BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

First Semester 2022-23 BIO F111 General Biology

COMPREHENSIVE EXAM

(OPEN BOOK)

16-Feb-2023 2 hours 10 minutes 75 Marks (25%)

- *The question paper is divided into 4 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**.*
- *Write specific and brief answers. **No justification, NO marks**.*
- *Any diagram asked should be labeled properly. No labeling, No marks.*

Section A

Q1. Indian Government has banned the use of polythene bags as the consumption of waste polythene bags results in serious health issues, particularly in road-side animals. Knowing this fact, your younger brother curiously asked you why such a ban has not been implemented on the use of paper-bags as he saw a cow eating paper-bags in street. Based on the biochemical composition of the above materials, give suitable justification for such an observation. **[4M]**

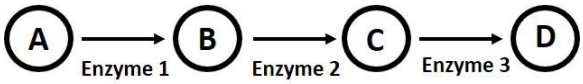
Q2. In case, Succinate dehydrogenase, the enzyme which catalyzes the reaction forming Fumarate became non-functional in a particular bacterial cell, then what would be the total number of following molecules generated per glucose molecule metabolized? Consider that the cell is still metabolizing glucose through aerobic respiration. Justify in each case. **[3M]**

(a) ATP **(b)** NADH **(c)** $FADH_2$

Q3. Prabhat founded a new startup company for manufacturing washing soap bar which utilizes fatty acids isolated from the unutilized crop straw. The company claimed to remove the "*oil stains*" from clothes. Why do you think the inclusion of fatty acids in washing soap is important? **[3M]**

Q4. Some plant species have a special capacity to reduce photorespiration and increase photosynthesis by using PEP carboxylase as the first enzyme in the photosynthesis process. What are these plant species called? Write about the specific strategy these plants use to increase the rate of photosynthesis. **[3.5M]**

Q5. You have done a genetic screen looking for mutants in the Compound D synthesis pathway (shown below). Compound D is essential for life. Fill in the table with the expected phenotype (LIVE or DIE) for cells carrying mutations in each of the listed enzymes. **[4.5M]**



Mutation cause loss of activity in:	Growth media is supplemented with:		
	A only	B and C	D only
Enzyme 1			
Enzyme 3			
Both Enzymes 1 & 3			

Section B

Q6. Microtubules display a dynamic property of polymerization and depolymerization, and they form stable structures inside a cell. Justify how the dynamic property of microtubules is helpful for a cell at different stages of the M phase of the cell cycle. **[2M]**

Q7. A scientist was investigating cultures of a single bacterial species from two different locations. He isolated the total DNA from these two bacterial cultures and performed density gradient centrifugation. In the first bacterial culture, he obtained two DNA bands resolved in the density gradient. Whereas in the

second bacterial culture, he obtained only one DNA band in the density gradient. He decided to sequence the DNA bands he detected, and given below are the percentage of nitrogenous bases he obtained.

Bacterial culture location 1:

Band 1: 35% A, 15 % G, 35%T, 15% C

Band 2: 15% A, 25 % G, 25%T, 35% C

Bacterial culture location 2:

Band 1: 35% A, 15 % G, 35%T, 15% C

What could be the source of these individual DNA bands that the scientist has detected in the bacterial cultures from two different locations? Justify your answer. **[4M]**

Q8. Given below is a hypothetical sequence of a very short chromosome of a eukaryotic cell. Replication starts at the nucleotide "a" highlighted with an arrow. One strand of the DNA has been labelled with heavy ^{15}N, hence written in capital letters. This cell divides twice in a ^{14}N containing media. where all newly synthesized DNA in the daughter cells will have ^{14}N represented by lowercase. Draw the chromosome sequence of daughter cells after 1st and 2nd round of division. Mention the 5' and 3' ends of the strands. **[3M]**

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        ↓
5'- agaattatccgg -3'
3'- TCTTAATAGGCC -5'
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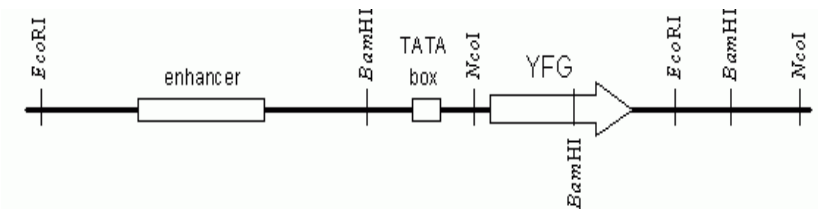
Q9. (a) "An action potential originates from dendrites to travel through the axon to reach to axon terminal". Mention True or False? Justify with appropriate reasoning. **[3M]**

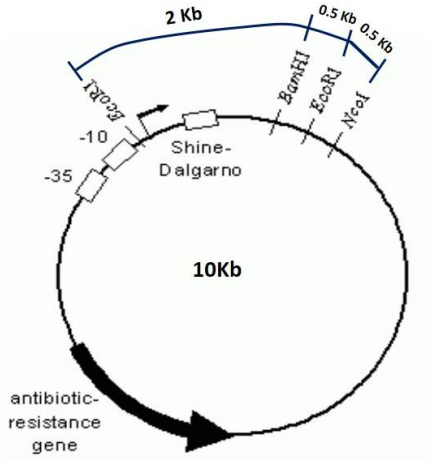
(b) What will be the difference in action potential pattern when you are bitten by a small ant to when you are hit strongly by a hammer? Draw a well labeled diagram showing the action potential pattern in each case. **[4M]**

