SECTION A [40 MARKS]

ANSWER **ALL** QUESTIONS

Question 1

a) **For each question, there are FOUR responses: A, B, C and D. Choose the corresponding letter of your response and CIRCLE it neatly. NO score will be awarded if you circle more than ONE letter.** **[25]**

i. The endosymbiont theory suggests that chloroplast in plant cell originated from

A aerobic bacteria.
B autotrophic bacteria.
C heterotrophic bacteria.
D chemotrophic bacteria.

ii. A patient has recently undergone an above-knee amputation of his left leg. The patient is now in the process of being fitted for a prosthetic leg to return to active lifestyle. Which is a key consideration while designing a prosthetic leg?

A Ease of cleaning
B Cost of materials
C Weight distribution
D Colour matching with skin

iii. Which of the following cells are primarily responsible for bone remodelling?

A Osteocyte
B Osteoclast
C Osteoblast
D Osteogenic cell

iv. The intake of diet high in cholesterols generally causes cardiovascular diseases such as hypertension and coronary artery disease. What dietary modification will be the most effective in lowering cholesterol in the body?

A Reduce intake of salt
B Reduce intake of soluble fibre
C Reduce intake of saturated fat
D Reduce intake of unsaturated fat

v. The article 5 of the constitution of the kingdom of Bhutan states "…a minimum of sixty percent of Bhutan's total land shall be maintained under forest cover for all time."

What is the direct benefit of the above clause to the citizens of Bhutan?

A It increases the natural soil fertility
B It ensures unlimited timber collection
C It ensures more land is available for agriculture
D It ensures sustainable use of natural resources

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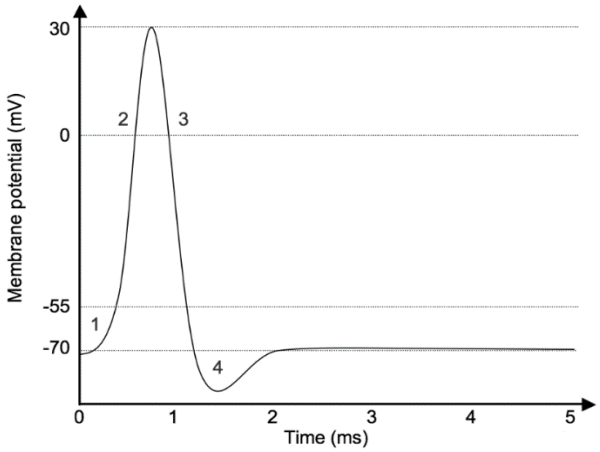
vi. The graph below shows the action potential of a neuron. Refer the graph to answer the question.



Which is the correct description of the graph?

A There is Na^+ efflux at point 2
B There is Na^+ influx at point 3
C There is K^+ influx in point 3
D There is K^+ efflux in point 4

vii. What triggers the activation of renin-angiotensin-aldosterone system in the body?

A Low blood volume and pressure
B High blood volume and pressure
C Low blood volume and high blood pressure
D High blood volume and low blood pressure

viii. The tissue which is mostly involved in the process of photosynthesis is

A xylem.
B phloem.
C parenchyma.
D sclerenchyma.

ix. In an experiment to investigate non-cyclic photophosphorylation, what would one expect to observe regarding photolysis?

A Photolysis occurs only if $NADP^+$ is present
B Photolysis occurs whether or not $NADP^+$ is present
C Photolysis occurs only if NADPH concentration decreases
D Photolysis occurs only if NADPH is present as electron acceptor

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x. Study the medical report of a patient obtained from the medical laboratory.

Metabolites	**Reference value (**µmol)	**Result (**µmol)
Glucose	100	90
Pyruvate	25	26
NAD+	75	10
NADH	50	400

Which stage of cellular respiration is inhibited in the body of the patient?

