EXERCISE QUESTIONS

CHAPTER-6 MOLECULAR BASIS OF INHERITANCE

1. Group the following as nitrogenous bases and nucleosides:

Adenine, Cytidine, Thymine, Guanosine, Uracil and Cytosine.

Ans -

Nitrogenous bases present in the list are adenine, thymine, uracil, and cytosine.

Nucleosides present in the list are cytidine and guanosine.

2. If a double stranded DNA has 20 per cent of cytosine, calculate the per cent of adenine in the DNA.

Ans - According to Chargaff's rule, the DNA molecule should have an equal ratio of pyrimidine (cytosine and thymine) and purine (adenine and guanine). It means that the number of adenine molecules is equal to thymine molecules and the number of guanine molecules is equal to cytosine molecules. % A = % T and % G = % C If DNA has 20% of cytosine, then according to the law, it would have 20% of guanine. Thus, percentage of G + C content = 40% The remaining 60% represents both A + T molecule. Since adenine and guanine are always present in equal numbers, the percentage of adenine molecule is 30%.

3. If the sequence of one strand of DNA is written as follows:

5' -ATGCATGCATGCATGCATGCATGCATGC-3'

Write down the sequence of complementary strand in 5'→3' direction.

Ans -

The DNA strands are complementary to each other with respect to base sequence. Hence, if the sequence of one strand of DNA is

5'- ATGCATGCATGCATGCATGCATGCATGC − 3’

Then, the sequence of complementary strand in direction will be

3'- TACGTACGTACGTACGTACGTACGTACG − 5’

Therefore, the sequence of nucleotides on DNA polypeptide in direction is

5'- GCATGCATGCATGCATGCATGCATGCAT− 3’

4. If the sequence of the coding strand in a transcription unit is written as follows:

5' -ATGCATGCATGCATGCATGCATGCATGC-3'

Write down the sequence of mRNA.

Ans - If the coding strand in a transcription unit is 5’− ATGCATGCATGCATGCATGCATGCATGC-3’ Then, the template strand in 3’ to 5’ direction would be 3’ − TACGTACGTACGTACGTACGTACGTACG-5’ It is known that the sequence of mRNA is same as the coding strand of DNA. However, in RNA, thymine is replaced by uracil. Hence, the sequence of mRNA will be 5’ − AUGCAUGCAUGCAUGCAUGCAUGCAUGC-3’

5. Which property of DNA double helix led Watson and Crick to hypothesise semi-conservative mode of DNA replication? Explain.

Ans - The nitrogenous bases form a complementary pair between the two polynucleotide chains of DNA was observed by Watson and Crick. Based on the X-ray diffraction data, they proposed that DNA consists of a double helix of two chains with nitrogen bases on the inside and sugar-phosphate on the outside. Then, they proposed that the two chains are antiparallel with 5'-3' orientation of the other. The appearance of the two chains is like that of a rope ladder twisted helically with rigid steps twisted into a spiral. This property of a double helix model of DNA led them to hypothesise the semiconservative model of DNA replication, where the two strands separate and act as a template for the synthesis of a new complementary strand, individually. Consequently, each daughter DNA molecule would have one parental strand and one newly synthesized daughter strand. As only one parental strand is conserved in each daughter molecule, it is called a "semi-conservative mode of replication".

6. Depending upon the chemical nature of the template (DNA or RNA) and the nature of nucleic acids synthesised from it (DNA or RNA), list the types of nucleic acid polymerases.

Ans - The list of the types of nucleic acid polymerases are as following:

(A) DNA-dependent DNA polymerase: It uses a DNA template to catalyze the polymerization deoxynucleotides for synthesising a new DNA strand.

(B) DNA-dependent RNA polymerase: It uses a DNA template strand for synthesising RNA.

7. How did Hershey and Chase differentiate between DNA and protein in their experiment while proving that DNA is the genetic material?

Ans - Alfred Hershey and Martha Chase in 1952 performed their experiments on bacteriophages. These are the viruses which infect bacteria. The bacteriophage infects the bacteria by entering the genetic material into the bacteria. The viral genetic material becomes a part of the bacterial cell which produces further viral particles. Aim of the experiment was to find out whether protein or DNA entered the bacteria. Virus particles were grown on medium containing radioactive sulfur and radioactive phosphorus as sulfur was the part of protein and phosphorus was the part of DNA. Procedure: The steps of the experiments are as following: Infection: The bacteriophage were made to infect the bacteria. Blending: The viral coats were removed by agitating in the blender. Centrifugation: The viral particles were separated from the bacteria by spinning in a centrifuge. Observation: It was observed that the bacteria contained radioactive phosphorus while the radioactive sulfur was found in the protein coat of the virus. Conclusion: It was concluded that it was DNA from the virus which entered the bacterial cells. Hence, it is the DNA which forms the genetic material and gets transferred from one generation to another.

