MOLECULAR BASIS OF INHERITANCE

<table>
<tr><th>Q.No</th><th>Question</th><th>Marks</th></tr>
<tr><td colspan="3">Multiple Choice Question</td></tr>
<tr><td>Q.76</td><td>Two statements are given below - one labelled Assertion (A) and the other labelled Reason (R).

Assertion (A): Only one strand of DNA is transcribed.

Reason (R): Strands having complementary bases code for the same proteins.

Which of the following is correct?

A. Both A and R are true, and R is the correct explanation for A.
B. Both A and R are true, but R is not the correct explanation for A.
C. A is true, but R is false.
D. A is false, but R is true.</td><td>1</td></tr>
<tr><td>Q.77</td><td>If a bacterial cell contains 'x' g of DNA, which of the following correctly depicts the amount of DNA at the end of each phase of the cell cycle?

<table><tr><th></th><th>G1</th><th>S</th><th>G2</th><th>M</th></tr><tr><td>P</td><td>x</td><td>2x</td><td>x</td><td>x</td></tr><tr><td>Q</td><td>2x</td><td>2x</td><td>x</td><td>x</td></tr><tr><td>R</td><td>2x</td><td>2x</td><td>2x</td><td>x</td></tr><tr><td>S</td><td>x</td><td>2x</td><td>2x</td><td>x</td></tr></table>
A. P
B. Q
C. R
D. S</td><td>1</td></tr>
<tr><td colspan="3">Free Response Questions/Subjective Questions</td></tr>
<tr><td>Q.78</td><td>Purines have two rings in their nucleotide structure whereas pyrimidines have only one ring. Given below is an image of their structures.</td><td>2</td></tr>
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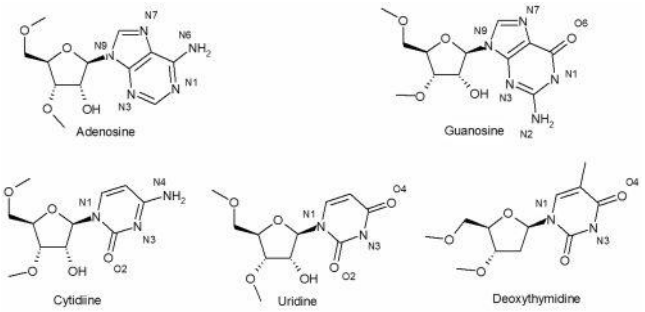
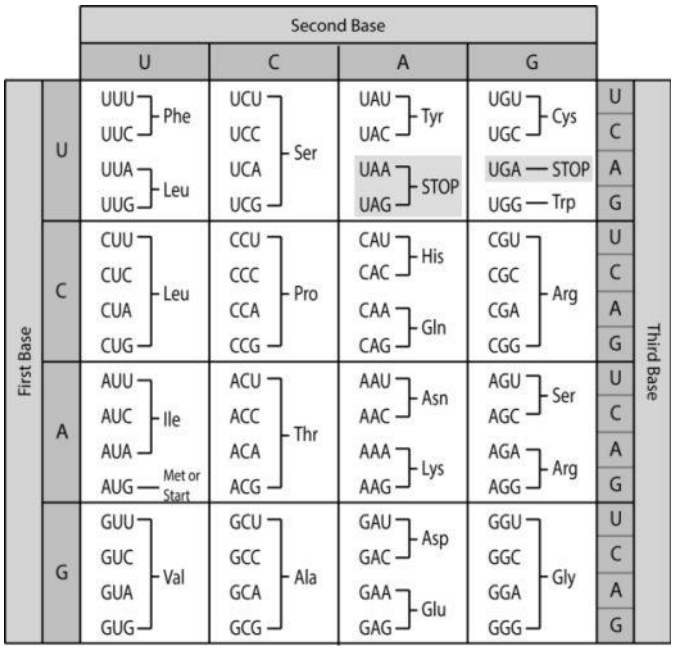
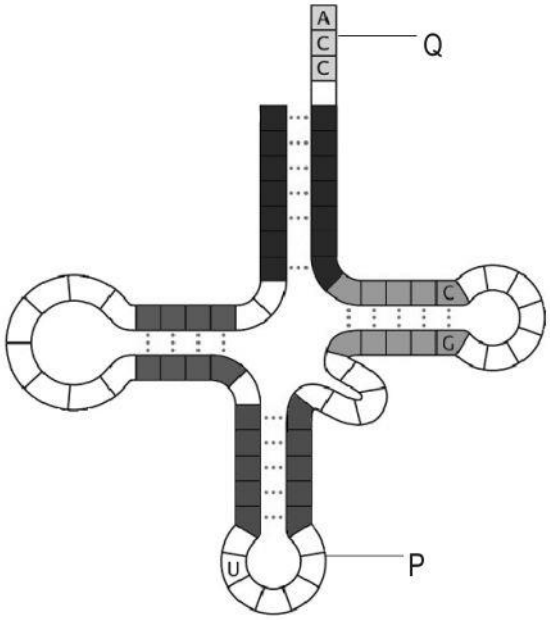
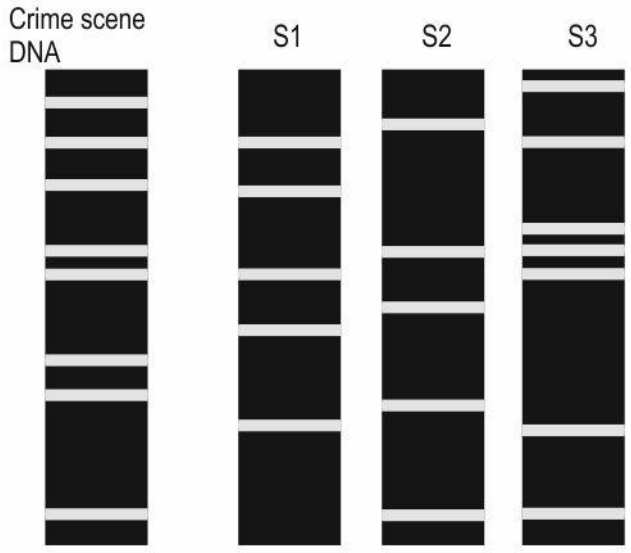
	 (a) The distance between the two strands of a DNA molecule _____ (increases/decreases/remains the same) from one end to another. (b) Under what hypothetical circumstances would the distance between two strands be different from what is seen presently?	
