BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

First Semester 2016-17 Comprehensive Examination

General Biology (BIO F111) (OPEN BOOK)

PART-2 Duration: 120 min Max Marks: 50 (25%) (06.12.2016)

The question paper is divided into 4 SECTIONS (A/B/C/D).

Answer all parts of the same section together; if you jumble them up, your answers won'tbe evaluated.

NO JUSTIFICATION, NO MARKS

Section "A"

1.

a. Suppose that a particular cell has 30 different kinds of transfer-RNA molecules, each with one of 20 possible amino acids attached at its distal end. On average, how many different sets of codon triplets in the messenger-RNA chain would each transfer-RNA have to recognize, in order to make all the proteins necessary for cell growth? *Give a number for your answer and show how you deduce it.* **[2.0]**

b. In Plant Biotechnology Lab of BITS Pilani, Pilani Campus, a research scholar prepared somatic hybrids by cell fusion experiments between Plant **A** and Plant **B** (both diploid) that have 34 and 54 chromosomes, respectively. Considering the above, determine the total number of double stranded DNA molecules in the resulting hybrid cell, if the fusion is made between cells in the following completed stages of cell cycle (*show calculations*):

	Plant A		***Plant B***
(i)	G1	X	S
(ii)	S	X	G2

[2.0]

c. A research laboratory cloned a yeast gene encoding a protein that is found in the mitotic spindle. The gene encodes a protein of 200 amino acids. What is the minimum size (in nucleotides) of the mRNA (mature) of this protein? Write how you derive your answer. **[2.0]**

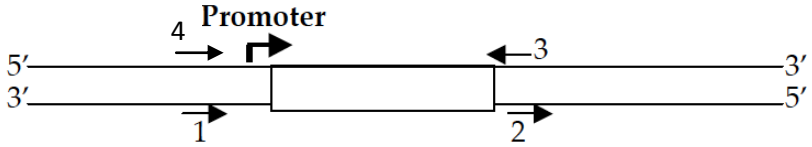
d. A stem cell goes through a division once a day to produce another stem cell and a precursor white blood cell. The precursor white blood cell then divides after one day to give rise to two differentiated cell types, the T-cell and the B-cell. You start with a single stem cell. Draw and fill in the chart indicating how many of each cell type will there be on the days listed (day **1, 2** and **3**). Assume the time for the cell division is one day. Write numbers for your answer. **[2.0]**

Cell Type/day	Day 0	Day 1	Day 2	Day 3
Stem Cell	1			
Precursor White Blood Cell	0			
T-Cells	0			
B-Cells	0			

e. One way to make transgenic sheep is to have a gene of interest inserted into the sheep genome. You introduce a viral gene into the embryonic sheep cells in culture. To make sure, that the sheep born from the embryonic cells is a transgenic sheep with the viral gene, you decide to check the presence of the transgene in cells isolated from the sheep. You have to PCR amplify your gene of interest. You have four primers that anneal to the DNA as diagrammed below, with your gene of interest shown in box.

i. Which primer/s (from **1, 2, 3, 4** below) would you use for the PCR? **[1.0]**

ii. Which of the following reagents (**a, b, c, d**) would you add to your PCR mixture (which already contains the following- DNA polymerase, enzyme buffer and DNA primers). Justify your answer.
a. Genomic DNA from the transgenic sheep cell; **b.** Reverse transcriptase; **c.** dNTPs; **d.** DNA ligase.
[1.0]



f. You are a conservation biologist dedicated to preserving rare species from around the world. You recently started a project to clone the rare red crabs by somatic cell nuclear transfer. This crab is the same species as the

normal purple crab but has a genetic mutation that gives it a red color. Given that you only have somatic, differentiated cells available, what is/are the trait/s desirable for an appropriate donor cell? Choose from the choices below. Justify your answer.

