BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
First Semester 2022-23 BIO F111 General Biology
MID-SEMESTER TEST (Close-book)
03-Jan-2023 11 AM 1½ hours 90 Marks (30%)

- *The question paper is divided into 3 sections. Answer all sub-parts of the same question together. Attempt all questions of one section before proceeding to the next section –* ***don't jumble questions across sections****.*
- *Answer briefly.* ***No justification, NO marks****.*
- *There are FOUR pages in this question paper.*

Section A

Q1. You have isolated a new protein X of unknown structure. The native protein has a molecular weight of 200 kDa. This single protein with 200kDa displays an enzymatic activity on cellulose. However, upon treatment with dithiothreitol (DTT, a reducing agent), the protein lost its enzymatic activity and was also separated into two units of 50kDa and 150 kDa molecular weight. Based on these results:

(a) Determine the highest level of structure of this protein. **[1.5M]**
(b) What according to you is the most likely molecular interaction that stabilizes this protein and affects its enzymatic activity? **[1.5M]**

Q2. A scientist has discovered a new plant species. She is interested in analysing the contents of this new plant. She made four different fractions (Fr1-Fr4) from the plant species and analysed the major contents in these fractions using the elemental analyser. The results obtained are given below:

Sample	C (units %)	H (units %)	N (units %)	S (units %)	O (units %)	P (units %)	Other elements (units %)
Fr 1	15	30	-	-	15	-	40
Fr 2	25	15	20	20	10	-	10
Fr 3	25	60	-	-	05	-	10
Fr 4	20	35	15	-	10	10	10

Based on the obtained results in the table above, what is the dominant macromolecule present in the fractions, Fr1-Fr4? Justify your answer for each fraction. **[2 x 4 = 8M]**

Q3. Your friend is a biologist and works on the functioning of cellular membranes. He isolated the fragments of an intrinsic/transmembrane protein- GLUT (a glucose transporter found in cell membrane). These fragments were present exclusively in the hydrophobic core region of the cell membrane. Surprisingly, these fragments of GLUT protein constituted of both hydrophobic as well as hydrophilic amino acids. Justify the observation briefly with proper reason. **[3M]**

Q4. A student wanted to study the properties of the fluid inside the thylakoid lumen/compartment. He extracted sample A during the day time and sample B during the night time. What do you think would be the difference between the two samples with respect to pH? Why? **[3M]**

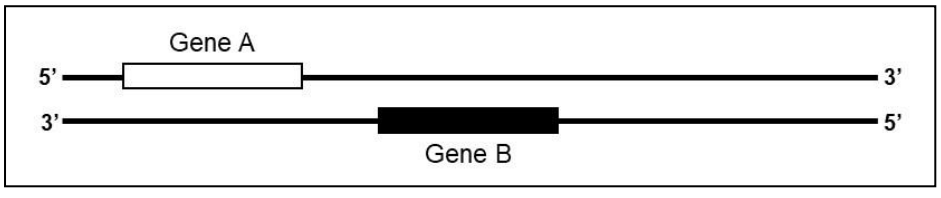
Q5. A diploid plant cell (n=3) is undergoing the cell division process.

(a) At which stage of cell cycle the cell should be stained for karyotypic analysis. Draw a picture of this cell with its chromosomes at this particular stage. Clearly label the regions of this cell. **[2M]**

(b) Draw the cell and chromosomes at Anaphase II of meiosis in this organism. **[2M]**

Q6. In the given figure, you observe the coding regions of two genes, Gene A (upper strand) and Gene B (lower strand) in their respective strands within a bacterial species. Draw the same figure in your answer sheet and specify the following for both Gene A and Gene B; **[1X4=4M]**

(a) Location of promoter region, (b) Location of terminator region,
(c) Transcription start site, (d) Direction of transcription.



Q7. The following chart shows the results of different matings between pea plants that had either purple or white flowers and round or wrinkled seed shape. **[2+3= 5M]**

Mating	Parents	Offspring Phenotypes			
		purple round	white round	purple wrinkled	white wrinkled
#1	purple round x purple round	913	307	289	110
#2	purple round x white round	897	921	312	282

(a) Identify the dominant phenotype for each of the two traits and explain how you did that.

(b) Derive the genotypes of the parents for cross #2 shown above, explaining how you arrived at the answer. Use letter "p" for colour and "r" for seed shape.

