SECTION A (40 MARKS)

*Answer **ALL** questions*

Question 1

a) **For each question, there are four alternatives A, B, C and D. Choose the correct alternative and circle it. DO NOT circle more than ONE alternative. If there are more than ONE circled alternatives, NO score shall be awarded.** **[25]**

i. Prokaryotic cell contain circular extra-chromosomal genetic material called a plasmid which is used as vector for gene transfer. Such chromosomes when integrated into the main chromosome is called

A episome.
B polysome.
C mesosome.
D desmosome.

ii. Which of the following muscle contraction events are correctly sequenced?

1. depolarization of sacrolemma
2. form a cross bridge
3. release a neurotransmitter
4. release calcium ions in sarcoplasm
5. sliding of actin filaments over myosin filament
6. remove the masking of active sites of myosin

A 1→ 2 → 5 → 6 → 3 → 4
B 2→ 1 → 3 → 6 → 4 → 5
C 3 → 1→ 4 → 6 → 2 → 5
D 6 → 3 → 4 → 2 → 5 →1

iii. A patient complained of a burning sensation in his chest region. On investigation, the doctor found the presence of a certain enzyme in his oesophagus and confirmed it was gastroesophageal reflux. Which of the following would be present in his esophagus?

A pepsin
B trypsin
C chymotrypsin
D carboxypeptidase

iv. A patient is found to have abnormally high concentrations of glucose in his urine. Which part of the nephron is likely to be dysfunctional?

A collecting duct
B loop of Henle
C distal convoluted tubule
D proximal convoluted tubule

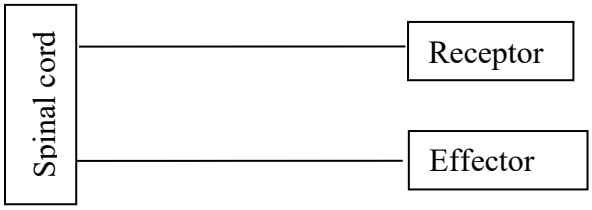
v. Respiration in eukaryotes is completed in four stages with varying amounts of ATP molecules produced as shown in the table given below. Study the table and answer the question.

Stages of respiration	**ATP molecules produced**	**Net gain of ATP molecules**
1. Glycolysis	1	6
2. Link reaction	0	6
3. Krebs cycle	2	24
4. Oxidative phosphorylation	0	8

Which of the following stages is correctly matched?

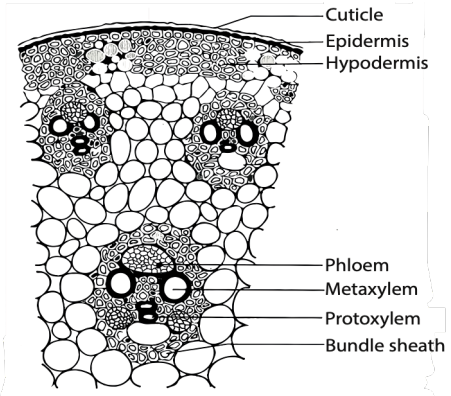
A 1 and 2
B 2 and 3
C 3 and 4
D 4 and 1

vi. The figure shows the reflex arc of a person having perceived stimulus from the environment. The correct path of the conduction of nerve impulse is



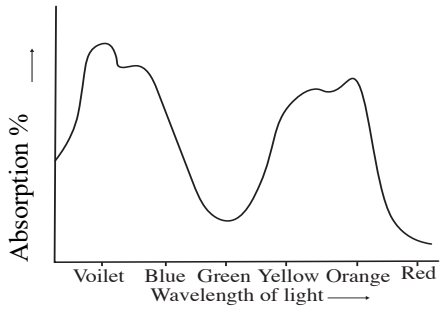
A receptor → sensory neuron → spinal cord → motor neuron → effector.
B sensory neuron → receptor → motor neuron → spinal cord → effector.
C effector → spinal cord → motor neuron → sensory neuron → receptor.
D spinal cord → sensory neuron → effector → motor neuron → receptor.

vii. A student conducted an experiment and observed the anatomical features of a specimen as shown in the figure. The specimen is a



A dicot root.
B dicot stem.
C monocot root.
D monocot stem.

viii. The figure represents the absorption spectrum of chlorophyll.