Q10. Cell A of Organ X secretes Factor M which allows the proliferation of Cell A as well as another group of the neighboring cells named Cell B in Organ X. Interestingly, upon the action of Factor M on Cell B, these cells secrete Factor N which acts on Cell C in Organ Y and block apoptosis of Cell C. Based on this information, what kind of signaling do "Factor M" and "Factor N" induce? Justify your answer. **[3M]**

Section C

Q11. The diagram below represents a section of the human genome. The coding sequence of a gene, YFG, is shown by an arrow, and boxes indicate the locations of some regulatory sequences. Locations of recognition sequences (cut sites) for three common restriction enzymes (*Eco*RI, *Bam*HI, and *Nco*I) are also marked.





You would like to clone this gene in *E. coli* for further study. You have a vector (plasmid) shown above:
(a) What does -10 in plasmid indicate? Why is it needed? **[2M]**
(b) Which restriction enzyme would you use to cut and clone this gene in the vector? Justify your choice. **[3M]**
(c) After the transformation of this vector in *E. coli*, you cultured the bacteria in the absence of antibiotic. What consequence do you expect? **[2M]**

(d) Draw an agarose gel showing DNA bands in three lanes after cutting the vector (10Kb) with restriction enzymes as follows (Mention the band size in each lane): **[3M]**

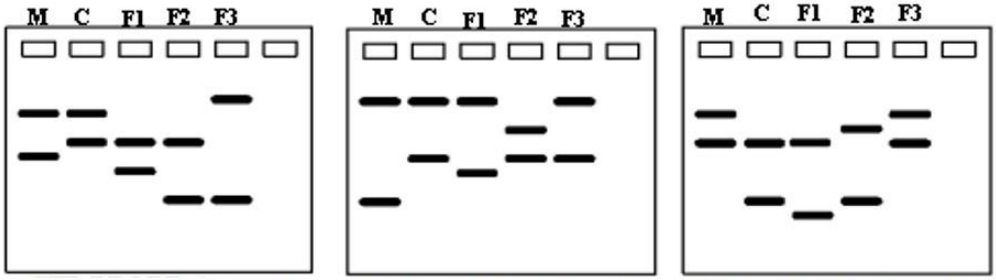
Lane 1: Cut with *Bam*HI

Lane 2: Cut with *Eco*RI

Lane 3: Cut with *Eco*RI and *Bam*HI

Q12. *John* wanted to find out his biological father. So he went for DNA fingerprinting to establish paternity. Below are the DNA fingerprints of 5 people in such a case: the child (C), the mother (M), and three potential fathers of the child (F1, F2, F3). In this experiment, three different STR loci (A, B, and C) were PCR amplified and run in three agarose DNA gels to visualize the bands, as given below. Based on the given information and gel images, answer the following questions. **[5M]**

(a) Which male or males can be eliminated as the biological father of child. Justify.
(b) Which male or males can theoretically be the biological father of child. Justify.



PCR product for locus A PCR product for locus B PCR product for locus C

Q13. (a) Your immune system is unique like you. How do your immune cells produce various (multiple) antibodies that are capable of fighting antigens your body may have never encountered? **[2M]**

(b) In order to spare a large number of people from unnecessary vaccination and therefore save on vaccine doses, we could find out before vaccinating a person whether he/she is already naturally immunized by conducting a blood test. What would be the biological basis of such a test? **[2M]**

Section D

Q14. As you observe the process of gamete formation in males and females, you surprisingly notice that cytoplasmic sharing is different in developing gametocytes. Specify a reason as to why it is so and favoured by natural selection. **[4M]**

Q15. Mention the non-gonadal source of steroid hormone/s in males, and prepare a flowchart to explain how this hormone (name it) might be associated with diabetes. **[4M]**

Q16. (a) After SCNT procedure both John Gurdon and Ian Wilmut provided an electrical shock. Which biological process was stimulated by the shock and mention its immediate effect? **[2M]**

(b) A single stem cell (A) present in the bone marrow, undergoes division following the "definition of stem cells" discussed in the class. It takes 'One Day' for it to form a differentiated cell (B). Given that you start with one stem cell, how many stem cell/s (A) and differentiated cell/s (B) would be obtained after 3 days [Consider that the differentiated cell does not divide but survives for three days]. Justify your answer. **[4M]**

Q17. A pathology lab technician analyzed the urine samples from two persons (A and B). The technician analyzed different biomolecules in their urine samples including glucose, urea, protein, and creatinine. After such analysis, the technician found that person A (whose blood glucose level was completely normal) had more glucose in urine than in the normal range. In contrast, person B had more quantity of protein in urine than in the normal range. Based on your knowledge of General Biology classes, which part of the Nephron do you think is most likely affected in these persons? Justify your answer. **[5M]**

--------- **End of the paper** ---------