A Glycolysis
B Citric acid cycle
C Pyruvate oxidation
D Electron transport chain

xi. "Trongsa, a dzongkhag with one of the highest human-wildlife conflict (HWC) cases, has noted about 580 livestock depredations by tiger from the year 2020 to 2024, out of which 360 cases were recorded from Nubi Gewog alone".
[Kuensel March 11, 2024]

Which of the following are the most appropriate strategies to address the human-wildlife conflict in reference to the given situation?

i. Restoration and conservation of habitats
ii. Installing physical barriers and corrals for livestock
iii. Strengthen anti-poaching efforts

A I
B ii
C I and ii
D ii and iii

xii. According to Kuensel, June 5th 2024, the springs in Bhutan are drying and depleting rapidly. About 25.1% of spring resources are in a degraded state, while 0.9% have completely dried up. This is posing serious challenges for sustainable water management in the country.

What is the most effective method to revive spring water?

A Plant trees in urban area
B Prevent rainwater infiltration into soil
C Control grazing practices in watershed area
D Divert underground water and collect in dams

xiii. If the rate of replication in a particular prokaryote is 200 nucleotides per second, how long would it take to make two copies of a 2000 base pair genome?

A 100 seconds
B 200 seconds
C 300 seconds
D 400 seconds

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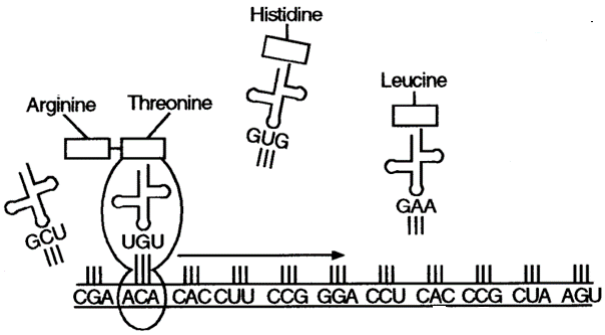
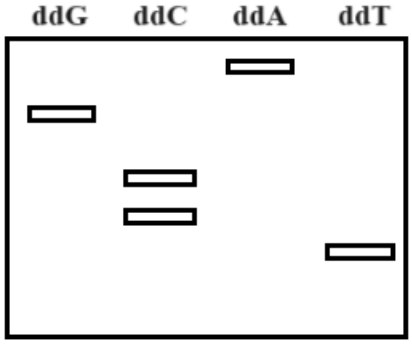
xiv. The figure below shows the protein synthesis in bacterium cell.



If CUU on mRNA is replaced by UGA due to mutation, then amino acid sequence in protein will be

A Arginine – Threonine – Histidine.
B Histidine – Threonine – Arginine.
C Arginine – Threonine – Histidine – Leucine.
D Leucine – Histidine – Threonine – Arginine.

xv. The figure given below shows the result of a DNA sequencing using Sanger Method.



What is the sequence of the template DNA?

A 5’ GCCAT’3
B 5’ AGCCT’3
C 5’ AGGCT’3
D 5’ TCCCGA’3

xvi. The duck-billed platypus is one of the nature’s strangest animals with a bill and webbed feet like a duck, furry body, and feeds its young ones with milk, produces snake-like venom, and lives mostly under water.

Considering the given characteristics of the duck-billed platypus, it represents a connecting link between

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A reptiles and aves.
B reptile and mammal.
C reptile and amphibian.
D mammal and amphibian.

xvii. In a malaria infested region, which group of human population is most likely to have a survival advantage due to natural selection?

A Population with genotype Hb^s
B Population with genotype Hb^A/Hb^A
C Population with genotype Hb^S/Hb^S
D Population with genotype Hb^A/Hb^S

xviii. A scientist studied a certain gene in a population of birds. This gene has two alleles: a dominant allele(P), and a recessive allele(p). The scientist collected data of the allele frequency for both alleles (P and p) of the given bird population twice over a period of 14 years as given in the table below:

Year	**Frequency of allele P**	**Frequency of allele p**
2010	0.19	0.81
2024	0.65	0.35

Identify the most correct interpretation of the above data.

A A population of birds is evolving
B A population of birds is not evolving
C Individuals in birds population are not migrating
D Individuals in birds population are mating randomly

xix. The table below is a medical report on renal Functional Test of a person.

