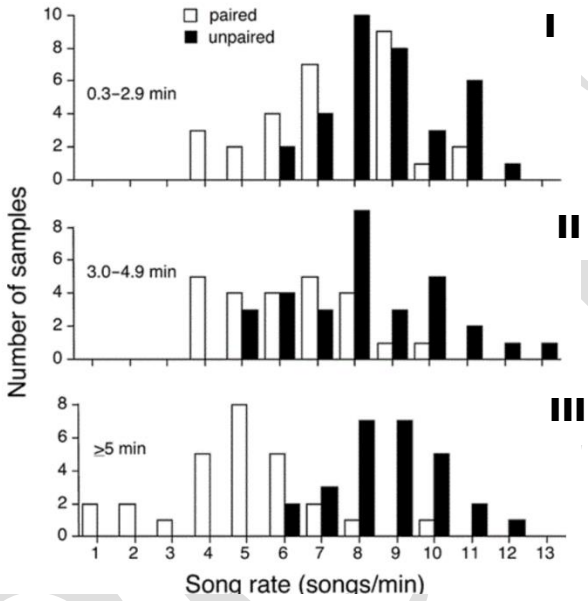
Match the above conditions with the curves shown in the diagram. *Choose the correct option and put a tick mark (✓) in the appropriate box.*



a. i-A, ii-B, iii-D, iv-C
b. i-D, ii-A, iii-B, iv-C
c. i-D, ii-C, iii-A, iv-B
d. i-C, ii-A, iii-B, iv-D

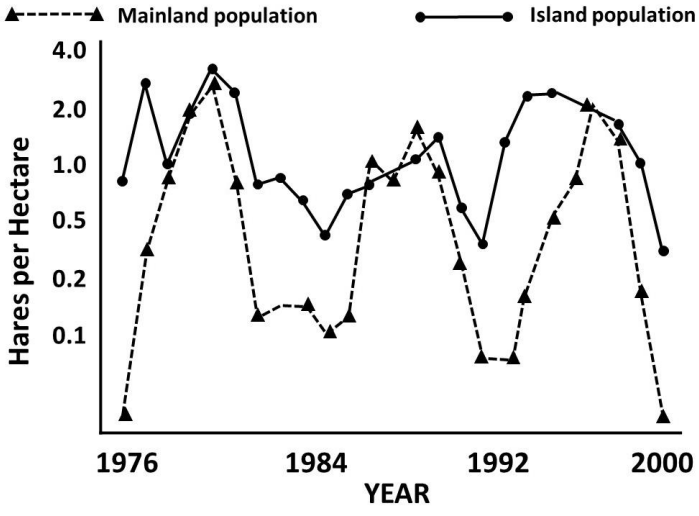
53. (2 points) Male birds of American Redstarts (*Setophaga ruticilla*) have two categories of song, and they use these in different social contexts. In Repeat mode, males sing one song

type in repetitive fashion; in Serial mode, they alternate among two or more other song types. In an experimental forest, ecologists studied the Repeat-song rates of paired versus unpaired males in more than fifty birds. The results are depicted in figure where "I" shows song recordings of short duration, "II" shows medium duration and "III" shows long duration. The sample duration indicates the length of the recording time in each graph.
Which of the following statement/s is/are correct? Choose the correct option/s and put tick mark/s (✓) in the appropriate box/es.



a. Unpaired males sang in repeat mode at significantly higher and less variable rates than did paired males.
b. The amount of overlap between the two samples of male birds decreased as the song duration decreased.
c. Unpaired males prefer to sing more types of songs than paired males.
d. Repeat songs are more useful in attracting females while serial songs are more useful in pair-bonding behaviours.

54. (2 points) The following figure shows hare population monitored on a lake island and the mainland adjoining the lake during 1976 to 2000. The trends obtained are shown below. What could be the possible reason for the observed variations in the densities of the two hare populations?