Energy used in photosynthesis is mostly obtained from

A green and yellow.
B violet blue and green.
C yellow and orange-red.
D orange red and violet blue.

ix. The habitat diversity within the community that depends on species richness and evenness is called

A alpha diversity.
B beta diversity.
C delta diversity.
D gamma diversity.

x. Read the statements given below:

1. framing of strict management policies and strategic plans
2. generating awareness on the importance of these species
3. strategies of reducing poverty of local populations
4. developing ex-situ conservation method

Which of the following combinations can help in the conservation of White-bellied Heron?

A 1, 2 and 3
B 2, 3 and 4
C 4, 3 and 1
D 1, 2 and 4

xi. The causes of land degradation is because of the following reasons **EXCEPT**

A overgrazing.
B urbanization.
C industrialization.
D sustainable cropping.

xii. A person working in a radioisotope laboratory did an analysis on DNA sequencing and found that the DNA template 3'ATGCATGC 5' had mutated to 3'AAGCATGC 5'. What would be the nitrogenous base sequence on mRNA transcript?

A 5' TTCGTACG 3'
B 3' UUGGUACG 5'
C 5' UUCGUACG 3'
D 3' TUCGUACG 5'

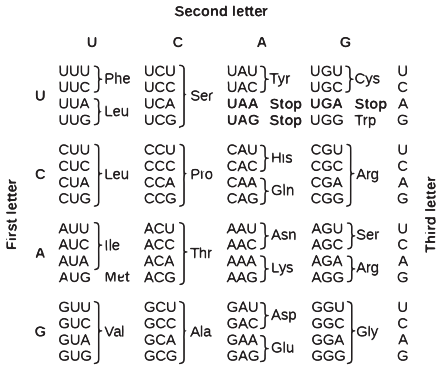
xiii. Suppose the first nitrogenous base of DNA segment ATC AGG ACC CCA mutates, it will affect the coding resulting in

A one amino acid less in protein.
B change in the first amino acid only.
C no change in the amino acid sequence.
D complete change in the amino acid sequence.

xiv. The formation of simple to complex organic molecules leading to emergence of life on the earth occurred in the reducing atmosphere of primitive earth. Such phenomenon was facilitated by

A absence of carbon.
B absence of oxygen.
C presence of nitrogen.
D presence of hydrogen.

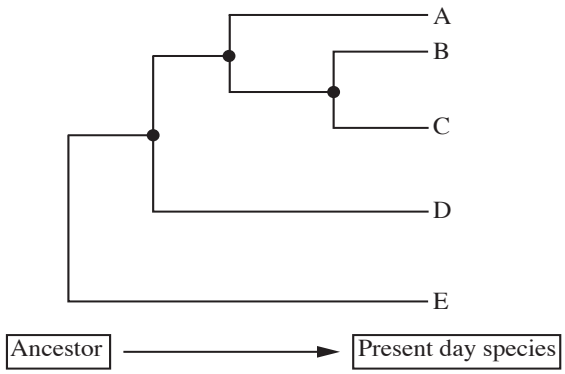
xv. You are given a DNA template strand which reads as 3' AAC CGA TGC CAT 5'.



Using the codon chart shown above, predict the amino acid sequence when this gene undergoes translation.

A Leu-Ala-Thr-Val
B Leu-Val-Ala-Thr
C Leu-Ala-Val-Thr
D Leu-Ala-Thr-Phe

xvi. To determine distant living relatives of different species, biologist construct phylogenetic tree as shown below. Which of the following best describe the idea of descent from common ancestor?