Parameters	**Normal Range**	**Test Result**
Urea	7 – 20 mg/dl	64 mg/dl
Creatinine	0.6 – 1.3 mg/dl	4 mg/dl
Glucose	0 – 0.8 mmol/L	0.9 mmol/L

Which of the following is the most appropriate description of a person's health?

A Increased creatinine in blood and limbs swelling
B Decreased urea in blood and frequent urination
C Increased glucose indicating diabetes mellitus
D Decreased creatinine in blood and frequent urination

xx. Muscle contraction requires energy. Which reaction releases energy for the muscle contraction?

A AMP + Phosphate $\longrightarrow$ ADP + H_2O
B ADP + Phosphate $\longrightarrow$ ATP + H_2O
C ATP + Water $\longrightarrow$ ADP + H_2O
D AMP + Diphosphate $\longrightarrow$ ATP + H_2O

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xxi. The table given below depicts the survey result of four apple orchards.

Types of apple varieties	% Population in orchard (A)	% Population in orchard (B)	% Population in orchard (C)	% Population in orchard (D)
Fuji	2%	23%	20%	15%
Granny smith	67%	25%	30%	0%
Gala	25%	27%	10%	5%
Red delicious	6%	25%	40%	75%

Which orchard is likely to be more resilient to climate change?

A Orchard A
B Orchard B
C Orchard A and C
D Orchard C and D

xxii. According to BBS, May 24,2024 the recent survey has revealed extensive growth of this invasive plant (polka dot plant) in many gewogs within Samtse district, posing significant challenges for farmers.
How does this invasive plant pose threat to the local species?

A It attracts more herbivores
B It disrupts the local water cycle
C It outcompetes for nutrition and shows aggressive growth
D It outcompetes local species by showing lesser adaptability

xxiii. Which part of DNA is examined during genetic finger printing?

A Repetitive DNA
B Complementary DNA
C Coding strand of DNA
D Transcription unit of DNA

xxiv. A scientist claims that cheetahs are more closely related to wolves than to sharks because, unlike sharks, both cheetahs and wolves have fur, four-chambered hearts, and specialized teeth.
Which evidence supports the scientist's claim?

A Fossil evidence
B Molecular evidence
C Anatomical evidence
D Embryological evidence

xxv. Galapagos finches inhabit different islands. Occasionally, finches from different island fly over to other islands.
Based on the given context, which is the most appropriate mechanism to alter the allele frequency of the finches' population?

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A Mutation
B Gene flow
C Genetic drift
D Natural selection

b) Fill in the blanks with appropriate word(s). [5]

i.	Bigger prokaryotes engulfed smaller prokaryotes that were capable of using oxygen and permanently established as _____ inside present day eukaryotic cells.	
ii.	The constriction of _____ sphincter results in prevention of gastrointestinal reflux.	
iii.	The deficiency of _____ ions will hinder the release of neurotransmitter at synaptic cleft.	
iv.	In trees, increase in the diameter of girth is due to the mitotic activity of _____.	
v.	Species _____is a measure of relative abundance of species within a community.	
vi.	The part of transcriptional unit of DNA that contains coding units are called _____.	
vii.	The main enzyme involved in transcription of mRNA from DNA is _____	
viii.	The gene frequency of _____ remains at equilibrium when the ratio of *p* alleles to *q* alleles is equal.	
ix.	The biological method of controlling pest by releasing natural enemies of pest is termed as _____.	
x.	The fins of fish and flippers of whale are the evidences of _____ evolution.	

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c) Write TRUE or FALSE for the following statements in the space provided in the 'Answer' column. **[5]**

	Statement	Answer	
i.	Prokaryotic cells have a high surface area-to-volume ratio, which facilitates efficient nutrient intake and waste elimination.		
ii.	Water is the final electron acceptor in the electron transport chain of aerobic respiration.		
iii.	The biodiversity of Bhutan provides aesthetic and recreational values for ecotourism.		
iv.	The ground water and biofuels are examples of provisioning services.		
v.	According to IUCN red list, Red Panda is categorized under vulnerable species.		
vi.	Gene therapy is designed to avoid unintended mutations despite the challenges involving several risks.		
vii.	The species with greater differences in their amino acid sequences are less likely related.		
viii.	The T.S of a sunflower root shows a well-developed pith.		
ix.	The evolution of melanic variety of peppered moth exhibits the disruptive selection.		
x.	The parenchyma cells provide mechanical strength and support to the plants.		