8. Differentiate between the followings:

(a) Repetitive DNA and Satellite DNA

(b) mRNA and tRNA

(c) Template strand and Coding strand

Ans - (a) Repetitive DNA and satellite DNA

	Repetitive DNA	Satellite DNA
1.	Repetitive DNA are DNA sequences that contain small segments, which are	Satellite DNA are DNA sequences that contain highly

	repeated many times.	repetitive DNA.

(b) mRNA and tRNA

	mRNA	**tRNA**
1.	mRNA or messenger RNA acts as a template for the process of transcription.	tRNA or transfer RNA acts as an adaptor molecule that carries a specific amino acid to mRNA for the synthesis of polypeptide.
2.	It is a linear molecule.	It has clover leaf shape.

(c) Template strand and coding strand

	Template strand	**Coding strand**
1.	Template strand of DNA acts as a template for the synthesis of mRNA during transcription.	Coding strand is a sequence of DNA that has the same base sequence as that of mRNA (except thymine that is replaced by uracil in DNA).
2.	It runs from 3' to 5'.	It runs from 5'to 3'.

9. List two essential roles of ribosome during translation.

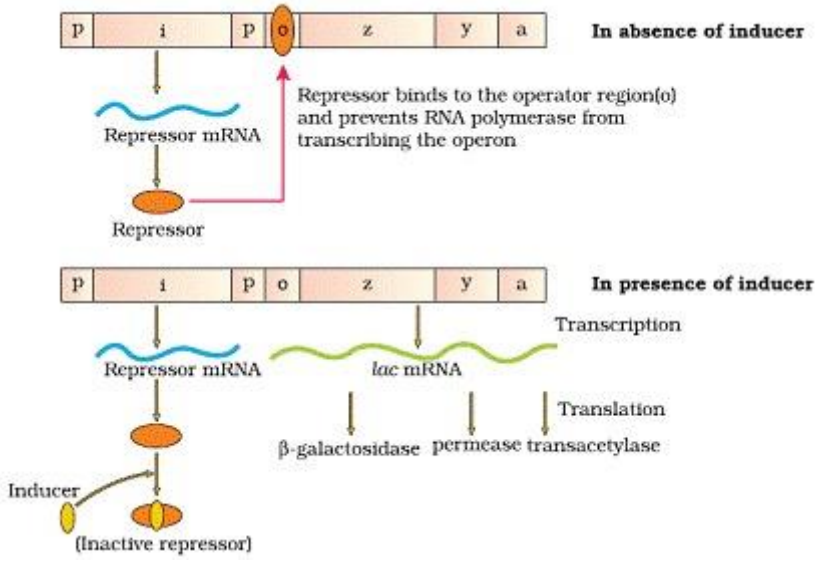
Ans - The important functions of ribosome during translation are as follows. Ribosome acts as the site where protein synthesis takes place from individual amino acids. It is made up of two subunits. The smaller subunit comes in contact with mRNA and forms a protein synthesizing complex whereas the larger subunit acts as an amino acid binding site. Ribosome

acts as a catalyst for forming peptide bond. For example, 23s r-RNA in bacteria acts as a ribozyme.

10. In the medium where E. coli was growing, lactose was added, which induced the lac operon. Then, why does lac operon shut down some time after addition of lactose in the medium?

Ans - Lac operon refers to a segment of DNA which consists of one regulatory gene (i) and three structural genes (y,z and a). Among the three structural genes, the z gene code for enzyme beta-galactosidase, that is responsible for the hydrolysis of the disaccharide lactose into its monomeric units, galactose and glucose. Gene y code for enzyme permease, which increases the permeability of the cell. The gene a encode for enzyme transacetylase. Lactose which is called the inducer is the substrate for enzyme beta-galactosidase and it regulates switching on and off of the operon. The regulatory gene, i code for the repressor of the lac operon. Lactose can bind to the repressor an inactivate it. When lactose is bound to the repressor, the RNA polymerase binds to the promoter of the lac operon. As a result of this, the transcription of three structural genes takes place and they form their respective enzymes. Further, these enzymes metabolize the lactose and lead to the formation of glucose and galactose. When the lactose metabolism is at its highest, the repressor protein is set free to bind with the operator gene. As

a result of this, the transcription of lac operon stops. Therefore, lac operon shut down sometime after addition of lactose in the medium.



11. Explain (in one or two lines) the function of the followings:

(a) Promoter

(b) tRNA

(c) Exons

Ans –

(a) Promoter Promoter is a region of DNA that helps in initiating the process of transcription. It serves as the binding site for RNA polymerase.