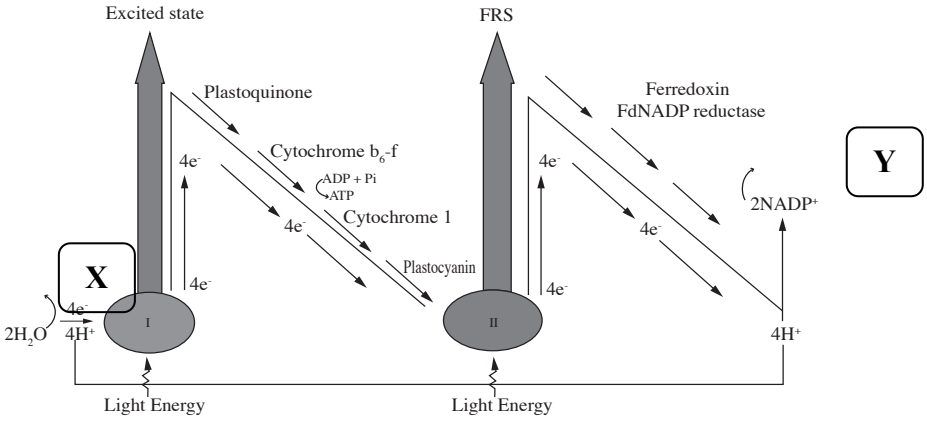
A species A and D has the most recent common ancestor
B species A and C has the most recent common ancestor
C species B and C has the most recent common ancestor
D species D and E has the most recent common ancestor

xvii. A population of giraffe comprises of long and short necked giraffes. Due to natural calamities, the food on the ground gets exhausted and the long necked giraffe evolved to reach food on tall trees. This idea of evolution is best explained by
A Darwinism.
B Mutation theory.
C Modern synthetic theory of evolution.
D Theory of inheritance of acquired characteristics.

xviii. In a panmictic population, the relative frequency of various alleles remains at equilibrium when evolutionary forces are not operating. According to Hardy-Weinberg's principle, it implies that
A population is evolving.
B population is not evolving.
C gene frequency is not constant.
D genotype frequency is changing.

xix. After a race, a runner experiences leg muscle fatigue and cramps. This is due to
A accumulation of lactic acid.
B production of more oxygen.
C formation of ethanol in his muscles.
D release of more ATP in his muscles.

xx. The light-dependent phase of photosynthesis involves photophosphorylation occurring in the thylakoids. The figure shows a type of photophosphorylation. Study the figure and answer the question.



Labels **X** and **Y** represents

A $4e^-$ and ATP respectively.
B O_2 and NADP respectively.
C NADPH and 4e- respectively.
D O_2 and $2NADPH_2$ respectively.

xxi. The table below shows digestion of different types of food in the alimentary canal.

Sl.No	Food	Enzymes	Site of action	Product
I	lipid	lipase	stomach	fat globules
II	starch	amylase	stomach	isomaltose
III	sucrose	invertase	duodenum	glucose and galactose
IV	protein	trypsin	duodenum	peptides

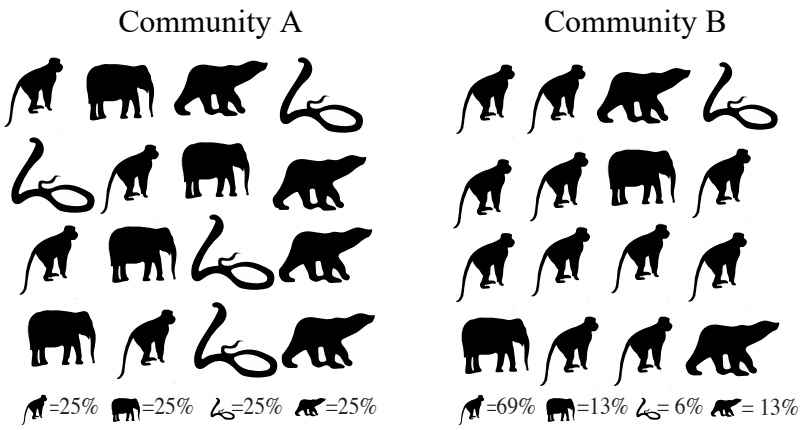
Which of the following options is correct regarding digestion?

A I and III
B II and IV
C I and IV
D II and III

xxii. Maintaining a rich biodiversity benefits agricultural practices. Which one of the following supports the statement?

A ensures insect pollination
B organic wastes are kept intact
C cellulose and fibers are maintained in original state
D chemical pollutants are released without degradation

xxiii. The figure shows the species diversity in community A and B.



We can conclude that

A both communities shows same species richness and evenness.
B community A shows large species richness over community B.
C community B shows same species evenness with community A.
D both communities shows same species richness but different species evenness.

xxiv. A researcher cut off the tails of lizards over generations but the tails neither disappeared nor shortened. What can be concluded from this investigation?

