

# MOLECULAR BASIS OF INHERITANCE

## STUDY-NOTES

### NUCLEIC ACIDS

Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are the two types of nucleic acids found in living systems. DNA acts as the genetic material in most of the organisms. RNA though it also acts as a genetic material in some viruses, mostly functions as a messenger.

### THE DNA

DNA is a long polymer of deoxyribonucleotides. The length of DNA is usually defined as number of nucleotides (a pair of nucleotide referred to as base pairs) present in it. DNA (deoxyribonucleic acid) is double helical structure that was cracked by Watson and Crick based on the X-ray crystallography results. Each strand of a DNA helix is composed of repeating units of nucleotides.

#### Structure of Nucleotide

- A nucleotide has three components – a nitrogenous base, a pentose sugar (ribose in case of RNA, and deoxyribose for DNA), and a phosphate group. There are two types of nitrogenous bases – Purines (Adenine and Guanine), and Pyrimidines (Cytosine, Uracil and Thymine).
- All nucleotides are common in DNA and RNA. But uracil is found in RNA, and thymine is present only in DNA. DNA is negatively charged due to the presence of negatively charged phosphate groups.
- A nitrogenous base is linked to the pentose sugar through the N-glycosidic linkage. Two nucleotides are linked through 3'-5' phosphodiester linkage to form a dinucleotide. A polymer formed in such a manner has a free phosphate group at 5'-end of ribose sugar, which is referred to as 5'-end of polynucleotide chain. The other end of the polymer has a free 3'-OH group of the ribose sugar. This is referred to as 3'- end of the polynucleotide chain. The bonding between sugar and phosphates forms the backbone of a polynucleotide chain. The nitrogenous bases are linked to sugar moiety and project from the backbone.

#### *The salient features of the double helix structure of DNA*

- Two polynucleotide chains wrap around each other, where the backbone is constituted by sugar-phosphate, and bases project inside.
- The two DNA chains are **antiparallel** to each other. It means, if one chain has the polarity 5'-3', the other has 3'-5'.
- The bases in the two strands are paired through **hydrogen bonding** forming base pairs. Adenine form two hydrogen bonds with thymine whereas cytosine form three hydrogen bonds with guanine.
- The two strands are coiled in right handed pattern.
- The plane of one base pair stacks over the other in double helix. This, in addition to H-bonds, confers stability of the helical structure.

#### *Packaging of DNA helix*

- The length of DNA double helix in a typical mammalian cell is calculated (simply by multiplying the total number of bp with distance between two consecutive bp, that is,  $6.6 \times 10^9 \text{ bp} \times 0.34 \times 10^{-9} \text{ m/bp}$ ), it comes out to be approximately 2.2 metres.
- The positively charged basic proteins that surround the DNA is known as **histones**. Histones are rich in basic amino acids such as lysine and arginine. Histones are organised to form a unit of eight molecules called histone

octamer. The DNA is negatively charged and is packaged by wrapping around the positively charged histone octamer. This forms a structure called **nucleosome**.

- A nucleosome typically contains 200 base pairs of DNA helix. Nucleosomes form the repeating unit of a structure called chromatin in nucleus.
- Chromatins are thread-like stained bodies seen in nucleus. The nucleosomes in chromatin appear as 'beads-on-string' structure when viewed under electron microscope (EM). The beads-on-string structure in chromatin is packaged to form chromatin fibres that are further coiled and condensed at metaphase stage of cell division to form chromosomes. At higher levels chromatin packaging requires additional proteins. These proteins are the Non-histone Chromosomal (NHC) proteins.
- In a typical nucleus, loosely packed region of chromatin stains light and are referred to as **euchromatin**. The densely chromatin stains dark are called **heterochromatin**. Euchromatin is said to be transcriptionally active chromatin, whereas heterochromatin is inactive.

### DNA AS A GENETIC MATERIAL

Griffith performed an experiment known as a transforming experiment. He used two strains of *Pneumococcus*. These two different strains were used to infect the mice. The two strains used were type III-S (smooth), that contains outer capsule made up of polysaccharide and type II-R (rough) strain does not contain capsule. The capsule protects the bacteria from the host immune system.