Q.79	With the help of experiments done by various scientists over 40 years, it was finally concluded that DNA is the genetic material. (a) Before DNA, which molecules were considered to be genetic material? (b) What was concluded from Griffith's experiments using S and R strains of mice? (c) Briefly describe two experiments that led to the conclusion that DNA is the genetic material. (d) Today, if the contents of a nucleus of a human cell were extracted, it can be concluded that DNA is the genetic material as that is the only biomolecule present in the nucleus. Justify this statement as true or false.	5
Q.80	Give a reason why: (a) The absence of RNA polymerase III can interfere with the translation of nuclear genes. (b) Defining a gene present in DNA is complicated, particularly in eukaryotes. (c) In bacteria, translation and transcription happen almost simultaneously.	3
Q.81	Given below is the sequence of an mRNA the image of the genetic code. Assume that this sequence begins with a start codon. 5' - GCUAUCAAGUACCUA - 3'	3

	 (a) Identify the amino acid sequence to which this mRNA will get translated. (b) Identify the type of mutation and the change in the protein sequence in the following: (i) cytosine in codon 4 gets modified to uracil (ii) GCU gets added after the second cytosine in the sequence	
Q.82	Given below is a representation of the structure of the tRNA with two of its parts marked P and Q. Q is the amino acid acceptor end of the tRNA.  (a) What is loop P called? (b) How can the polarity of the tRNA molecule be identified from the image? (c) Write the 5'-3' anticodon sequence in a tRNA molecule for the start and stop codon.	2