A mutation theory is wrong
B natural selection failed to operate
C tail is an essential organ for the survival of lizards
D inheritance of acquired characters failed to operate

xxv. The skeleton is one of the largest system in the human body which was described in two statements by biologist as given below:

I. An important function of the skeleton is to enable the human body to move.
II. The skeleton provides for attachment of muscles that enable people to move their bones.

Which of the following option is correct with regard to above statements?

A I is true and II is false.
B I is false and II is true.
C Both I and II are true but II is NOT the explanation of I.
D Both I and II are true and II is the correct explanation of I.

b) **Fill in blanks with appropriate word/s.** **[5]**

i.	When you consume rice and bread for breakfast, the final product of digestion is _____.	
ii.	Reabsorption of sodium ions in the distal convoluted tubules is one of the ways to maintain electrolytes in the body. This action is under the control of _____.	
iii.	A specimen observed under a microscope had a thin cell wall, compactly arranged homogenous cell which underwent active cell division. This type of cell is called _____.	
iv.	The release of oxygen during the non-cyclic photophosphorylation is due to _____.	
v.	Activities such as construction of roads, dams and bridges involve felling of trees which can lead to _____.	
vi.	Using the natural resources that meets the need for the present and future generations is the practice of _____ management.	
vii.	After mRNA transcript is copied from DNA, it undergoes post-transcriptional modifications to remove non-coding regions. This is called _____.	
viii.	The event that changed the atmosphere from primitive to modern atmosphere is _____.	
ix.	A student noticed that the arms of human and wings of bird contains almost the same number of bones, blood vessels and nerves arranged in a same pattern with same mode of development. This is called _____.	
x.	Humans and chimpanzees are believed to share about 98% of similarities in their DNA sequences. This indicates humans and chimpanzees have evolved by _____ evolution.	

c) **Match each item of Column A with the most appropriate item of Column B. Rewrite the correct pairs by writing the alphabet against the number in the spaces provided.** **[5]**

Column A	Column B
i. Uniform distribution of material within the cell	a) *In situ* conservation
ii. Thorns of Bougainvillea and tendrils of Cucurbita	b) Divergent evolution
iii. One glucose molecule is broken down into two molecules of pyruvic acid	c) Amoeboid movement
iv. Assimilatory power are ATP and $NADPH^{+}H^{+}$	d) Aerobic respiration
v. Streaming movement of protoplasm in the pseudopodia	e) Ex-situ conservation
vi. Pyruvic acids are completely broken down into carbon dioxide and water	f) Anaerobic respiration
vii. Assimilatory power is ATP	g) Non-cyclic photophosphorylation
viii. Conservation of biotic resources in the natural habitat	h) Cyclosis
ix. Forelimbs of man and flippers of whale	i) Convergent evolution
x. Conservation of biotic resources outside the natural habitat	j) Cyclic photophosphorylation
	k) Flageller movement
	l) Microevolution

Column A	Column B
i.	
ii.	
iii.	
iv.	
v.	
vi.	
vii.	
viii.	
ix.	
x.	

d) State true/false for the following statements in the boxes provided. [5]

i.	Alpha and beta cells of pancreas secretes antagonistic hormones, namely insulin and glucagon respectively that control blood glucose concentration.		
ii.	Glomerulus filtration of blood takes place in the Malpighian capsule which is a ATP-driven process.		
iii.	The morpho-anatomical features of xerophytes ensure their adaptation to drought, salinity and heat stress habitat.		
iv.	During photosynthesis, water is oxidized and loses electrons while the carbon dioxide is reduced and gains electrons.		
v.	Exotic species create healthy ecosystems and boost the survival of the native species either by increasing fertility of soil or retention of water in the soil.		
vi.	The fragmentation of habitat and habitat loss causes adverse effects on biodiversity.		
vii.	Climate change is a major factor influencing the distribution of species across the globe.		
viii.	Clearance of vast tracts of forest and plantation of a single species of plants promotes the sustainable management of natural resources.		
ix.	The sequence of nucleotides provides a code for constructing a protein.		
x.	The presence of free oxygen and living organisms on the Earth at the present day are considered to prevent the abiotic origin of life.		

