UNIT – VII : GENETICS AND EVOLUTION

Term-I

MOLECULAR BASIS OF INHERITANCE

Syllabus

➢ *Search for genetic material and DNA as genetic material; Structure of DNA and RNA; DNA packaging; DNA replication; Central dogma; transcription, genetic code, translation; gene expression and regulation—lac operon; genome and human and genome projects; DNA fingerprinting.*

STAND ALONE MCQs (1 Mark each)

Q. 1. In a DNA strand, the nucleotides are linked together by

(A) glycosidic bonds

(B) phosphodiester bonds

(C) peptide bonds

(D) hydrogen bonds R

Ans. Option (B) is correct.

Explanation : In a DNA strand, the nucleotides are linked together by 3′–5′ phosphodiester linkage (bonds) to form a dinucleotide. More nucleotides can be joined in such a manner to form a polynucleotide chain.

Q. 2. A nucleoside differs from a nucleotide. It lacks the

(A) base **(B)** sugar

(C) phosphate group **(D)** hydroxyl group U

Ans. Option (C) is correct.

Explanation : A nitrogenous base is attached to the pentose sugar by an N-glycosidic linkage to form a nucleoside, that is, Nucleoside = Nitrogen base + Pentose sugar When a phosphate group is attached to the 5′-OH of a nucleoside through phosphodiester linkage, a nucleotide is formed, that is, Nucleotide = Nitrogen base + Pentose sugar + Phosphate (PO_4). So, a nucleoside differs from a nucleotide as it lacks the phosphate group.

Q. 3. Both deoxyribose and ribose belong to a class of sugars called

(A) trioses **(B)** hexoses

(C) pentoses **(D)** polysaccharides R

Ans. Option (C) is correct.

Explanation : Both deoxyribose and ribose belongs to the class pentoses as it contains '5' carbon atoms.

Q. 4. The fact that a purine base always paired through hydrogen bonds with a pyrimidine base leads to, in the DNA double helix

(A) the antiparallel nature

(B) the semi-conservative nature

(C) uniform width throughout DNA

(D) uniform length in all DNA R

Ans. Option (C) is correct.

Explanation : The diameter of the strand is always constant due to a pairing of purine (adenine and guanine) and pyrimidine (cytosine and thymine). This specific bonding gives uniform width to the DNA.

Q. 5. The net electric charge on DNA and histones is

(A) both positive

(B) both negative

(C) negative and positive, respectively

(D) zero R

Ans. Option (C) is correct.

Explanation : DNA consists of a nitrogenous base, pentose sugar and a phosphate group. DNA has negative charge due to the presence of phosphate group. Histones are rich in the basic amino acids lysine and arginine, which carry positive charges in their side chains. Therefore, histones are positively charged.

Q. 6. The first genetic material could be

(A) protein **(B)** carbohydrates

(C) DNA **(D)** RNA R

Ans. Option(D) is correct.

Explanation : RNA was the first genetic material. There is now enough evidence to suggest that essential life processes (e.g., metabolism, translation and splicing), evolved from RNA. RNA is used to act as a genetic material as well as a catalyst (there are some important biochemical reactions in living systems that are catalysed by RNA catalysts and not by protein enzymes). But, RNA being a catalyst was reactive and hence unstable. Therefore, DNA has evolved from RNA with chemical modifications that make it more stable. DNA being double-stranded and having complementary strand, further resists changes by evolving a process of repair.

Q. 7. With regard to mature mRNA in eukaryotes

(A) exons and introns do not appear in the mature RNA.

(B) exons appear, but introns do not appear in the mature RNA.

(C) introns appear but exons do not appear in the mature RNA.

(D) both exons and introns appear in the mature RNA. R

Ans. Option (B) is correct.

Explanation : In eukaryotes, the mono-cistronic structural genes have interrupted coding sequences, that is, the genes in eukaryotes are split. The coding sequences or expressed sequences are defined as exons. These sequences (exons) appear in mature or processed RNA, thus exons are interrupted by introns or intervening sequences which do not appear in mature or processed RNA.