i. Egg cell; **ii.** Sperm cell; **iii.** Multi-nucleated somatic cell; **iv.** Somatic cell in G_2 phase; **v.** Somatic cell in M phase; **vi.** An enucleated egg cell; **vii.** Somatic cell in G_0 phase. **[2.0]**

Section "B"

2.

a. In the poultry, feathered legs (L) are dominant over clean legs (l) and pea comb (E) over single comb (e). Two cocks **A and B** are bred to two hens **C and D**. All four (**A, B, C and D**) are feathered-legged and pea-combed. Cock A with both hen produces offspring that are all feathered legged and pea-combed. Cock B with hen C produces both feathered and clean but all pea-combed offspring; but with hen D, he produces all feathered but some pea-combed and some single combed offspring. What are the genotypes of these four birds? Show how you derive your answer. **[4.0]**

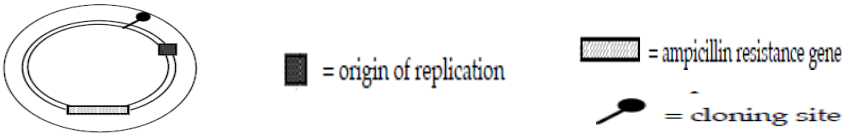
b. In a clinic, you came across an individual whose karyotyping revealed that he possesses the following chromosomal abnormality - **XXY**. Based on your understanding of chromosome separation during gamete formation, mention whether non-disjunction occurred in his mother or his father (or both) and at which division(s), meiosis I or meiosis II? Justify your answer with a schematic diagram. **[2.0]**

c. State **True or False** and justify your answer. "Gene transcription does not necessarily result in the production of a functional protein." **[1.0]**

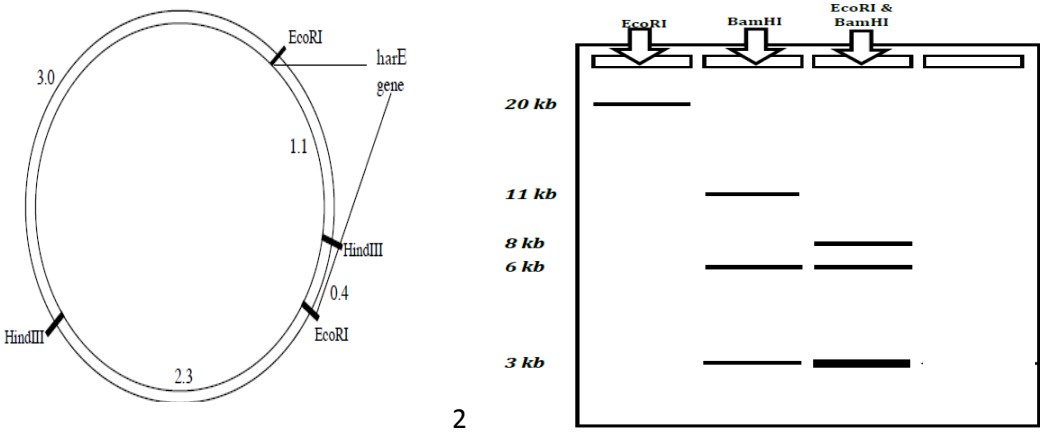
d. Which of the following: 5' GCGCGC 3' or 5' GGCCGG 3' could be a restriction enzyme site? Justify. **[1.0]**

e. You wake up one morning to find your roommate excited about her sudden hair growth. She has been supplementing her diet with a strange new plant purchased at the local farmer's market. You take samples of the plant to your lab and find that this plant does indeed make a protein (the **hair-B** protein) that stimulates hair growth. You wanted to clone the hair-B gene, and if you succeed you will become a billionaire. You obtain DNA from the plant, digest it with a restriction enzyme, and clone it into a plasmid vector.