SECTION B (60 MARKS)

*Attempt **ANY SIX** questions*

Question 2

a) Mitochondria are regarded as semi-autonomous cell organelles. Construct an argument to support or refute the claim that mitochondria in many of the eukaryotic cells have evolved from prokaryotic cells. **[2]**

b) Life on the earth originated due to chemical reactions occuring in primitive ocean with phenomena like condensation and polymerisation leading to formation of coecervates. State **TWO** characteristics of coacervates that are similiar to living organism. **[1]**

c) The wings of species X and Y are built on same basic pattern but are modified for flying. Based on the statement, discuss the type of evolution they represent. **[2]**

d) *Ageratina adenophora* (crofton weed) is an invasive species rapidly outcompeting native plant species. To investigate the negative impact of crofton weed on native species diversity, quadrant sampling was used and species compositions of two communities were recorded as shown in the table.

Name of native species recorded in Community X and Y	***Ageratina adenophora* invaded community (Community X)**	***Ageratina adenophora* free community (Community Y)**
	Species recorded	**Species recorded**
A	2	4
B	0	4
C	1	5
D	1	5

$$D(or\ \lambda) = \sum\left[\frac{n_i(n_i - 1)}{N(N-1)}\right]$$

Where D = diversity index

n_i = The total number of particular plant species.

N = The total number of plant species of all the species in a given community.

i. Using the given formula, calculate the diversity index of the recorded species in each community. **[1]**

ii. Which community has more diversity? Give **ONE** reason. **[1]**

e) Why is the nephric filtrate in the descending loop of Henle hypertonic? **[2]**

f) What would happen to the volume and concentration of the glomerular filtrate if the lumen of the efferent aretiole is wider than that of afferent arteriole? **[1]**

Question 3

a) By reading the type and number of codons on the given mRNA strand mention the number of amino acids that will be used for synthesising protein. **[1]**

5’ AUGCGUAGUUCGCCCUAA 3’

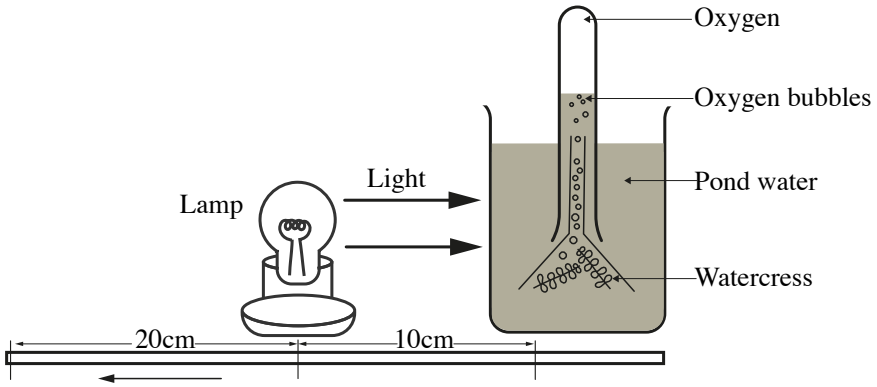
b) A population of yaks in Gasa is in Hardy-Weinberg equilibrium where allele for black fur (B) has an allele frequency of 0.25, and the allele for white fur (b) has an allele frequency of 0.15. Using the formula $p^2 + 2pq + q^2 = 1$, calculate the percentage of heterozygous individuals in the population. **[2]**

c) One of the challenges that confront Bhutan is the excessive production of wastes mainly due to shift in consumption pattern and increasing population rate. Design **TWO** solutions to curb the waste problems in Bhutan. **[2]**

d) The experimental set-up shown in the figure below examines the effect of light intensity on the rate of photosynthesis. Read the procedures and answer the questions that follow.