Q. 8. Which of the following are the functions of RNA?

(A) It is a carrier of genetic information from DNA to ribosomes synthesising polypeptides.

(B) It carries amino acids to ribosomes.

(C) It is a constituent component of ribosomes.

(D) All of the above R

Ans. Option (D) is correct.

Explanation : Ribosomal RNA (rRNA), messenger RNA (mRNA) and transfer RNA (tRNA) are major classes of RNAs that are involved in gene expression. rRNAs bind protein molecules and give rise to ribosomes. mRNA carries coded information for translation into polypeptide formation. rRNA is also called soluble or adaptor RNA and carries amino acids to mRNA during protein synthesis.

Q. 9. While analysing the DNA of an organism a total number of 5,386 nucleotides were found out of which the proportion of different bases were : Adenine = 29%, Guanine = 17%, Cytosine = 32% and Thymine = 17%. Considering the Chargaff's rule, it can be concluded that

(A) it is a double-stranded circular DNA.

(B) it is single-stranded DNA.

(C) it is a double-stranded linear DNA.

(D) no conclusion can be drawn. A

Ans. Option (B) is correct.

Explanation : According to Chargaff's rules of base pairing, (i) The amount of adenine is always equal to the amount of thymine and the amount of guanine is always equal to the amount of cytosine. (ii) Adenine is joined to thymine with two hydrogen bonds and guanine is joined to cytosine by three hydrogen bonds. (iii) The ratio of adenine to thymine and that of guanine to cytosine is always equal to one, that is., AG : TC = 1 . In the given organism, the DNA is not following the Chargaff's rule, hence it can be concluded that it is a single-stranded DNA, not double-stranded.

Q. 10. If the sequence of nitrogen bases of the coding strand of DNA in a transcription unit is : 5'-ATGAATG-3', the sequence of bases in its RNA transcript would be

(A) 5'-AUGAAUG-3' **(B)** 5'-UACUUAC-3'

(C) 5'-CAUUCAU-3' **(D)** 5'-GUAAGUA-3' A

Ans. Option (A) is correct.

Explanation : 5'-ATGAATG-3' (coding strand) 5'-TACTTAC-3' (complementary strand) 5'-AUGAAUG-3' (RNA)

Q. 11. One of the following is true with respect to AUG.

(A) It codes for methionine only.

(B) It is also an initiation codon.

(C) It codes for methionine in both prokaryotes and eukaryotes.

(D) All of the above R

Ans. Option (D) is correct.

Explanation : Polypeptide synthesis is signalled by two initiation codons - commonly AUG or methionine codon and rarely GUG or valine codon. AUG serves two main functions. It signals the start of translation and codes for the incorporation of the methionine into the growing polypeptide chain. AUG codes for methionine in both prokaryotes and eukaryotes.

Q. 12. The promoter site and the terminator site for transcription are located at

(A) 3′ (downstream) end and 5′ (upstream) end, respectively of the transcription unit.

(B) 5′ (upstream) end and 3′ (downstream) end, respectively of the transcription unit.

(C) the 5′ (upstream) end.

(D) the 3′ (downstream) end. R

Ans. Option(B) is correct.

Explanation : The promoter site and the terminator site for transcription are located at 5' (upstream) end and 3' (downstream) end, respectively of the transcription unit. The promoter is the binding site for RNA polymerase for initiation of transcription.

Q. 13. Which of the following steps in transcription is catalysed by RNA polymerse?

(A) Initiation (B) Elongation

(C) Termination (D) All of the above R

Ans. Option(B) is correct.

Explanation : The DNA-dependent RNA polymerase helps in transcription by catalysing the polymerisation in only one direction (i.e., 5'-3').

Q. 14. In some viruses, DNA is synthesised by using RNA as template. Such a DNA is called

(A) A-DNA (B) B-DNA

(C) cDNA (D) rDNA R

Ans. Option (C) is correct.

Explanation : In some viruses, like retro-viruses (e.g., HIV), an enzyme called reverse transcriptase is used to generate complementary DNA (cDNA) from an RNA template. This process is termed reverse transcription.

