CHAPTER

5

MOLECULAR BASIS OF INHERITANCE

CLASS 12TH

NCERT EXERCISE AND SOLUTIONS - BIOLOGY

Q. 1. **Group the following as nitrogenous bases and nucleosides: Adenine, Cytidine, Thymine, Guanosine, Uracil and Cytosine.**

ANSWER:-

Nitrogenous base: Adenine, Thymine, Uracil, Cytosine

Nucleosides: Cytidine, Guanosine

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

ANSWER:-

According to Chargaff's rule, DNA molecules must maintain an equal ratio of purines (adenine and guanine) to pyrimidines (cytosine and thymine). In other words, the number of adenine molecules is equal to the number of thymine molecules, and the number of guanine molecules is equal to the number of cytosine molecules.

- Percentage of adenine = percentage of thymine
- Percentage of guanine = percentage of cytosine

Cytosine = Guanine = 20%

Adenine + Thymine + Cytosine + Guanine = 100%

Adenine + Thymine = 100-40 = 60%

Adenine = Thymine = 30%

Q. 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.

ANSWER:-

DNA strands are complementary to each other in terms of their base sequences. For example, if one strand of DNA has the sequence: 5′ -ATGCATGCATGCATGCATGCATGCATGC-3′

The complementary strand in the 3′ --> 5′ direction would be:

3′ – TACGTACGTACGTACGTACGTACGTACG – 5′

Then, the sequence of the complementary strand in the 5′ -⟶ 3′ direction is:
5′ – GCATGCATGCATGCATGCATGCATGCAT – 3′

Q. 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.

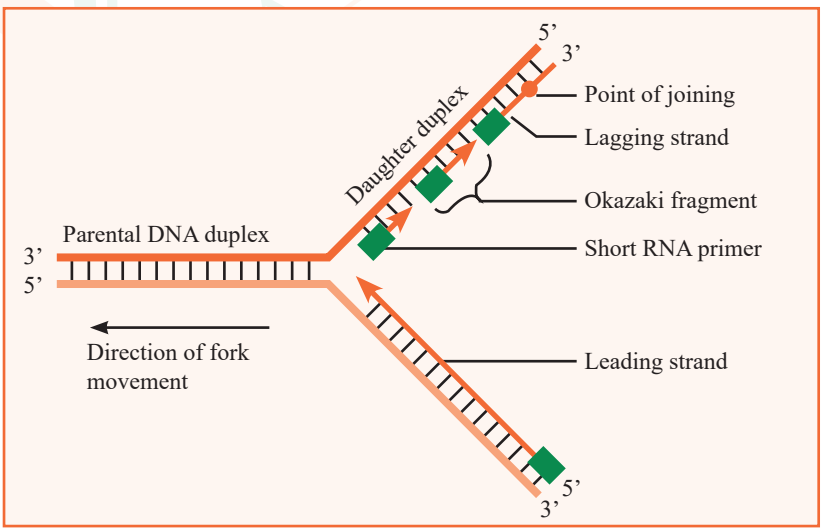
ANSWER:-

In a transcription unit, if the coding strand has the sequence:
5′ -ATGCATGCATGCATGCATGCATGCATGC-3′
The sequence of mRNA, which codes for the same information but with uracil replacing thymine, would be:
5′ -AUGCAUGCAUGCAUGCAUGCAUGCAUGC-3′

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

ANSWER:-

Watson and Crick observed that the two DNA strands are anti-parallel and complementary to each other in terms of their base sequences, allowing each strand to act as a template for synthesizing a new strand. This structure of the DNA molecule supported the idea that DNA replication is semi-conservative. In this process, the double-stranded DNA molecule splits, and each separated strand serves as a template to produce a new complementary strand. As a result, each DNA molecule consists of one parental strand and one newly synthesized daughter strand. Since one parental strand is retained in each daughter molecule, this type of replication is called semi-conservative.



The sequence of bases in the template strand determines the sequence of bases in the daughter strand through complementary base pairing. This characteristic of DNA led Watson and Crick to propose the semi-conservative model of replication.

Q. 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.

ANSWER:-

The list includes four types of nucleic acid polymerases:

- DNA-dependent DNA polymerases
- DNA-dependent RNA polymerases
- RNA-dependent DNA polymerases
- RNA-dependent RNA polymerases

DNA-dependent DNA polymerases use a DNA template to synthesize a new DNA strand, while DNA-dependent RNA polymerases use a DNA template to synthesize RNA.