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d) Match each item in column A with the most appropriate item in column B. [5]
Write the correct letter in the space provided in the 'Answer' column.

Column A		Column B	Answer
i.	Activation of pepsin	a. Spliceosome	i.
ii.	Oxidative decarboxylation	b. I-band	ii.
iii.	Change in allele frequency	c. Degenerate code	iii.
iv.	Lack of casparian strips	d. A-band	iv.
v.	Primary electron acceptor of PS II	e. Pyruvate to Acetyl CoA.	v.
vi.	Chemiosmotic hypothesis	f. Electrophoresis	vi.
vii.	Post-transcriptional modification	g. Ferredoxin	vii.
viii.	Prevents mutation	h. Passage cells	viii.
ix.	Separates the DNA fragments	i. Pheophytin	ix.
x.	Actin filament	j. Polymerase chain reaction	x.
		k. Hydrochloric acid	
		l. ATP synthase	
		m. Habitat destruction	

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SECTION B [60 MARKS]

ATTEMPT **ANY SIX** QUESTIONS

Question 2

a) Most of the older people generally suffer from worn-out cartilage between the joints of two bones. How would this affect the movement? **[1]**

b) Bacteria are most often used in diary and bakery. Give **TWO** reasons why bacteria are efficient and suitable to be used in food industry. **[2]**

c) Small intestine has millions of villi that are primarily adapted for maximum absorption of food particles. How are villi structurally adapted for greater absorption of nutrients in the small intestine? **[2]**

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d) A group of marathon runners is participating in a race. How are specific metabolic pathways activated during the initial phase and towards the late phase of the race to generate energy in muscle cells? **[2]**

e) From an evolutionary perspective, how do myelinated neurons provide certain species with adaptive advantages in a specific environment? **[2]**

f) Describe **ONE** way in which the Human Genome Project improves human health. **[1]**

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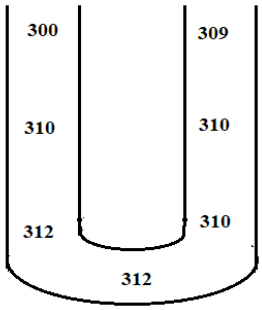
Question 3

a) The figure below shows a Loop of Henle. Refer the figure to answer the following questions.



i. Based on the given values of osmolarity in the Loop of Henle, what will be the urine concentration and volume? **[1]**

ii. How does less ADH secretion affect the blood volume? **[1]**

b) The radial arrangement of vascular bundle is structural adaptation of roots to enhance water and nutrient absorption.

i. How does such arrangement of vascular bundle contribute to efficient water absorption by roots? **[1]**

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ii. How are the roots of orchids adapted to absorb water and nutrients from the atmosphere? **[1]**

c) In a photosynthesis experiment, a student investigated effect of red, blue and yellow light on rate of production of O_2 and obtained the data given below.

Light	**Distance between light source and plant (cm)**	**Number of O_2 bubbles produced every after 1 minute**		
		1 min	**2 min**	**3 min**
Red	10	13	10	7
Blue	15	10	7	4
Yellow	20	4	3	2

i. Why do you think the number of O_2 bubbles decreases with the progress in time? **[1]**

ii. Mention any **TWO** changes you would make in the experiment to draw more valid comparison of O_2 production by different types of light? **[1]**

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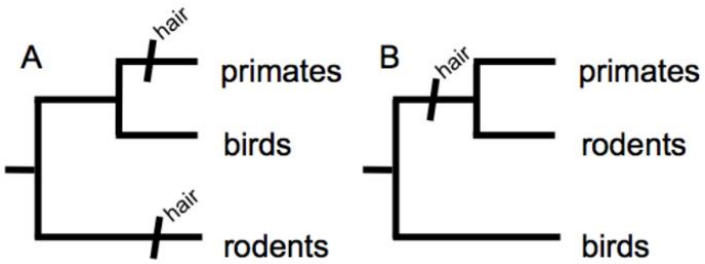
d) How is in-situ conservation strategy considered more advantageous than ex-situ conservation strategy for the wildlife? Justify with **TWO** reasons. **[2]**

e) Two students have derived phylogenetic tress A and B of three different organisms as shown below.



i. Justify which phylogenetic tree is the most valid. **[1]**

ii. How does the presence of vestigial organs provide evidences for common ancestry? **[1]**

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Question 4

a) Mars is a cold desert planet. It has a thin atmosphere made up mostly of carbon dioxide, nitrogen, and argon gases. It has high solar radiation. The average temperature on Mars is minus 85 degree Fahrenheit.