Q. 15. To initiate translation, the mRNA first binds to

(A) the smaller ribosomal sub-unit.

(B) the larger ribosomal sub-unit.

(C) the whole ribosome.

(D) No such specificity exists. R

Ans. Option (A) is correct.

Explanation : The ribosome consists of structural RNAs and about 80 different proteins. In its inactive state, it exists as two subunits, a large subunit and a small subunit. When the smaller subunit encounters the mRNA, the process of translation of the mRNA to protein begins.

Q. 16. Control of gene expression takes place at the level of

(A) DNA-replication (B) transcription

(C) translation (D) None of the above R

Ans. Option(B) is correct.

Explanation : Gene expression, which results in the formation of a polypeptide, can be regulated at several levels. In eukaryotes, the regulation occurs at transcriptional level (formation of primary transcript), processing level (regulation of splicing), and transport of mRNA from nucleus to the cytoplasm, and translational level. While in prokaryotes, control of the rate of transcriptional initiation is the predominant site for control of gene expression.

Q. 17. Regulatory proteins are the accessory proteins that interact with RNA polymerase and affect its role in transcription. Which of the following statements is correct about regulatory protein?

(A) They only increase expression.

(B) They only decrease expression.

(C) They interact with RNA polymerase, but do not affect the expression.

(D) They can act both as activators and as repressors.

Ans. Option (D) is correct.

Explanation : Regulatory proteins, the accessory proteins that interact with RNA polymerase and affect its role in transcription. It controls the functions of structural genes and are called regulatory genes. Promoters, terminators, operators and repressor are some important regulatory genes. They can act both as activators and as repressors.

Q. 18. The RNA polymerase holoenzyme transcribes

(A) the promoter, structural gene and the terminator region.

(B) the promoter and the terminator gene.

(C) the structural gene and the terminator regions.

(D) the structural gene only. R

Ans. Option (C) is correct.

Explanation : The RNA polymerase holo-enzyme transcribes the structural gene and the terminator regions. RNA polymerase consists of a number of sub-units, including a sigma factor (transcription factor) that catalyses the process of transcription. It recognises the start signals or promoter region on DNA which then along with RNA polymerase binds to promoter to initiate the transcription. In eukaryotes there are three RNA polymerases : I, II and III. The process includes a proof-reading mechanism.

Q. 19. Which one of the following pairs of codons is correctly matched with their function or the signal for the particular amino acid ?

(A) GUU, GCU – Alanine

(B) UAG, UGA – stop

(C) AUG, ACG – Start/methionine

(D) UUA, UCA – Leucine U

Ans. Option (B) is correct.

Explanation : Three codons UAG, UAA and UGA are the stop or termination codons.

Q. 20. Which one of the following is not a part of transcription unit in DNA ?

(A) The inducer (B) A terminator

(C) A promoter (D) The structural gene

R

Ans. Option (A) is correct.

Explanation : The segment of DNA that takes part in transcription is called transcription unit. It has three components (i) a promoter (ii) the structural gene and (iii) a terminator.

ASSERTION AND REASON BASED MCQs (1 Mark each)

Directions : In the following questions a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as :

(A) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).

(B) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).

(C) Assertion (A) is true but reason (R) is false.

(D) Assertion (A) is false but reason (R) is true.

AI **Q. 1. Assertion (A) :** In RNA uracil is present at the place of thymine.

Reason (R) : 5-methyl uracil is chemical name of thymine.

Ans. Option (B) is correct.

> ***Explanation :*** Both assertion (A) and reason (R) are true. Since the half-life of the RNA molecules i shorter uracil would suffice to achieve the function of RNA. On the other hand, DNA remains same until cell dies/divides. The functions of thymine and uracil are the same.

Q. 2. Assertion (A) : Chargaff's rule is applicable to RNA.

Reason (R) : RNA contains deoxyribose sugar in them.

Ans. Option (D) is correct.