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

ANSWER:-

- To demonstrate that DNA is the genetic material, Hershey and Chase conducted experiments with bacteriophages and *E. coli*.
- They used different radioactive isotopes to label the protein coat and DNA of the bacteriophage. Bacteriophages were cultivated in a medium containing radioactive phosphorus (32P) to label DNA and in a medium with radioactive sulphur (35S) to label protein. These labelled bacteriophages were then used to infect *E. coli* bacteria. After infection, the protein coat of the bacteriophage was separated from the bacterial cells by mixing and centrifuging.
- It was observed that, in the supernatant, the lighter protein coat remained, while the infected bacteria settled at the bottom of the centrifuge tube.
- In the first case, the supernatant was radioactive, indicating that the protein coat did not enter the bacterial cell. However, in the second case, the bacterial cells were radioactive, showing that they contained radioactive DNA.
- This experiment provided evidence that DNA is the genetic material, as it was transferred from the virus to the bacteria.

Q. 8. Differentiate between the followings:
(a) Repetitive DNA and Satellite DNA
(b) mRNA and tRNA
(c) Template strand and Coding strand

ANSWER:-

(a) Repetitive DNA and Satelite DNA

Repetitive DNA	Satellite DNA
Consists of DNA sequences with small segments repeated multiple times	A type of repetitive DNA that contains highly repetitive sequences
Varies in length from several base pairs to hundreds or thousands	Shorter in length, typically around a hundred base pairs long

Can be separated from bulk DNA by density gradient centrifugation, resulting in light bands	Can be separated from bulk DNA by density gradient centrifugation, forming dark bands and small peaks

(b) mRNA and tRNA

mRNA	tRNA
Messenger RNA acts as a template for the transcription process	Transfer RNA functions as an adaptor molecule, carrying a specific amino acid to the mRNA for polypeptide synthesis
mRNA is a linear molecule	tRNA has a cloverleaf-like structure
mRNA attaches only to the ribosome	tRNA attaches at one end to the ribosome and at the other end to an amino acid

(c) Template strand and Coding strand

Template Strand	Coding Strand
Acts as a template for mRNA synthesis during transcription	Serves as the complementary strand to the template strand
Contains a sequence that is complementary to the mRNA	Contains a sequence identical to the mRNA, except that thymine in DNA is replaced by uracil in mRNA
The template strand runs from 3′ to 5′	The coding strand runs from 5′ to 3′

Q. 9. List two essential roles of ribosome during translation.

ANSWER:-

Two key functions of the ribosome during translation are:

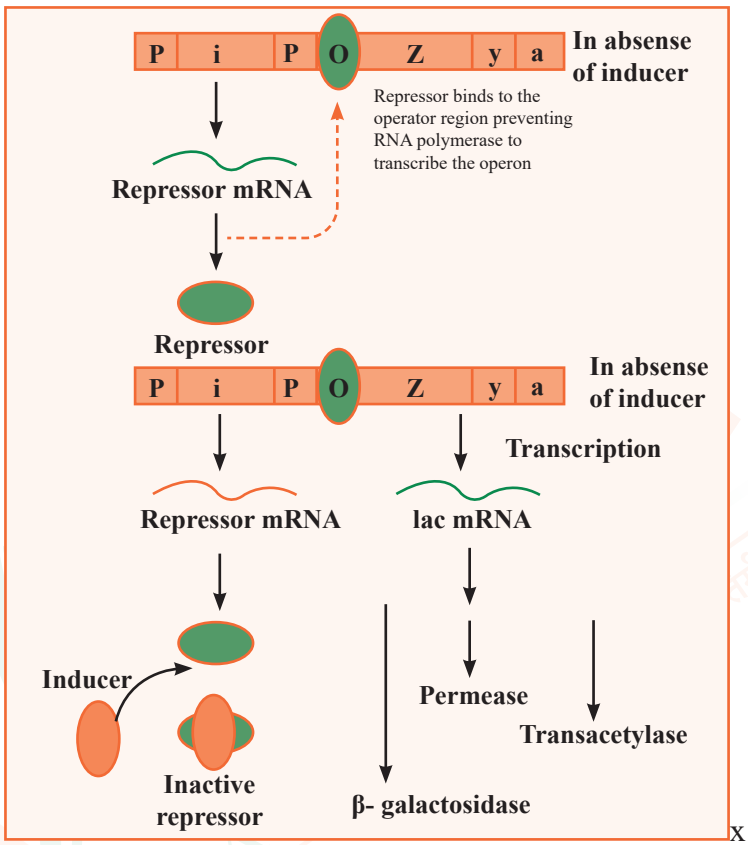
- Ribosomes are the sites where proteins are synthesized from individual amino acids. They consist of two subunits—the larger subunit serves as the amino acid binding site, while the smaller subunit binds to the mRNA, forming the protein-synthesizing complex.
- The large subunit of the ribosome has two distinct sites for tRNA attachment, allowing amino acids to be brought closer together for peptide bond formation. Additionally, the ribosome acts as a catalyst for the formation of the peptide bond. For instance, 23S rRNA functions as a ribozyme in bacteria.