Suggest any **TWO** creative solutions how you can design a plant that can grow and thrive in harsh environmental conditions of Mars. **[2]**

b) White Bellied Heron (WBH) is the critically endangered bird. In 2023, Bhutan recorded 25 WBH.

i. Mention **TWO** key threats that pose risk to the loss of habitat of WBH. **[2]**

ii. Mention **TWO** critical roles of WBH in ecology **[1]**

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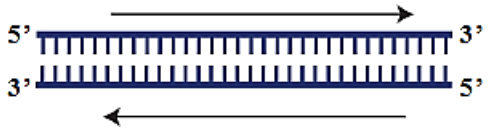
c) Which strand of DNA is copied by the mRNA during transcription? **[1]**

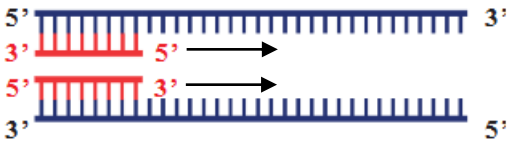
d) Imagine you are working in a forensic laboratory. You have received a DNA sample from a blood stain left at a crime scene. You are going to perform PCR. DNA sample and two primers are shown in the figure below. Refer the figure to answer the following questions.

Sample DNA



Primers

i. While performing a PCR, the primers mistakenly attached to DNA strands as shown below. Redraw a diagram and depict the correct attachment of primers to DNA strands and indicate by arrow. **[1]**



ii. Scientist are trying to design an artificial Taq Polymerase to be used in PCR. What should be the main characteristic of artificial Taq Polymerase? **[1]**

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e) Which factor has more influence on evolution of organisms, natural selection or artificial selection? Justify. **[1]**

f) Explain allele frequency of a population. **[1]**

Question 5

a) The parliament has adopted the Biosafety Act of Bhutan in 2015. Give **ONE** reason how the Biosafety Act prevents threatening of native species from GMOs and exotic species. **[1]**

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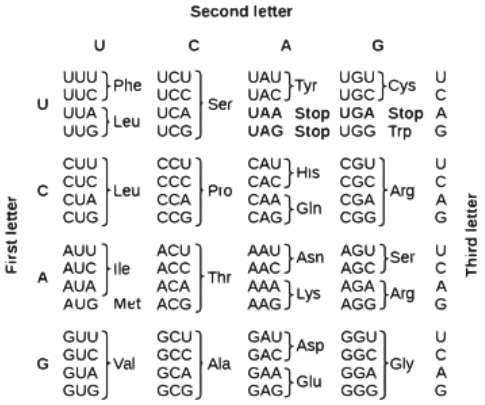
b) Suppose the coding sequence of DNA has the sequence 5' ATGCGTTATCGGGAGTAG 3'. A mutation changes the base sequence to read 5' ATG**AGG**TATGGGGAGTAG 3'. Refer the given codon chart to answer the following questions.



i. Will the mutation affect the amino acid sequence? Why? **[1]**

ii. How do the 5' cap and the 3' poly-A tail work together to enhance mRNA stability? **[1]**

c) Mutation in DNA is permanent while mutation in mRNA is temporary. Justify. **[2]**