(b) tRNA tRNA or transfer RNA is a small RNA that reads the genetic code present on mRNA. It carries specific amino acid to mRNA on ribosome during translation of proteins.

(c) Exons Exons are coding sequences of DNA in eukaryotes that transcribe for proteins.

12. Why is the Human Genome project called a mega project?

Ans - Human genome project was considered to be a mega project because it had a specific goal to sequence every base pair present in the human genome. It took around 13 years for its completion and got accomplished in year 2006. It was a large scale project, which aimed at developing new technology and generating new information in the field of genomic studies. As a result of it, several new areas and avenues have opened up in the field of genetics, biotechnology, and medical sciences. It provided clues regarding the understanding of human biology.

13. What is DNA fingerprinting? Mention its application.

Ans - DNA Fingerprinting is a technique which is used to find out the variations in individuals of a population at the DNA level. It works on the principle of polymorphism in the DNA sequences.

The applications of DNA fingerprinting are as follows:

It used in establishing a connection in the family

It helps in solving disputes regarding paternity.

It is used in forensic science.

It helps in tracing the evolutionary relationship between the organisms.

14. Briefly describe the following:

(a) Transcription

(b) Polymorphism

(c) Translation

(d) Bioinformatics

Ans -(a**) Transcription** - Transcription is the process of synthesis of RNA from DNA template. A segment of DNA gets copied into mRNA during the process. The process of transcription starts at the promoter region of the template DNA and terminates at the terminator region. The segment of DNA between these two regions is known as transcription unit. The transcription requires RNA polymerase enzyme, a DNA template, four types of ribonucleotides, and certain cofactors such as Mg2+.

The three important events that occur during the process of transcription are as follows.

(i) Initiation (ii) Elongation (iii) Termination

The DNA-dependent RNA polymerase and certain initiation factors (σ) bind at the double stranded DNA at the promoter region of the template strand and initiate the process of transcription. RNA polymerase moves along the DNA and leads to the unwinding of DNA duplex into two separate strands. Then, one of the strands, called sense strand, acts as template for mRNA synthesis. The enzyme, RNA polymerase, utilizes nucleoside triphosphates (dNTPs) as raw material and polymerizes them to form mRNA according to the complementary bases present on the template DNA. This process of opening of helix and elongation of polynucleotide chain continues until the enzyme reaches the terminator region.

As RNA polymerase reaches the terminator region, the newly synthesized mRNA transcripted along with enzyme is released. Another factor called terminator factor (ρ) is required for the termination of the transcription.

(b**) Polymorphism** - Polymorphism is a form of genetic variation in which distinct nucleotide sequence can exist at a particular site in a DNA molecule.

This heritable mutation is observed at a high frequency in a population. It arises due to mutation either in somatic cell or in the germ cells. The germ cell mutation can be transmitted from parents to their offsprings. This results in accumulation of various mutations in a population, leading to variation and polymorphism in the population. This plays a very important role in the process of evolution and speciation.

(c) **Translation** - Translation is the process of polymerizing amino acid to form a polypeptide chain. The triplet sequence of base pairs in mRNA defines the order and sequence of amino acids in a polypeptide chain.

The process of translation involves three steps.

(i) Initiation (ii) Elongation (iii) Termination

During the initiation of the translation, tRNA gets charged when the amino acid binds to it using ATP. The start (initiation) codon (AUG) present on mRNA is recognized only by the charged tRNA. The ribosome acts as an actual site for the process of translation and contains two separate sites in a large subunit for the attachment of subsequent amino acids. The small subunit of ribosome binds to mRNA at the initiation codon (AUG) followed by the large subunit. Then, it initiates the process of translation. During the elongation process, the ribosome moves one codon downstream along with mRNA so as to leave the space for binding of another charged tRNA. The amino acid brought by tRNA gets linked with the previous amino acid through a peptide bond and this process continues resulting in the formation of a polypeptide chain. When the ribosome reaches one or more STOP codon (VAA, UAG, and UGA), the process of translation gets terminated. The polypeptide chain is released and the ribosomes get detached from mRNA.

(d) **Bioinformatics** - Bioinformatics is the application of computational and statistical techniques to the field of molecular biology. It solves the practical problems arising from the management and analysis of biological data. The field of bioinformatics developed after the completion of human genome project (HGP).

This is because enormous amount of data has been generated during the process of HGP that has to be managed and stored for easy access and interpretation for future use by various scientists. Hence, bioinformatics involves the creation of biological databases that store the vast information of biology. It develops certain tools for easy and efficient access to the information and its utilization. Bioinformatics has developed new algorithms and statistical methods to find out the relationship between the data, to predict protein structure and their functions, and to cluster the protein sequences into their related families.