i. You clone your restriction digested hair-B gene into the plasmid given below. How would you distinguish the bacterial cells (*E. coli*) that carry the plasmid from those that do not? **[1.0]**



ii. Given below is the map of the plasmid with the hair-B gene inserted in the plasmid. The numbers denote size in kb (kilobases). Draw an agarose gel, in which the first lane shall have the plasmid digested with only *EcoR1enzyme*, the second lane shall have the plasmid digested with only *HindIII* and third with *EcoR1* and *HindIII*. Draw the approximate position and mention the size of the digested DNA bands on the electrophoreses gel (*no other text is required*). *For reference, a* ***representative*** *agarose gel is shown next to the plasmid (the band sizes and enzyme names in this picture do not relate to your study and must be changed appropriately according to your answer).* **[3.0]**



Section "C"

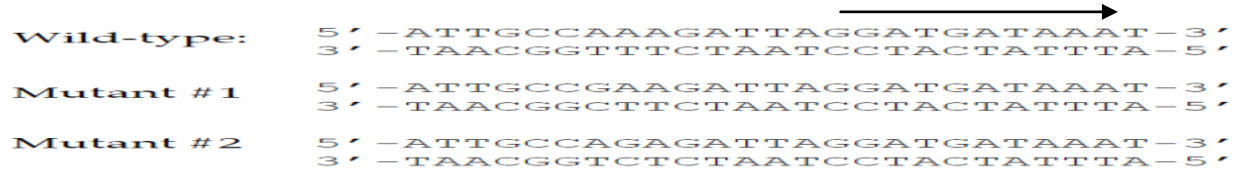
3.

a. Suppose you discover a mutant yeast whose glycolysis pathway is shorter because of the presence of a new enzyme that catalyzes the reaction:
glyceraldehyde 3 phosphate + H_2O + NAD^+ ---> 3-phosphoglycerate + NADH + H^+
What is the net yield of ATP made anaerobically in this mutant yeast during the conversion of 1 molecule of glucose to pyruvate by this shortened pathway? *Give a **number** as your answer & justify your answer.* **[2.0]**

b. In two test tubes you add the same amount of identical growth medium and same number of identical yeast cells and grow these cells. They grow under identical conditions except for the presence or absence of oxygen.
i. Which of the two cultures (aerobic or anaerobic) will consume more amount of glucose to derive equal amount of energy in terms of ATP? Justify your answer. **[1.0]**
ii. Under aerobic and anaerobic conditions, the carbon from pyruvate will immediately be found in which molecule/s? Mention the name of the molecules in each case. **[1.0]**

c. Given a solution of isolated chlorophyll molecules and intact chloroplasts, which one of the two is expected to release more heat upon exposure to light and why? **[2.0]**

d. The following figure shows part of the DNA sequence of a wild type protein (200 amino acids [aa] long). DNA sequences for the same protein **(#1 and #2**) with point mutation in it are also given below. The DNA sequence in each case includes codons representing the last five amino acids of the protein, termination codon and also part of UTR. The arrow denotes the carboxy terminus of the protein & the direction of UTR.
i. Mention the position of the amino acid (number wrt the protein) undergoing mutation in #1 and #2. **[2.0]**
ii. In which of the following (choose from # 1 or # 2) can there be an effect on the protein function? Justify your answer (Refer to codon table from book). **[2.0]**



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e. A very sensitive instrument shows that one of the carbon atoms in Mahatma Gandhi's last breath is assimilated as part of your stored body carbohydrate molecule. By a ***flow chart,*** show how this carbon atom might have travelled from Gandhiji to you and list some of the molecules it could have passed through (ignore the time difference between you and Gandhiji's existence). **[2.0]**

f. Which of the organisms listed below would have smallest total biomass in an ecosystem. Justify your answer.
i. Aquatic photosynthetic organism that fixes CO_2, ii. Eagle that preys on pigeon, iii. Pigeon that feeds on grain, iv. Fungi that decomposes dead matter. Justify your answer. **[1.0]**

Section "D"