Q. 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?

ANSWER:-

- A lac operon is a segment of DNA that includes three adjacent structural genes: a promoter gene, an operator gene, and a regulator gene. It functions in a coordinated manner to metabolize lactose into galactose and glucose.
- In the lac operon, lactose acts as an inducer by binding to the repressor and inactivating it. When lactose binds to the repressor, RNA polymerase can then attach to the promoter region.

- This allows the structural genes to be expressed, resulting in the production of the corresponding enzymes that metabolize lactose into galactose and glucose. As the enzymes metabolize the lactose, the inducer level decreases, leading to the synthesis of the repressor from the regulator gene.
- The repressor then binds to the operator gene, preventing RNA polymerase from transcribing the operon and stopping transcription. This type of regulation is known as negative regulation.



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

(a) Promoter

(b) tRNA

(c) Exons

ANSWER:-

(a) Promoter: The promoter is a region of DNA that helps initiate the transcription process by serving as the binding site for RNA polymerase.

(b) tRNA: Transfer RNA (tRNA) is a small, cloverleaf-shaped RNA molecule that interprets the genetic code on mRNA. It transports specific amino acids to the mRNA-ribosome complex during protein translation. Each tRNA is specific to a particular amino acid.

(c) Exons: Exons are the coding regions of DNA in eukaryotes that encode proteins. These coding sequences are interrupted by non-coding regions known as introns.

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

ANSWER:-

- The Human Genome Project was a monumental undertaking due to its vast scale and ambitious goals.
- Its objective was to sequence every base pair in the human genome, a task that took approximately 13 years to complete and was finished in 2003.
- The project aimed to develop new technologies and generate valuable insights in genomic research.
- As a result, it opened numerous possibilities in fields such as biotechnology, genetics, and medical sciences, advancing our understanding of various aspects of human biology.

Q. 13. What is DNA fingerprinting? Mention its application.

ANSWER:-

DNA fingerprinting is a technique used to identify and analyze genetic variations between individuals at the DNA level. It relies on the principles of DNA sequence variability and polymorphism.

Its applications include:

- Identifying potential crime suspects in forensic science
- Establishing familial and paternity relationships
- Identifying and preserving commercial varieties of livestock and crops
- Exploring the evolutionary history of organisms, helping trace connections between different species.

Q. 14. Briefly describe the following:

(a) Transcription
(b) Polymorphism
(c) Translation
(d) Bioinformatics

ANSWER:-

(a) **Transcription:** Transcription is the process in which an RNA molecule is synthesized from a DNA template. During this process, RNA polymerase binds to the promoter region of a gene, unwinds the DNA, and synthesizes a complementary RNA strand. This RNA strand, known as messenger RNA (mRNA), carries the genetic information from the DNA to the ribosome for protein synthesis.

(b) **Polymorphism:** Polymorphism refers to the occurrence of two or more different alleles or genetic variations at a particular locus in a population. It can involve changes in DNA sequence, and these variations can be used to study genetic diversity, identify individuals, or assess the risk for certain diseases.

(c) **Translation:** Translation is the process by which the mRNA sequence is decoded to synthesize a specific protein. It occurs in the ribosome, where tRNA molecules bring amino acids corresponding to the codons on the mRNA. The amino acids are linked together to form a polypeptide chain, which then folds into a functional protein.

(d) **Bioinformatics:** Bioinformatics is the field of science that combines biology, computer science, and information technology to analyse and interpret biological data, particularly genetic sequences. It involves the use of software tools, databases, and algorithms to manage and analyse large-scale biological data, aiding in research areas such as genomics, proteomics, and systems biology.