Section B

Q8. A neurodegenerative disorder was studied in a group of people above 70 years and the changes in their cell samples was observed. Draw a cell structure indicating only the affected organelle/s or structure for the following functional disorder: **[1.5+1.5+3 = 6M]**

(a) Steroid biosynthesis
(b) Polymerization of Actin protein
(b) Misfolded proteins and their accumulation

Q9. Maltose is a good source of energy in the form of ATP. Wheat, cornmeal, barley and several ancient grains are rich in maltose. Fruits are another common source of maltose in the diet, especially peaches and pears. How many ATPs can be generated if one molecule of maltose is used as substrate in aerobic respiration and from the alcoholic fermentation? Justify in each case. **[2+2 = 4M]**

Q10. Your friend Rohan went to the Himalayan region in this summer vacation and found a new plant species. He informed about this new discovery to a scientist in National Plant Research Institute who analysed the process of photosynthesis in this plant. Surprisingly, the scientist reported that this plant follows C_6 cycle for carbon fixation, and not the Calvin cycle. Which one major change is likely that you identify in this C_6 plant? Justify your answer. **[3M]**

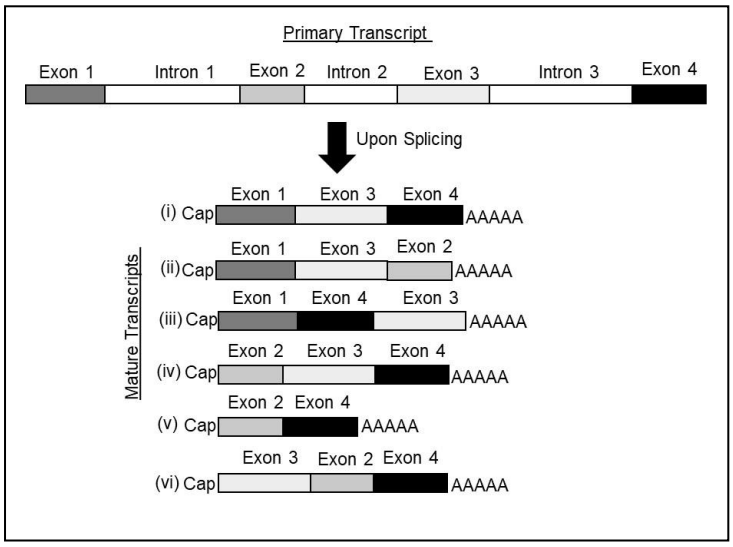
Q11. As a biologist, you have identified a new protein X from an animal cell. You observed that when the corresponding gene is mutated, it leads to abundant proliferation of cells. What would be the ideal terminology that can be given to this class of proteins and why so? **[3M]**

Q12. What is the probability that each of the parental pairs will produce the indicated offspring? (Assume independent assortment of all gene pairs) **[4M]**

(a) AABbCc X AaBbCc = AAbbCC
(b) AABBCC X aabbcc = AaBbCc
(c) aaBbCC X AABbcc = AaBbCc
(d) AaBbCc X AaBbCc = AaBbCc

Q13. Messelson and Stahl's Experiment in 1958 provided evidence that DNA replication occurs in a semi-conservative mode. In their experiments, they initially used a heavy isotope of N^{15} DNA containing bacteria followed by growing them for the next one cycle of cell division in a N^{14} (normal isotope) containing nutrient media in order to assess the density of the DNA using CsCl density gradient centrifugation. In this experiment, they observed the pattern of bands appearing in the CsCl column based on the quantity of N^{14} or N^{15} in such DNA. Let us consider in a hypothetical situation, what would Messelson and Stahl have observed in the band pattern in the CsCl column that would have proven the mode of replication to be "dispersive", and not "conservative" or "semi-conservative"? Draw the schematic representation of band pattern and justify with a comparative band pattern for all the modes of DNA replication. **[6M]**

Q14. The given figure describes the formation of six different mature transcripts from (i) to (vi) from primary transcript through splicing, capping and tailing which is happening in a cell. Answer the following questions based on the given information;



(a) Which **type** of cell is this?