> ***Explanation :*** According to Chargaff's is rule the DNA helix contain equal molar ratio of A & T, G & C.... . This does not apply to RNA, as uracil is present in RNA instead of DNA. RNA contains ribose sugar in them.

AI **Q. 3. Assertion (A) :** The enzyme involved in the continuous replication of DNA strand is DNA polymerase .

Reason (R) : The polarity of the template strand is 3'→5'.

Ans. Option (C) is correct.

> ***Explanation :*** DNA polymerase enzyme is responsible for synthesizing DNA, they add nucleotides one by one to the growing DNA chain, adding those which are complementary to the template. The template strand has polarity in 3'→5'.

Q. 4. Assertion (A) : Primary transcripts in eukaryotes are non-functional.

Reason (R) : Methyl guanosine triphosphate is attached to 5′ – end of hnRNA. **(CBSE SQP 2020)**

Ans. Option (B) is correct.

> ***Explanation :*** Primary transcripts contains both introns and exon, in which introns are non-coding parts.

Q. 5. Assertion (A) : In Griffith's experiment, the dead R strain bacteria was capable of causing the transformation of the live S-strain bacteria.

Reason(R) : The S-strain is non-virulent strain.

Ans. Option (D) is correct.

> ***Explanation :*** It was concluded by the transforming principle', that bacteria is transferred from heat killed S-strain to live R-strain which is non virulent.

Q. 6. Assertion (A) : Termination codons or stop codons are UAA, UAG and UGA.

Reason (R) : Stop codons represent termination of translation.

Ans. Option (A) is correct.

> ***Explanation :*** Both assertion and reason are true. stop codons are also known as non-sense codons or termination codons as they do not code for an amino acid. If they are not present, then protein synthesis will continue and result in defective protein.

Q. 7. Assertion (A) : Aminoacylation is an essential step for the synthesis of protein.

Reason (R) : It is the process of adding an activated amino acid to the acceptor arm of a transfer RNA.

Ans. Option (A) is correct.

> ***Explanation :*** Both assertion and reason are true and reason (R) is the correct explanation of the assertion (A). This attachment is an essential step in the synthesis of protein. This attachment is brought by aminoacyl-t-RNA synthetase.

Q. 8. Assertion (A) : Genetic codes are commaless.

Reason (R) : Genetic codes are overlapping.

Ans. Option (C) is correct.

> ***Explanation :*** Genetic codes are commaless, but they are not overlapping as no single base take part in the formation of more than one codon, therefore they are non-overlapping.

Q. 9. Assertion (A) : The newly formed mRNA has same sequence as the coding strand of transcriptional unit with uracil present at place of thymine.

Reason (R) : The rule of complementarity guides the formation of DNA and RNA.

Ans. Option (A) is correct.

> ***Explanation :*** The sequence of mRNA will be identical to the given sequence of coding strand except for the presence of uracil in place of thymine in mRNA.

Q. 10. Assertion (A) : DNA fingerprinting is applied in paternity testing in case of disputes.

Reason(R) : It employs the principle of polymorphism in DNA sequences as polymorphisms are inheritable from parent to children.

Ans. Option (B) is correct.

> ***Explanation :*** DNA fingerprinting involves identifying differences in some specific regions in DNA sequence called as respective DNA, because in these sequences, a small stretch of DNA is repeated many times. These sequences normally do not code for any proteins, but they form a large portion of human genome. These sequence show high degree of polymorphism and form the basis of DNA fingerprinting. As the polymorphisms are inheritable from parents to children, DNA fingerprinting is the basis of paternity testing in case of disputes.

CASE-BASED MCQs

Attempt any four sub-parts from each question. Each sub-part carries 1 mark.

I. Read the following and answer the question Q.1 to Q.S. given below:

The lac operon consists of a regulation gene and three structural gene. The lactose acts as inducer. In the presence of an Inducer such as lactose, the repressor is in inactivated during the interaction. This allows RNA polymerase access to the promoter and transcription proceeds. The repressor is synthesized which in turn binds with the operator region of the operon and prevents RNA polymerase from transcribing the operon.