#### Transforming Principle : Griffith Experiment

Frederick Griffith, in a series of experiments with *Streptococcus pneumoniae* (bacterium responsible for pneumonia), witnessed a miraculous transformation in the bacteria.

The Griffith experiment is explained below.

- Rough strain of *Pneumococcus* is injected in mouse. The mouse is alive.
- Smooth strain of *Pneumococcus* is injected in mouse. The mouse dies.
- When heat killed smooth strain of *Pneumococcus* is injected into mouse, the mouse is alive.
- In the last set of experiment, rough strain and heat killed smooth strain are injected into mouse. The mouse dies.

This proves that there is some transforming substance present in heat killed S strain that is converting or transforming the rough strain into virulent strain that is responsible for the death of the mouse. This transforming substance was later found to be DNA.

#### The Genetic Material is DNA: Hershey and Chase Experiment

The genetic material is DNA, Alfred Hershey and Martha Chase (1952) performed an experiment to prove that DNA is the genetic material. They worked on bacteriophages, which are viruses that infect the bacteria. When the bacteriophage attaches to the bacteria, its genetic material enters into the bacterial cell. The viral genetic material uses the bacterial cell to synthesise more viral particles. Hershey and Chase grew some viruses on a medium that contained radioactive phosphorus and other medium that contained radioactive sulfur. When radioactive phosphorus was present in the medium the viruses contained radioactive DNA but not radioactive protein. This is because DNA contains phosphorus, but protein does not. Similarly, when the growth medium contained radioactive sulphur the viruses contained radioactive protein but not radioactive DNA. This is because DNA does not contain sulphur.

This experiment proves that DNA is the genetic material.

#### Properties of Genetic Material

A molecule that can act as a genetic material must fulfill the following criteria:

- (i) It should be able to generate its replica (Replication).
- (ii) It should be chemically and structurally, stable.
- (iii) It should provide the scope for slow changes (mutation) that are required for evolution.
- (iv) It should be able to express itself in the form of 'Mendelian Characters'.

## CENTRAL DOGMA OF MOLECULAR BIOLOGY

It is an explanation about how the flow of genetic information occurs in a biological system. This explains how DNA replicates and then gets converted into messenger RNA (mRNA) via transcription. Then this mRNA is translated to form proteins.

### DNA REPLICATION

- DNA replication is a process of producing two identical copies of DNA from a single DNA molecule. It is a process of biological inheritance.
- Before the cell enters the mitosis, the DNA is replicated in S phase of interphase.
- Replication begins on the specific site on the DNA, known as origin of replication.
- DNA is a double helix in which two strands are complementary to each other. These two strands of a helix separate at the time of replication to form two new DNA molecules. Out of the two strands of DNA formed, one is identical to one of the strand and another strand is complementary to the parent strand. This form of replication is known as **semi-conservative** replication.
- DNA **polymerase** is the most important enzyme involved in DNA replication.
- DNA replication is an energy dependent process. During the process of replication, the two DNA strands do not separate completely. The replication occur within the small opening of the DNA helix known as replication fork. The DNA polymerase catalyse the reaction in 5' to 3'.
- Consequently, on one strand (the template with polarity 3'-5'), the replication is continuous, while on the other (the template with polarity 5'-3'), it is discontinuous.
- The enzyme **DNA ligase** later joins the discontinuously synthesised fragments. The strand which is synthesised continuously is known as leading strand whereas the one synthesised discontinuously is known as lagging strand.