Procedures

1. Set up the apparatus as shown in the diagram.
2. Leave the experiment set up in the pond water for five minutes.
3. Count and record the number of bubbles produced in five minutes.
4. Move the light 10 cm away from the lamp.
5. Leave the set-up for five minutes.
6. Count the number of bubbles produced and record in the observation table.
7. Then move the lamp away by 10 cm intervals until 50 cm is reached and record the observations.



i. Identify the independent and dependent variables of the above experimental set-up. **[1]**

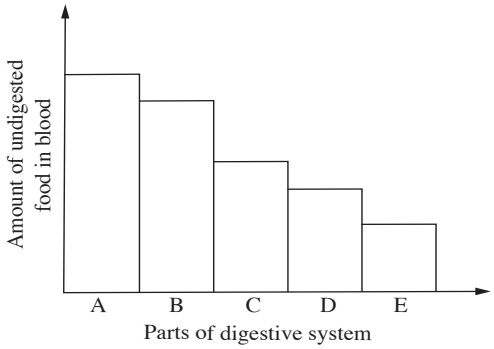
ii. State the hypothesis for the experimental set-up. **[1]**

e) According to taxonmists, many species on the earth are documented and given scientific names but many more remain unidentified. Give **TWO** reasons to support the statement. **[2]**

f) During DNA replication, DNA polymerase polymerise a kind of deoxyribonucleotide strand in the direction from carbon 5' end to carbon 3' end of the sugar molecule using carbon 3' end to carbon 5'end strand of parental DNA as template in fragments. Mention the kind of strand. **[1]**

Question 4

a) The figure shows the changes in the amount of undigested food as it courses through the alimentary canal. Deduce the information from the graph. **[2]**



b) The Consitution of Bhutan states that, a minimum of 60% of Bhutan's total land shall be maintained under forest cover for all time. Support or refute giving **TWO** reasons. **[1]**

c) Discuss the role of healthy ecosystem services as a pre-requisite for a wide range of economic, environmental, aesthetic goods and services. **[2]**

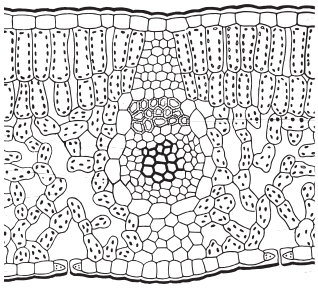
d) Community forest (CF) is the concept of participatory forest management by local people taking ownership, using it sustainably and managing it. The practice of adopting CF had benefited the local community at large. Do you agree? Justify. **[2]**

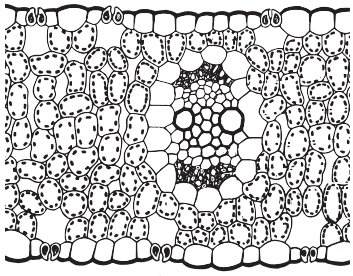
e) As per the Road Safety and Transport Authority vehicle statistics 2021, Thimphu alone has registered around 61240 motor vehicles. From an environmental perspective, it is a huge concern as issues such as wildlife-vehicle collision, pollution and disturbances on wildlife habitats are becoming widespread. Based on the aforementioned issue, propose an alternative solution to help save our natural biodiversity. **[3]**

Question 5

a) State the genetic drift theory. **[1]**

b) An experiment was performed to study the anatomical features of a dicot and monocot leaf. The temporary stained mount of a transverse section of leaves was observed as shown in the figure.



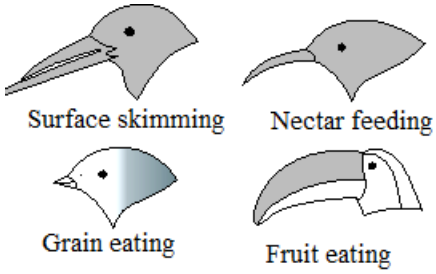


i. Mention any **TWO** precautionary measures that should be considered while performing the experiment. **[1]**

ii. Discuss the unique anatomical features that make each plant better adapted to the different environmental conditions. **[1]**

c) Although anaerobic respiration is not as efficient as aerobic respiration in producing energy, do you think anaerobic respiration is still important? Give **TWO** reasons to support your answer. **[2]**

d) The figure below shows the beaks of different birds which have originated from a common ancestor.



i. What is the evolutionary phenomenon represented by the figure? **[1]**

ii. Provide **ONE** reason to support the evolutionary phenomenon identified in i. **[1]**

e) The conduction of nerve impulse is faster in myelinated neuron than in non-myelinated neuron. With the help of a diagram, show the conduction of impulse in a myelinated neuron. **[2]**

f) Why is the flow of biological information from DNA to RNA to protein synthesis called central dogma of life? **[1]**