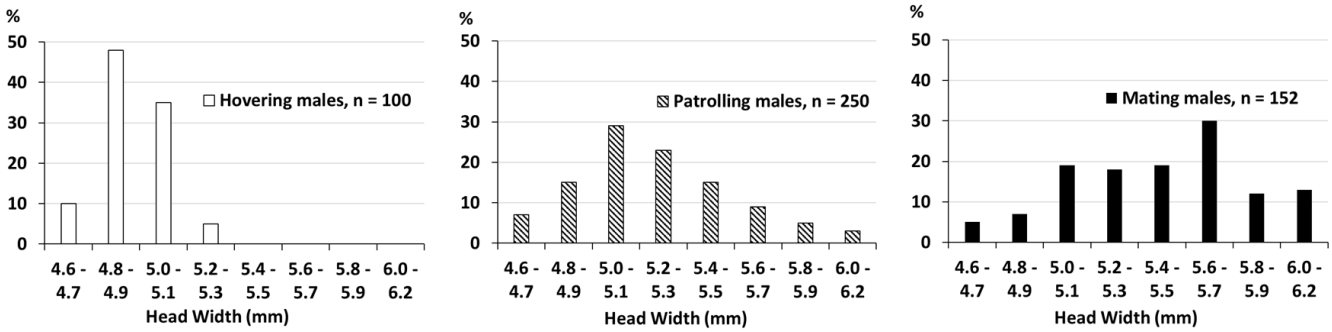
Choose the correct option and put a tick mark (✓) in the appropriate box.

a. Lack of predator pressure on the island allows this population to reproduce freely and maintain certain population density for a prolonged period.
b. The mainland population has greater predator pressure that increases the intensity of population cycles (the difference between maximum and minimum densities).
c. Since both the habitats are close enough, the predator pressure from the birds of prey would be almost similar which explains the differences in the lower values of population densities.
d. Higher predation success could explain the magnitude of dip in the density of the population on the island.

ETHOLOGY (6 points)

55. (2 points) Studies on the ground-nesting digger bee *Centris pallida*, showed that the males practice one of two very different mate-location behaviors – patrolling and hovering. Patrolling involves hunting over a home range, searching for sites where buried female virgins are about to emerge from pupation, finding the females, excavating them and mating with them. The hovering males, on the other hand, hover in and around emergence areas or near flowering trees.

The distribution of male bees with different head widths that were captured while hovering, patrolling and copulating is shown in the given graphs.

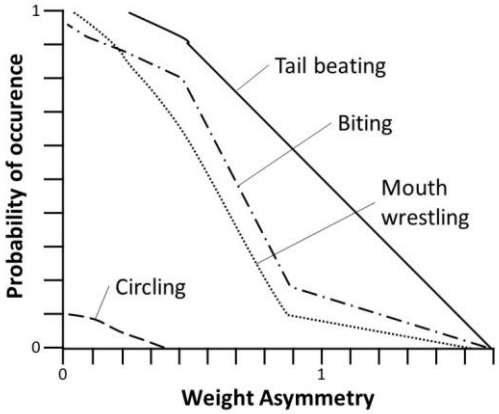


Based on the data, mark each statement as true or false by putting tick marks (✓) in the appropriate boxes.

a. Mate-location behavior exhibited by the bees can be predicted across the head widths studied.
b. Hovering males are unsuccessful in attaining mating success.
c. Male bees with smaller head width generally hover rather than patrol, even though large males do most of the mating.
d. It is likely that females who emerge from the nest when hovering males are fighting, escape and fly off to flowering trees where they become potential mates for the patrolling males.

56. (2 points) In a study on fighting in the cichlid fish *Nannacara anomala*, the number of times each of the four behaviors exhibited were recorded against weight asymmetry. Weight

asymmetry is measured as logarithm of the weight of the heavier fish divided by the weight of the lighter fish. The observations are represented in the given graph.