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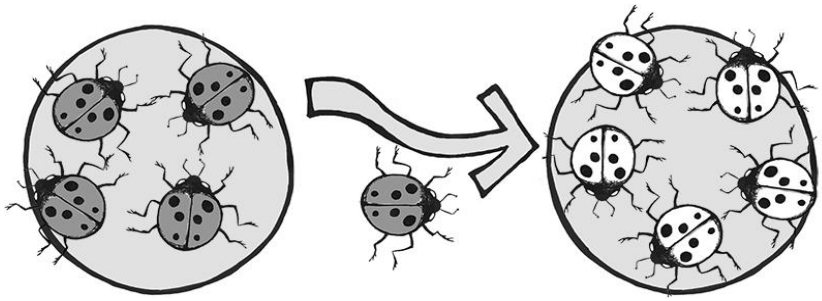
d) Evidences from fossils records have more credibility than evidences from basic life processes to study phylogenetic relationship among organisms. Justify. **[2]**

e) There are two varieties of beetle bugs population occupying different ecological regions as shown in the figure below. Refer the figure to answer following questions.



Population A Population B

i. If there is only one way migration of individuals from population **A** to population **B**, which population is likely to thrive in future due to natural selection? Why? **[2]**

ii. Mention any **ONE** drawback of Darwin's theory of natural selection. **[1]**

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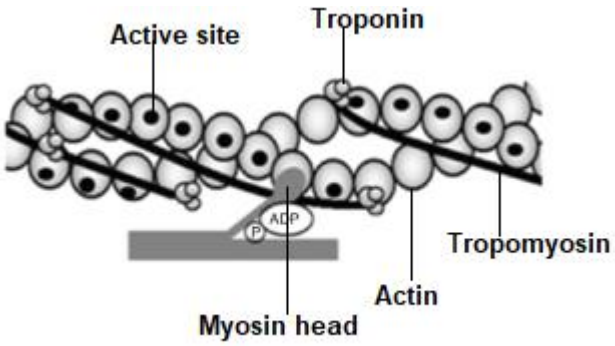
Question 6

a) The figure below represents the cross-bridge formed during the occurrence of muscle contraction. Study the figure and answer the following questions.



i. How do calcium ions help in the formation of cross-bridge during the muscle contraction? **[2]**

ii. Other than Ca^{+} ions, what are the two pre-requisites of the activation of myosin head? **[1]**

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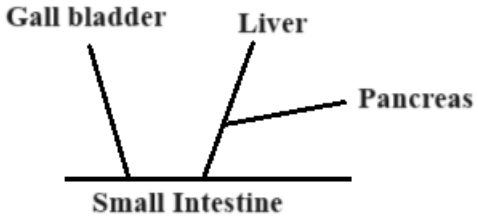
b) The figure given below incorrectly shows how ducts from different organ connect to the small intestine. Refer the figure to answer to the following questions.



i. Redraw the illustration by showing correct connections of different ducts. **[1]**

ii. Write a word equation of protein digestion involving any one enzyme produced by pancreas. **[1]**

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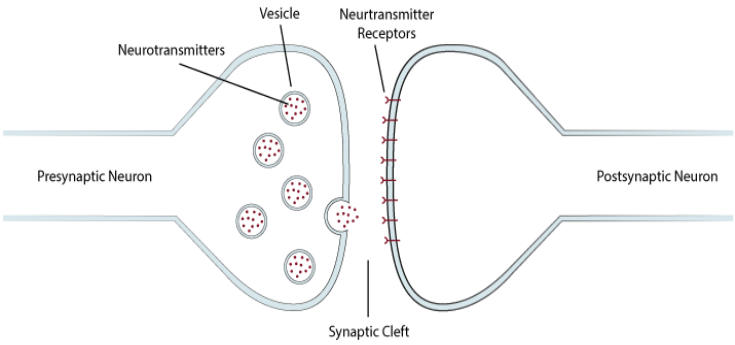
c) Study the figure given below on the transmission of nerve impulses from pre-synaptic neuron to post-synaptic neuron. Refer the figure to answer the following questions.



i. How does the width of the synaptic cleft affect the transmission of nerve impulses? **[1]**

ii. Can nerve impulse transmission take place from postsynaptic neuron to presynaptic neuron? Explain. **[1]**

d) Which wavelength of light is the most effective for Calvin cycle, 680 nm or 700 nm? Justify. **[1]**