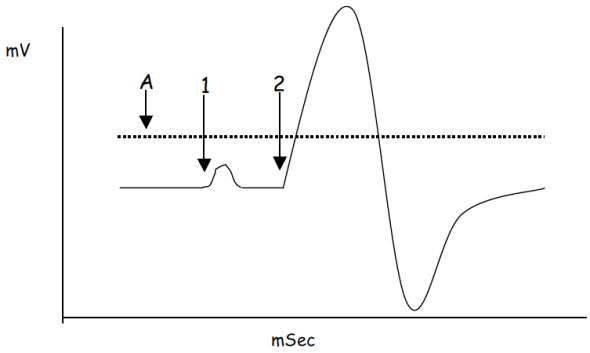
4.

a. Liver cells do not produce insulin whereas pancreas cells do, because cells of the liver do not contain the gene for insulin production. State whether the given statement is **True or False** and justify your answer. **[1.0]**

b. Your uncle is suffering from high blood sugar and associated diabetes. He went for his blood hormonal profile check up, which suggested lack of hormone insulin as the probable cause towards his high sugar levels. Instead of going for a doctor, he purchased over-the-counter insulin (at an appropriate dose) from medical shop and consumed it orally instead of recommended intra-venous administration. Specify an appropriate reason as to why insulin taken orally may not lower his blood glucose. **[2.0]**

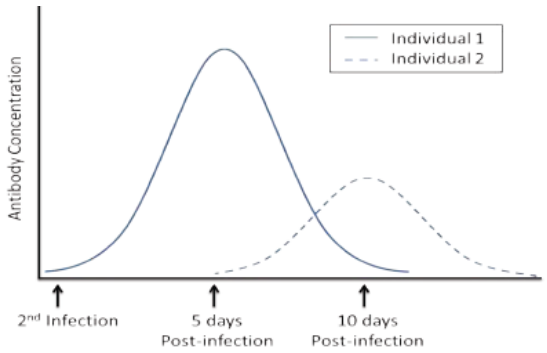
c. Sudhir was not attending his General Biology classes. Just a week before the comprehensive examination, he started studying the topic. Because of not attending the classes the topics seemed new and took a lot of time for him to grasp. This made him sleep late almost every day for a period of 7 days. He ultimately became ill just before the exam. Given that, sleep deprivation is known to increase adrenal steroid secretions in the blood, how can this be correlated to Sudhir falling sick? Justify. **[2.0]**

d. Inspired by your General Biology classes you decided to research on artificial intelligence and memory. You hence join a neurophysiology lab for your final thesis. Your supervisor wanted to check your basic knowledge of neuronal biology. He asks you to inject a small amount of Na^+ to the axon hillock region of a neuron (say, neuron, X). When you inject 1 nanogram of Na^+ at time point **1**, you see a small change in membrane potential, but by **just** injecting twice as much at time point **2**, you see a **very large** change. See the adjacent data.



i. What is "A" denoting in the figure. What can be the possible reason for the specific response observed at time point (1) compared to time point (2)? **[1.0]**

ii. Your supervisor then asks you- "Why this nerve impulse generated (by 2) when reaches the axon terminal of neuron (X), the impulse is transferred to adjoining neuron (Y) only and not *vice versa* or back." What would be your answer? **[1.0]**



e. Arrange the following cell types with decreasing order of mitochondrial number present- RBC, sperm and skin cell. Justify your answer. **[1.0]**

f. One year after being vaccinated by a flu vaccine two individuals encounter a new form of flu virus. You assay their immune response specific to the flu virus and obtain the following profile. Explain why the immune response of **Individual 1** to the flu virus differs from that of **Individual 2**? Refer to adjacent figure. **[2.0]**

g. Why do you think during spermatogenesis, unlike oogenesis, the developing spermatocytes derived by meiosis from a single spermatogonial cell are connected by cytoplasmic bridges between them? **[1.0]**

h. A person is exposed to a toxin that can cross the blood brain barrier and act on neurons. The toxin can irreversibly block voltage gated calcium channels. What would be the effect on neuronal conductivity? Be specific and support your answer with a labeled representative diagram only. **[2.0]**

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Best of Luck