Based on the graph, indicate whether each of the following statements is true or false by putting tick marks (✓) in the appropriate boxes.

a. Two fish of similar weight do not expend energy in the act of circling.
b. Fish of similar size are likely to show tail beating as the preferred behaviour.
c. The relative occurrence of biting is higher than mouth wrestling when the fish are of almost comparable weights.
d. It is likely that one of the fish adopts the Dove strategy and retreats when the weights of fish are almost similar leading to reduced aggression.

57. (2 points) By making appropriate observations and comparisons, behavioral scientists have been able to build a plausible case that each behavioral trait observed in specific bird species has adaptive significance. A list of behavioral interpretations is given below.

(i) Reflects importance of territory ownership by a male if he has to acquire a mate.
(ii) Needs to attract distant females in areas with other related species.
(iii) Selection for a high degree of territorial aggressiveness in males leads to a low threshold for attacking any intruder into its own territory.
(iv) Selection favors different actions leading to reduction in aggressiveness, synchronization of physiology and willingness to cooperate.

Correlate the reasons with the appropriate trait by choosing from the list of traits and filling in the correct alphabet against each interpretation.

a. Females are attracted to territory owners only.
b. Males give loud calls to announce territory ownership.
c. Courtship, mutual and contact displays.
d. Males are likely to attack females initially.

BIOSYSTEMATICS (5.5 points)

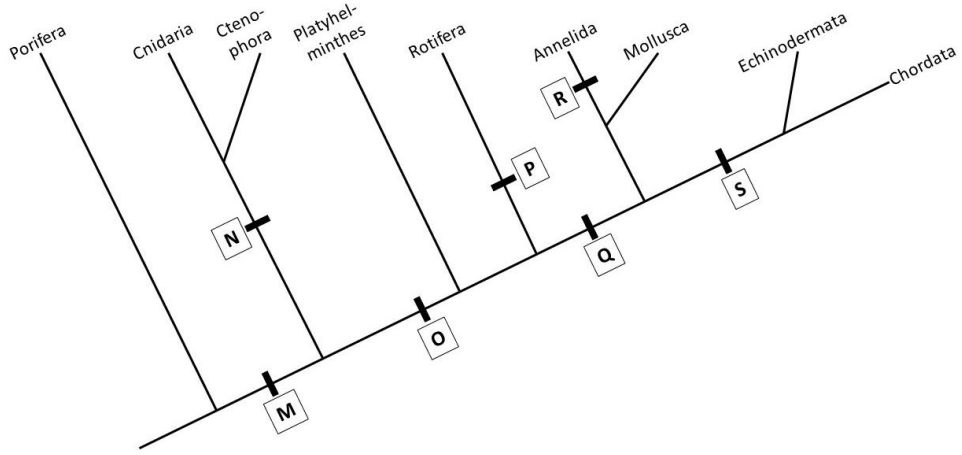
58. (2 points) The four major clades of extant molluscs are Chitons, Bivalves, Gastropods and Cephalopods. A table of few features for each clade is given. Note: + indicates presence of that feature.

Feature	Clade 1	Clade 2	Clade 3	Clade 4
P	+	Modified for burrowing	+	Modified into arms and tentacles
Q	+	+	+	+
R	Feeding structure modified for scraping	+	+	+

Based on the table, mark each statement as correct or incorrect by putting tick marks (✓) in the appropriate boxes.

a. Q could be gills.
b. 4 represents a gastropod.
c. R could be mantle.
d. 2 is a bivalve.

59. (3.5 points) A relationship tree for some animals is depicted below.



Match the evolutionary traits M – S with the correct options. *Choose from the options below and fill in the blanks with the correct option numbers.*

Options:

a. Pseudocoelom
b. Radial symmetry
c. True coelom
d. Segmentation
e. Diploblasty
f. Deuterostomy
g. Protostomy

**********END OF PART B**********