(b) Based on the concept you have learned on splicing in your *General Biology* class, which **mature transcript/s are most unlikely to be formed**? Justify your answer with appropriate reasoning. **[1+3= 4M]**

Section C

Q15. Of the wide variety of biomolecules that are available on our planet, nature has chosen only a specific biomolecule to form membranes for several cellular organelles. Which biomolecule did nature choose to form these membranes and why according to you nature has chosen this biomolecule? Draw a schematic diagram to explain the biochemical basis of these molecules to form membranes. **[4M]**

Q16. A researcher is performing a genetic analysis on a population of dividing animal cells. This analysis revealed that the ploidy status of the analyzed cells is aneuploid (have more or fewer chromosomes than normal) and is rapidly dividing. Why does the analyzed population of cells have abnormalities in their chromosome number? Which checkpoint is being compromised that led to these abnormalities? Justify. **[3M]**

Q17. A student planted a neem seedling weighing 200 grams in a pot containing 5 kg soil and watered the plant as and when required. After a year, he measured the plant and soil weights again and found it to be 2 kg and 4.95 kg, respectively. He concluded that the plant gained all its extra weight from the water he provided. Whether his conclusion is correct? Justify your answer. **[3M]**

Q18. Given below is a pedigree chart representing the appearance of a particular trait from one generation to the next. Males are depicted by a square and females by a circle. Based on this pedigree chart, answer the given questions:

[1+2.5+2+2.5 = 8M]

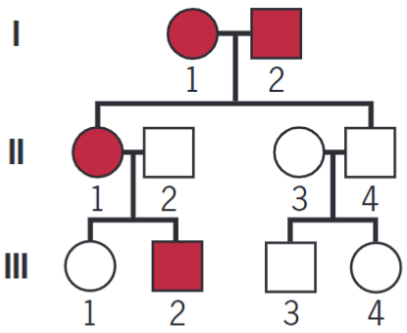
(a) Is this a dominant or recessive trait?

(b) What is the probable genotype of each individual.

(c) Is there any homozygous dominant individual in the above pedigree? Justify your answer

(d) What is the chance that the offspring of the following matings will show the trait:

(i) III-1 × III-3 (ii) III-2 × III-4



Q19. It is well known that there are 64 different triplet codons in mRNA, out of which 3 are stop codons and 61 coding for specific amino acids as defined by tRNAs (carrying the anti-codon) that the amino acids are bound to. This suggest that human should have 61 types of tRNAs carrying unique anti-codon sequences that can bind to each of these unique 61 codon sequences in the mRNA. Interestingly, however, there are around 40 different anti-codon containing tRNAs that are currently present in your cells yet translation is happening successfully with these 40 tRNAs. From the knowledge gained in the course, how do you think it is possible? Justify with appropriate reasoning. **[3M]**

Q20. Following is the sequence of a mature mRNA. Based on this information answer the following questions:

5'Cap GACUGAUGGCCACCAUGGAAUGACGGUGAUGCAAAAAA3'

(a) Derive the polypeptide sequence that will be synthesized from this mRNA after reading by the ribosomal machinery? Mention the **directionality** of the polypeptide sequence along with writing the amino acid sequence of the polypeptide. (Please see the codon table) **[3M]**

(b) What will be the sequence of the triplet codon present in the A-site of the ribosome when the start codon is present in the P-site of the ribosome? **[2M]**

(c) Mention the sequence of the anti-codon present in the tRNA for that specific codon in A-site. Specify the 5' and 3' sites for such sequences of codon and anti-codon (no marks will be awarded if the direction ality of these sequences is not specified). **[2M]**

(d) Write this mature mRNA sequence and highlight the UTR region(s). **[2M]**

Second letter

First letter	U	C	A	G	Third letter
U	UUU, UUC: Phe; UUA, UUG: Leu	UCU, UCC, UCA, UCG: Ser	UAU, UAC: Tyr; **UAA Stop**; **UAG Stop**	UGU, UGC: Cys; **UGA Stop**; UGG Trp	U C A G
C	CUU, CUC, CUA, CUG: Leu	CCU, CCC, CCA, CCG: Pro	CAU, CAC: His; CAA, CAG: Gln	CGU, CGC, CGA, CGG: Arg	U C A G
A	AUU, AUC, AUA: Ile; **AUG Met**	ACU, ACC, ACA, ACG: Thr	AAU, AAC: Asn; AAA, AAG: Lys	AGU, AGC: Ser; AGA, AGG: Arg	U C A G
G	GUU, GUC, GUA, GUG: Val	GCU, GCC, GCA, GCG: Ala	GAU, GAC: Asp; GAA, GAG: Glu	GGU, GGC, GGA, GGG: Gly	U C A G