Question 6

a) A person suffering from knee injury will take some time to recover due to torn knee cartilage. Give **TWO** reasons. **[2]**

b) In a laboratory, a student was given a permanent slide of *Euglena* to study. The student observed the presence of chloroplast found in plants, and pellicle and contractile vacuole found in animals.

i. From the findings mentioned above, what can you conclude? **[1]**

ii. Mention the important laboratory equipment that the student used to study the specimen. **[1]**

c) Bile juice lacks digestive enzymes yet it is important for digestion. Explain. **[2]**

d) Is it necessary for Bhutan to follow strict conservation strategies to contribute to global conservation of biodiversity? Comment. **[2]**

e) According to Darwin's theory, which lizard, green or red coloured will better survive and reproduce? **[1]**

f) The evolution of chloroplast has a significant impact on various life forms. Interpret the statement. **[1]**

Question 7

a) Gene therapy holds great potential in treating genetic disorders caused by a non-functional gene. However, it still remains a subject of intense discussion as there are many ethical issue associated with it. Explain. **[2]**

b) Glucose is broken down to form pyruvic acid in cytoplasm during glycolysis through a series of enzymatic reactions. What will happen to the pyruvic acid before entering into mitochondria? **[2]**

c) Is a DNA molecule considered a better hereditary material than a RNA molecule? Support your answer with scientific reasons. **[2]**

d) The table below shows the anatomical features of a root. **[3]**

Characteristics	**Description**
Pericycle	Gives rise to lateral roots and parts of vascular cambium
Vascular bundles	Number of xylem bundles is usually 2-4
Conjunctive tissue	Parenchymatous; its cells is differentiated into vascular cambium
Cambium	It appears as a secondary meristem at the time of secondary growth
Pith	Absent or poorly developed

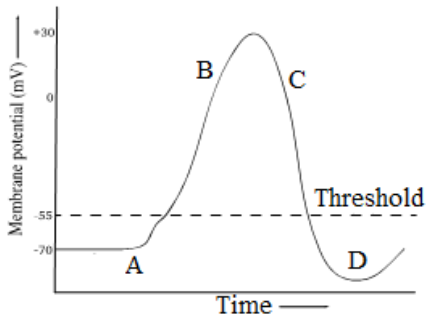
Using the information from the table, identify the root and draw a labelled diagram.

e) State any **TWO** limitations of Darwinism. **[1]**

Question 8

a) 'Aerobic respiration is always beneficial for all organisms'. Do you agree? Support your answer with **TWO** reasons. **[2]**

b) The figure represents the different states of a nerve fibre. Study the figure and mention the states of the nerve fibre at point **B** and **D**. **[1]**



c) Terrestrial animals have more juxtamedullary nephron than cortical nephron. Comment. **[2]**

d) An ecosystem has the following characteristics:

- ✓ complex food web
- ✓ greater number of successful species
- ✓ less likey to be hostile

i. What would be the magnitude of species diversity? **[1]**

ii. Mention **TWO** significance of species diversity. **[1]**

e) The coexistence of community and biodiversity has brought many advantages in the community. Mention **TWO** social benefits of biodiversity to a community. **[2]**

f) What are coacervates? **[1]**

Question 9

a) Photosynthesis is critical in mitigating the effects of atmospheric greenhouse gasses and restoration of soil organic matter. Comment. **[2]**

b) Mention the dual role of enzyme oxygenase in plants during varying conditions such as temperature and carbon dioxide concentration. **[1]**

c) Artificial Intelligence is a computer-based system designed to function similar to that of a Human Nervous System. In this regard, would you prefer to have a robot teacher teaching you in the classroom? **[2]**

d) Issues such as invasion of farms and crops by wild animals are widespread in many parts of rural Bhutan. If you are appointed as a forestry official, mention **TWO** eco-friendly measures to combat human-wildlife conflict. **[1]**

e) Fossils serve as evidence to conditions of life on primitive Earth and provide clues in predicting environmental changes. How do animal and plant fossils help to forecast environmental changes today? Mention **TWO** points. **[2]**

f) According to Oparin-Haldane's concept of origin of life, the life on the primitive Earth originated in the ocean and as a result of chemical reactions formed Haldane's hot dilute soup. Account for the formation of components of hot dilute soup. **[2]**