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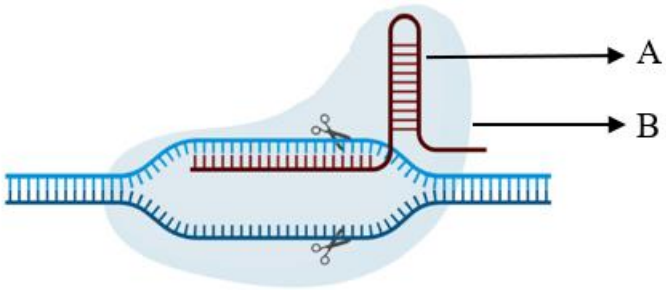
e) "Cordyceps collection has been a significant source of income for Bhutan's highlanders, but the ecological consequences are becoming increasingly apparent. Records show that Laya has experienced a decline in the abundance and quality of cordyceps in recent years." [Kuensel, July 11, 2023]

As an environmentalist, suggest **TWO** strategies that directly help highlanders to harvest cordyceps in sustainable manner **[2]**

Question 7

a) The figure below is a CRISPR Cas9 complex which is the latest genome editing technology. Refer the figure to answer the following questions.



i. Identify parts labelled A and B. **[1]**

ii. What is the main function of part labelled A? **[1]**

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b) Study the following data that shows amino acid sequence of four different species. Refer the data and answer the following question.

Species	Amino acid sequence
Gorrila	Arg-Lys-Ala-Pro
Horse	Arg-Lys-His-Lys
Sparrow	Ala-Val-Pro-Meth
Zebra	Arg-Lys-His-Pro

i. Represent the relationship between four species with a cladogram. **[1]**

ii. What is the category of evidence of common ancestry depicted by the above presentation? Why? **[1]**

c) Explain how evolution of population of species is affected if population is separated into two subpopulations due to river formation. **[1]**

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d) A hypothetical population of 10,000 humans has 6840 individuals with the blood type AA, 2860 individuals with blood type AB and 300 individuals with the blood type BB.

i. What is the frequency of genotype AA and BB in this population **[1]**

ii. If the next generation contained 25,000 individuals, how many individuals would have blood type BB, assuming the population is in Hardy-Weinberg equilibrium? **[1]**

e) The World Bank report points out that Bhutan could invest in its wood-based manufacturing industries to make more valuable products from its forests." Do you think this will benefit Bhutan? Justify. **[2]**

f) The mRNA vaccine contains synthetic mRNA. Explain how mRNA vaccine instructs cells to produce antibodies. **[1]**

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Question 8

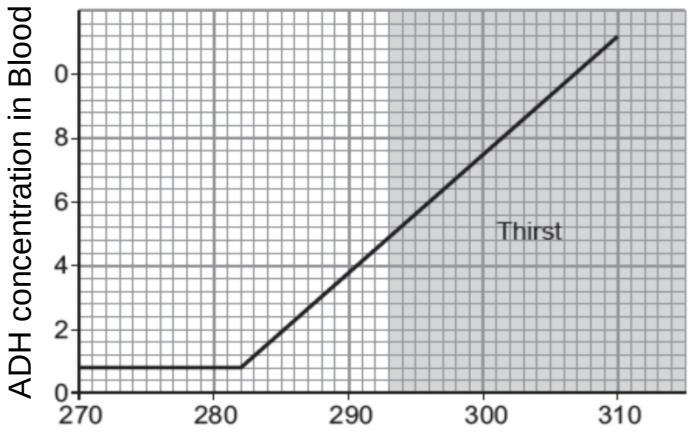
a) Ginger (*Zingiber officinale*) is well-regarded for its therapeutic effects on digestive disorders. Mention any **TWO** digestive disorders treated by the ginger **[1]**

b) The following equation represents the oxidative decarboxylation. **[2]**

$$2Pyruvate + 2NAD^{+} + 2CoA \xrightarrow{Pyruvate\ dehydrogenase} 2AcetylCoA + 2NADH + CO_2$$

How does the deficiency of pyruvate dehydrogenase impact on human's energy system? Mention any **TWO** impacts.

c) The graph shows the relationship between Antidiuretic hormone (ADH) and plasma solute concentration in blood of a person. Refer the graph to answer the following questions.