Q.1. When the process of Lac operon is blocked by a repressor it represents :

(A) Positive regulation

(B) Negative regulation

(C) sometimes positive sometimes negative

(D) both positive and negative regulation

Ans. Option (B) is correct.

> ***Explanation :*** The lac operon regulation can be in both negative and positive ways. It is a negative control system because expression is typically blocked by an active repressor (the lac repressor) that turns off transcription. And when CAP (catabolite gene activating protein) binds upstream of this operator region near the promoter and transcription increases, this is an example of a positive system.

Q.2. Identify the correct sequence of the structural genes in the lac operon.

(A) lacA-lacZ-lacY **(B)** lacZ-lacA-lacY

(C) lacZ-lacY-lacA **(D)** lacA-lacY-lacZ

Ans. Option (C) is correct.

> ***Explanation :*** The lac operon consists of 3 structural genes, and a promoter, a terminator, regulator, and an operator. The three structural genes are: lacZ, lacY, and lacA.

Q.3. Which of the following statement is true in reference to the lac operon process in *E.coli*?

(i) Galactosidase is the only enzyme produced in large quantities when lac operon is turned on

(ii) The messenger RNA in lac operon is a polycistronic mRNA

(A) Only i is correct

(B) Only ii is correct

(C) Both (i) and (ii) are correct

(D) None of them are correct

Ans. Option (B) is correct.

> ***Explanation :*** The messenger RNA produced by transcription carries information for the synthesis of all three proteins found in all three structural genes. Hence, it is a polycistronic messenger RNA.

Q.4. What provides binding site to RNA polymerase?

(A) Exons **(B)** Promoter

(C) Inducer **(D)** Repressor

Ans. Option (B) is correct.

> ***Explanation :*** Promoter helps in starting the process of transcription and provides a binding site to RNA polymerase.

Q.5. The lac operon of E. coli contains genes involved in lactose metabolism. It's expressed only when lactose is_____(1) and glucose is _____(2).

(A) 1: Present, 2: Absent

(B) 1: Absent, 2: Present

(C) 1: More, 2: less

(D) 1: repressed, 2: promoted

Ans. Option (A) is correct.

> ***Explanation :*** The lac operon of E. coli contains genes involved in lactose metabolism. It's expressed only when lactose is present and glucose is absent.

II. Read the following text and answer the following questions on the basis of the same :

DNA, a long polymer of deoxyribonucleotide. Altmann and these substances to be acidic hence he named nucleic acid. The basic unit of DNA is a nucleotide which has three components—a nitrogenous base, a pentose sugar (deoxyribose) and a phosphate group. There are two types of nitrogenous bases in DNA, Purine and Pyrimidine. J. Watson and F. Crick proposed a double helix model for the structure of DNA. There are four types of DNA *i.e.,* A, B, C, Z.

Q. 1. Which DNA form has maximum number of base pairs per turn ?

(A) A-DNA **(B)** B-DNA

(C) C-DNA **(D)** Z-DNA.

Ans. Option (D) is correct.

> ***Explanation :*** Z DNA is the zigzag DNA that has maximum number of base pairs per turn. It is left-handed helix. There are 12 base pair per turn, with a rise of 0.38 nm per base pair.

Q. 2. Which among the following does not confer stability to the helical structure of DNA ?

(A) Phosphodiester bond **(B)** H-bond

(C) N-glycosidic linakge **(D)** All of these.

Ans. Option (C) is correct.

> ***Explanation :*** N-glycosidic linkage in DNA, is the nitrogen carbon linkage between the nitrogen of purine or pyrimidine bases and the carbon of the sugar group. This bond does not provide stability.

Q. 3. Cytidine is a :

(A) Nucleoside

(B) Nitrogen base

(C) Nucleotide

(D) Common dinucleotide in DNA and RNA.

Ans. Option (A) is correct.

> ***Explanation :*** Cytosine (C) is a pyrimidine i.e., a nitrogenous base. A combination of a nitrogenous base (purine or pyrimidine) with a pentose sugar is known as nucleoside. Thus, the combination of cytosine with ribose sugar results in the formation of a nucleoside called as cytidine.