Q.83	The *lac* operon is a polycistronic gene that helps a bacterial cell in metabolising lactose. It consists of an inducer (*i*) gene that represses the transcription of *lac* genes under certain environmental conditions. (a) Why is the *lac* gene called polycistronic? (b) What would happen if there was a mutation blocking the translation of: (i) gene z (ii) gene y (c) What happens to the expression of the lac operon when the growth medium is provided with: (i) both glucose and lactose (ii) only galactose	5
Q.84	Like the *lac* operon, prokaryotes contain several other operons that are regulated in different ways. *Trp* operon is one such operon that has five genes that code for enzymes required for tryptophan biosynthesis. Tryptophan is an amino acid that is required by the bacterial cell for the formation of various proteins. Tryptophan itself regulates the expression of the *trp* operon. The *lac* operon is induced by lactose whereas the *trp* operon is repressed by tryptophan. Using the understanding of how the *lac* operon works, justify why this statement could be true.	2
Q.85	Describe TWO DNA technological processes that were used in the Human Genome Project.	2
Q.86	Expressed sequence tags (ESTs) are short cDNA molecules formed from mRNA molecules isolated from a cell. In eukaryotes, ESTs are said to be useful to identify coding regions of a genome but not DNA sequences. Justify why this statement is TRUE.	3
Q.87	Over the years, researchers have gathered enough evidence to suggest that RNA was the first genetic material which was slowly replaced by DNA. Give TWO reasons why RNA was replaced by DNA as the genetic material.	2
Q.88	Justify the following statements: (a) The amino acid sequence can be derived from the mRNA sequence but the reverse cannot be done easily. (b) mRNA synthesis happens in the nucleus but protein synthesis happens outside the nucleus. (c) Splicing of the hnRNA is an important post-translational modification.	3
Q.89	The process of DNA fingerprinting involves the use of the Southern blotting technique. In this technique, DNA that has run on an agarose gel and then	3

	transferred to a nitrocellulose or nylon membrane. Finally, the DNA bands are visualised through autoradiography. (a) Share your understanding of why the DNA needs to be transferred to the nitrocellulose membrane. (b) What would be the charge on the nitrocellulose membrane? Give a reason to support your answer. (c) Identify the type of label present on the VNTR probe. Justify your answer.	
Q.90	In a quiet neighbourhood, a woman had been murdered at her home when her roommates were supposedly away. Her roommates were two twin brothers (S1 and S2) and another woman (S3). The investigating officer found the skin of the murderer under her fingernails. The officer sent the DNA from the skin sample along with DNA from the roommates for DNA profiling. Given below is an image of the bands obtained.  (a) Who is likely to be the murderer? Give a reason to support your answer. (b) S1 and S2 are twin brothers. What can you conclude about them from the image?	2

Answer key and Marking Scheme

Q.No	Answers	Marks
Q.76	C. A is true, but R is false.	1
Q.77	D. S	1
Q.78	(a) remains the same (b) The distance would vary if purines or pyrimidines base paired within themselves i.e if a purine paired with another purine that part of the double strand would be broader than areas where two pyrimidines paired with one another.	2
Q.79	(a) proteins (b) The transfer of genetic material can transform a cell to perform a different function. (c) 1 mark each for the following: - Avery, MacLeod and McCarthy purified biochemicals (DNA, RNA and protein) from the heat-killed S cells to see which ones could transform live R cells into S cells and found that DNA alone from S bacteria caused R bacteria to become transformed. - Hershey and Chase allowed bacteriophages with radioactively (^{32}P) labelled DNA and bacteriophages with radioactively (^{35}S) labelled protein coats to infect two separate populations of bacteria and found that only radioactively (^{32}P) labelled DNA was found to enter/get transferred to the bacterial cells. (d) - false *[0.5 marks]* - The nucleus contains other biomolecules such as proteins as well and so the extract would also show the presence of other biomolecules. *[1 mark]*	5
Q.80	(a) RNA polymerase III is responsible for the transcription of tRNA which is crucial for the process of translation. (b) In eukaryotes, the coding sequences (exons) are interrupted by non-coding sequences (introns) which do not appear in the mature mRNA which complicates the definition of a gene in a DNA segment. (c) Since the mRNA does not require any processing to become active	3