### TRANSCRIPTION

- The process of copying genetic information from one strand of the DNA into RNA is termed as transcription.
- It is a process of formation of RNA such as messenger RNA from DNA before gene expression or protein synthesis occurs.
- During transcription, one of the strand of DNA acts as template for mRNA formation. The synthesis of mRNA occurs via RNA polymerase enzyme.
- Transcription usually occurs for a particular DNA segment which is required further for gene expression. Other than the messenger RNA, other forms of RNA such as ribosomal RNA (rRNA), micro RNA, small nuclear RNA (snRNA) can also be transcribed in the similar manner.
- A transcription unit in DNA consists of following three regions- a promoter, structural gene and a terminator. DNA dependent RNA polymerase catalyses the polymerisation in 5'-3' direction.
- Promoter is the region where RNA polymerase binds. Terminator defines the end of transcription.
- Transcription consists of three steps- initiation, elongation and termination.
- **Initiation** involves the binding of the RNA polymerase to promoter. Single type of DNA dependent RNA polymerase catalyses the transcription of all types of RNA in bacteria.
- **Elongation** is the process of addition of nucleotides to form the RNA.
- Termination factor helps in termination of transcription.
- The RNA synthesised after transcription is known as primary transcript. The primary transcript undergoes modification such as splicing, capping, tailing etc. Primary transcript consist of introns and exons. The removal of introns is known as **splicing**. Addition of poly-A tail at the 3'-end of the RNA is known as **tailing**. In **capping** an unusual nucleotide (methyl guanosine triphosphate) is added to the 5'-end of RNA.
- Some viruses have a property of reverse transcription. They are able to convert RNA template into DNA. The enzyme used is known as **reverse transcriptase**.

### TRANSLATION

- Translation refers to the process of polymerisation of amino acids to form a polypeptide.

- The order and sequence of amino acids are defined by the sequence of bases in the mRNA. The amino acids are joined by a bond which is known as a peptide bond
- This is the process of gene expression or protein synthesis that occurs in cytosol.
- Ribosomes are the cell organelles that are involved in protein synthesis. The messenger RNA formed by the process of transcription is decoded by ribosomes to form a polypeptide made up of amino acids.
- Messenger RNA is composed of a polymer of nucleotides or codons. Each codon consists of 3 nucleotides that will code for a single amino acid.
- Some important components that are involved in protein synthesis- ribosomes, messenger RNA and transfer RNA (tRNA).
- Transfer RNA is involved in physically linking mRNA and the amino acid sequence of proteins.

#### **4 major steps in Translation**

- Activation of amino acids: amino acids bind to specific tRNA molecules.
- Initiation of polypeptide synthesis: In capping an unusual nucleotide (methyl guanosine triphosphate) is added to the 5'-end of RNA.
- Elongation of polypeptide synthesis: It involves the addition of amino acids to the growing polypeptide chains.
- Termination of polypeptide synthesis: It involves the end of the translation of protein synthesis.

#### **GENETIC CODE**

The set of rules by which information encoded in genetic material is translated into proteins in the living cells. Salient features of genetic code are as follows:

- The codon consists of three nucleotides. 61 codons code for 20 different amino acids.
- One codon codes for one amino acid.
- One amino acid can be coded by more than one codon.
- The code is universal.

#### **REGULATION OF GENE EXPRESSION**

All the genes in the living cells are not active all the time. They become active when needed. Regulation in eukaryotes can occur at the following levels:

- Transcriptional level
- Processing level
- Transport of mRNA from nucleus to the cytoplasm
- Translational level

#### **Lac operon or lactose operon**

- An operon consists of structural genes, operator genes, promoter genes, regulator genes, and repressor.
- Lac operon consists of lac Z, lac Y and lac A genes.
- Lac Z codes for galactosidase, lac Y codes for permease and lac A codes for transacetylase. When repressor molecules bind the operator, genes are not transcribed.
- When repressor does not bind the operator and inactivated by interaction with the inducer, transcription is switched on.
- In case of lac operon, lactose is an inducer. So, binding the lactose switch on the transcription.

#### **HUMAN GENOME PROJECT**

Human genome project was a mega project that aimed to sequence every base in human genome. This project has yielded much new information. Many new areas and avenues have opened up as a consequence of the project.

The salient features of the human genome project are as follows:

- Human genome consists of a large portion of repeated sequences.
- Chromosome 1 has the most genes (2968), and the Y has the fewest (231).

- Humans are said to have about 30,000 genes.
- The functions are unknown for over 50 per cent of the discovered genes.
- The human genome contains 3164.7 million nucleotide bases.
- The average gene consists of 3000 bases, but size varies.
- Less than 2 percent of the genome codes for proteins.