Plasma Solute Concentration in Blood

i. How does ADH prevent person from feeling thirsty till plasma solute concentration is 293? **[1]**

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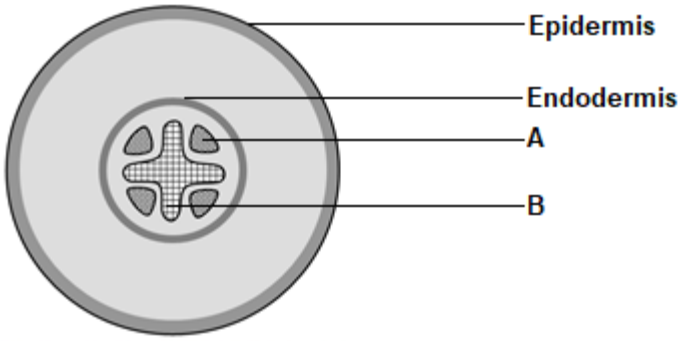
ii. What happens to aldosterone secretion when a person feels thirsty? **[1]**

d) The figure below shows a cross section of a plant root. Refer the figure to answer the following questions.



i. Name the tissues labelled A and B. **[1]**

ii. What are the two substances transported by tissue B? **[1]**

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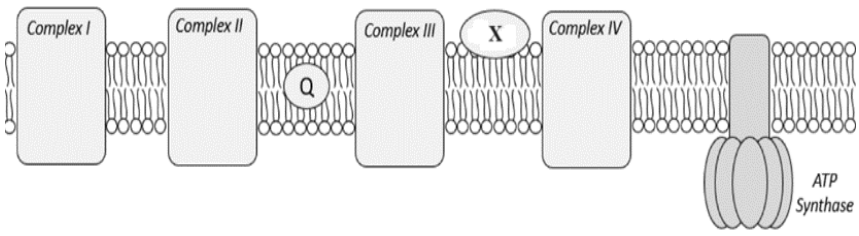
e) The national assembly of Bhutan has adopted 9th biological corridor which connects Sakteng Wildlife Sanctuary and Bumdeling Wildlife Sanctuary in 2023. How will this benefit in conserving biodiversity? **[2]**

f) Explain any **ONE** challenge in management of natural resource in your community. **[1]**

Question 9

a) Explain the Variable Number of Tandem Repeats (VNTR) on DNA. **[1]**

b) The figure below shows the Electron Transport Chain (ETC) on inner mitochondrial membrane. Refer the figure to answer the following questions.



i. Name a compound that donates electron to complex I. **[0.5]**

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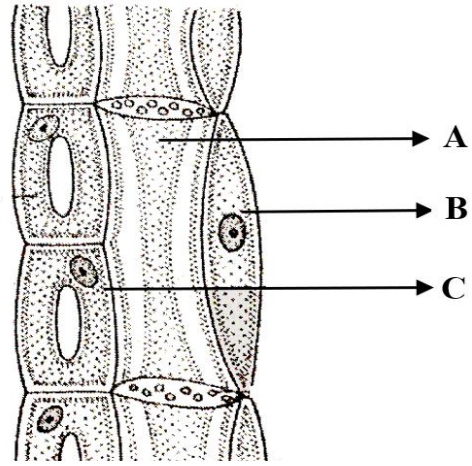
ii. Identify **X** **[0.5]**

iii. How does absence of oxygen affect the operation of ETC? **[1]**

c) The figure below shows phloem tissue of a plant. Refer the figure to answer the following questions.



i. Name part labelled A and B. **[1]**

ii. What is the main function of C? **[1]**

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d) The table below represents the types of flower species in community. Refer the table to answer the following questions.

Flower Species	**Species Number**
Dandelion	4
Buttercup	5
Daisy	4
Tulip	6

i. Calculate the Simpson's Diversity Index(D) and interpret the finding. **[2]**

ii. Mention **TWO** reasons why measuring biodiversity index is important. **[1]**

e) Explain how is desert animal able to conserve water in their body. **[1]**

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f) Which type of gene therapy is preferred, somatic or germline gene therapy? Justify. **[1]**

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