Q. 4. Heaviest molecule of protoplasm is :

(A) Lipids **(B)** Proteins

(C) DNA **(D)** RNA.

Ans. Option (C) is correct.

> ***Explanation :*** The heaviest molecule in the protoplasm is DNA. DNA is a compound of very high molecular weight (over one million), it has a giant molecule made of smaller molecules linked together, but its molecular weight is variable.

Q. 5. Phosphoric acid is found in :

(A) Nucleic acids **(B)** NAD and FAD

(C) Phosphoprotein **(D)** All of these.

Ans. Option (D) is correct.

> ***Explanation :*** Phosphoric acid. H_3PO_4 provides the unit that holds the various segments of the nucleic acid chain to each other. It is present in all the three i;e: Nucleic acids; NAD and FAD; Phosphoprotein.

III. The DNA replication is semi-conservative is proved by an experiment conducted by Meselson and Stahl in 1958. To perform their experiment they use heavy nitrogen (^{15}N) in *E. coli*. The process of replication in living cells requires a set of enzymes. The main enzyme is DNA dependent DNA polymerase. The DNA-A dependent DNA polymerase catalyse polymerization only in one direction, that is 5→3'. In eukaryotes, the replication of DNA takes place at the S-phase of the cell cycle.

Q. 1. Viruses grown in the presence of radioactive phosphorus contained radioactive _____ but not radioactive _____ .

(A) DNA, protein **(B)** Protein, DNA

(C) RNA, Nucleoside **(D)** mRNA, Protein

Ans. Option (A) is correct.

> ***Explanation :*** DNA is the genetic material came from the experiments of Hershey and Chase (1952). They worked with viruses that infect bacteria called bacteriophages. They worked to discover whether it was protein or DNA from the virus that entered the bacteria. They grew some viruses on a medium that contained radioactive phosphorus and some others on a medium that contained sulfur. Viruses grown in the presence of radioactive phosphorus contained radioactive DNA but not radioactive protein because DNA contains phosphorus but protein does not. Similarly, viruses grown on radioactive sulfur contained radioactive protein but not radioactive DNA because DNA does not contain sulphur.

Q. 2. During DNA replication, the breaking of H-bonds is performed by :

(A) Topoisomerase **(B)** Gyrase

(C) Helicases **(D)** None.

Ans. Option (C) is correct.

> ***Explanation :*** DNA replication starts with unwinding of DNA duplexes which are held together by hydrogen bond. Helicases move along the double stranded DNA and separate the strands by breaking hydrogen bonds between base pairs.

Q. 3. How many types of DNA polymerases are associated with eukaryotic cell ?

(A) Three **(B)** Six

(C) Five **(D)** One.

Ans. Option (C) is correct.

> ***Explanation :*** 5 types of DNA polymerases are associated with eukaryotic cell.

Q. 4. DNA replication is :

(A) Semi-conservative, continuous

(B) Semi-continuous, conservative

(C) Semi-conservative, semi-discontinuous

(D) Conservative.

Ans. Option (C) is correct.

Explanation : DNA replication is said to be semi-conservative because of the process of replication, where the resulting double helix is composed of both an old strand and a new strand. ... The two resulting double helices, which each contain one "old" strand and one "new" strand of DNA, are identical to the initial double helix.
Due to this reason, replication occurs continuously on one strand and discontinuously on the other strand. This is known as the semi-discontinuous mode of replication. Every new DNA molecule that is formed has a new and an old strand of the DNA. Thus, during DNA replication, entirely new DNA copies are not generated.

Directions : In the following questions a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as :

(A) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).

(B) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).

(C) Assertion (A) is true but reason (R) is false.

(D) Assertion (A) is false but reason (R) is true.

Q. 5. Assertion (A) : Teminism is bidirectional flow of information.

Reason (R) : It requires DNA dependent RNA polymerase enzyme.

Ans. Option (C) is correct.

Explanation : Teminism is popularly known as reverse transcription, *i.e.,* DNA can be synthesized by RNA.