	OR Since transcription and translation take place in the same compartment of the cell.	
Q.81	(a) ALA ILE LYS TYR LEU (b) 0.5 marks each for the following: (i) - point mutation - no change in the protein sequence (ii) - frameshift mutation/insertion - An alanine amino acid gets added between isoleucine and lysine. OR An amino acid, alanine, gets added in the third position. *[Accept any other valid answer]*	3
Q.82	(a) anticodon loop (b) The amino acid acceptor end is 3' (c) 0.5 marks each for the following: - Start codon anticodon: 5' - UAC - 3' - Stop codon does not have a tRNA molecule.	2
Q.83	(a) It has a single promoter for multiple connected genes. OR A single mRNA is transcribed to be translated to multiple proteins. (b) 1 mark each for the following: (i) Lactose would not be able to enter/permeate into the bacterial cell. (ii) Lactose would enter the cell but not be broken down into glucose and galactose. (c) 1 mark each for the following:	5

	(i) Glucose is the preferred carbon source is consumed first while lactose induces the *lac* operon producing small levels of the *lac* proteins. (ii) In the absence of lactose, the repressor protein will continue binding to the operator of the *lac* operon preventing transcription of its genes.	
Q.84	1 mark each for the following: - The *lac* operon encodes for proteins required for the breakdown of lactose and hence needs to be produced when lactose is present in the cell. So here lactose acts as an inducer of gene expression. - The *trp* operon encodes for proteins required for tryptophan biosynthesis and hence is not required when tryptophan is present in the medium. So tryptophan acts as a repressor to prevent the expression of the *trp* operon genes. *[Accept any other valid answer]*	2
Q.85	1 mark each for the following: - Restriction digestion: DNA being very long, had to be broken into smaller pieces which could be done using restriction digestion. - rDNA technology: The small sequences of DNA had to be amplified for sequencing and since the sequence was not known, it had to be cloned in a suitable host using vectors for amplification. *[Accept any other valid answer.]*	2
Q.86	1 mark for each of the following: - Genes in eukaryotes generally have non-coding sequences called introns present between the coding sequences or exons. - The mRNA in eukaryotes is formed after post-transcriptional modifications such as intron splicing and the addition of a poly-A chain. - So, the cDNA formed from it will not have the intron sequence in the actual DNA sequence but just have the sequence of the exons.	3
Q.87	1 mark each for any two of the following: - RNA consists of ribose sugars where the hydroxyl group (-OH) is exposed to hydrolysis and degradation whereas DNA consists of deoxyribose sugars. - RNA is single-stranded whereas DNA is double-stranded with complementary bases forming hydrogen bonds that release free energy making it thermodynamically stable.	2

	- The double helix helps to keep the nucleotide bases away from reactive species that may exist in the cell's environment. *[Accept any other valid answer]*	
Q.88	1 mark each for the following: (a) Each codon codes for only one amino acid and so the amino acid sequence can be derived from an mRNA sequence, however, each amino acid is coded for by more than one codon and so each amino acid can be back-traced to one or more codons. (b) The DNA is transcribed into an mRNA sequence which is present in the nucleus whereas translation is done by ribosomes which are present in the cytoplasm or on the rough endoplasmic reticulum. (c) If splicing does not happen, the non-coding portions of the DNA/introns will also get translated disrupting the amino acid sequence of the intended protein. *[Accept any other valid answer]*	3
Q.89	(a) An agarose gel contains pores and DNA may not firmly attach on the gel. For hybridization and visualization, the DNA needs to be immobilised for which a nitrocellulose membrane is used. *[Accept any other valid answer]* (b) 0.5 marks each for the following: - positively charged - Since DNA is negatively charged, the positive charge on the membrane will help with easy binding. (c) 0.5 marks each for the following: - radioactive label - Since autoradiography is used, it can be concluded that the VNTR probe would be radioactively labelled.	3
Q.90	(a) 0.5 marks each for the following: - S3/woman is the murderer - The DNA profile of S3 has the greatest match/50% match with the DNA obtained on the crime scene. (b) 0.5 marks each for the following:	2

	- They could be non-identical twins. - Since their DNA profiles do not match completely with each other they are likely to be non-identical twins.	