### DNA Fingerprinting

- DNA Fingerprinting is a technique to find out variations in individuals of a population at DNA level. It works on the principle of polymorphism in DNA sequences. It has immense applications in the field of forensic science, genetic biodiversity and evolutionary biology.
- This technique is used to determine the probable identity of a person based on the nucleotide sequences of certain regions of human DNA that are unique to individuals.
- It involves identifying differences in some specific regions in DNA sequence is called **repetitive DNA**.
- Since DNA from every tissue (such as blood, hair-follicle, skin, bone, saliva, sperm etc.), from an individual show the same degree of polymorphism, they become very useful identification tool in forensic applications.
- The technique of DNA Fingerprinting was initially developed by Alec Jeffreys. He used a satellite DNA as probe that shows very high degree of polymorphism. It was called **Variable Number of Tandem Repeats (VNTR)**.

## QUESTION BANK

### MULTIPLE CHOICE QUESTIONS

1. Select the two correct statements out of the four (i –iv) statements given below about lac operon.

- (i) Glucose or galactose may bind with the repressor and inactivate it.
- (ii) In the absence of lactose the repressor binds with the operator region.
- (iii) The z gene codes for permease.
- (iv) This was elucidated by Francois Jacob and Jacques Monod.

The correct statements are

- (a) (ii) and (iii)
- (b) (i) and (iii)
- (c) (ii) and (iv)
- (d) (i) and (ii).

2. The 3' 5' phosphodiester linkages inside a polynucleotide chain serve to join

- (a) one DNA strand with the other DNA strand
- (b) one nucleoside with another nucleoside
- (c) one nucleotide with another nucleotide
- (d) one nitrogenous base with pentose sugar

3. The lac operon consists of

- (a) four regulatory genes only
- (b) one regulatory gene and three structural genes
- (c) two regulatory genes and two structural genes
- (d) three regulatory genes and three structural genes

4. In eukaryotic cell transcription, RNA splicing and RNA capping take place inside the

- (a) ribosomes
- (b) nucleus
- (c) dictyosomes
- (d) ER

5. Which one of the following statements about the particular entity is true?

- (a) Centromere is found in animal cells, which produces aster during cell division.
- (b) The gene for producing insulin is present in every body cell.
- (c) Nucleosome is formed of nucleotides.
- (d) DNA consists of core of eight histones.

6. Whose experiments cracked the DNA and discovered unequivocally that a genetic code is a "triplet"?

- (a) Hershey and Chase
- (b) Morgan and Sturtevant
- (c) Beadle and Tatum
- (d) Nirenberg and Matthaei

7. An octamer of 4 histones complexed with DNA forms  
 (a) endosome (b) nucleosome (c) mesosome (d) centromere
8. In the genetic dictionary, there are 64 codons as  
 (a) 64 amino acids are to be coded  
 (b) 64 types of tRNAs are present  
 (c) there are 44 nonsense codons and 20 sense codons  
 (d) genetic code is triplet
9. DNA replication is  
 (a) conservative and discontinuous (b) semiconservative and semidiscontinuous  
 (c) semiconservative and discontinuous (d) conservative
10. Genetic code consists of  
 (a) adenine and guanine (b) cytosine and uracil  
 (c) cytosine and guanine (d) all of these
11. The final proof for DNA as the genetic material came from the experiments of  
 (a) Hershey and Chase (b) Avery, MacLeod and McCarty  
 (c) Hargobind Khorana (d) Griffith
12. If there are 999 bases in an RNA that code for a protein with 333 amino acids, and the base at position 901 is deleted such that the length of the RNA becomes 998 bases, how many codons will be altered?  
 (a) 11 (b) 33 (c) 333 (d) 1
13. During DNA replication, Okazaki fragments are used to elongate  
 (a) the lagging strand towards replication fork (b) the leading strand away from replication fork  
 (c) the lagging strand away from the replication fork (d) the leading strand towards replication fork
14. Which of the following RNAs should be most abundant in animal cell?  
 (a) tRNA (b) mRNA (c) miRNA (d) rRNA
15. Spliceosomes are not found in cells of  
 (a) fungi (b) animals (c) bacteria (d) plants
16. The association of histone H 1 with a nucleosome indicates that  
 (a) DNA replication is occurring (b) the DNA is condensed into a chromatin fibre  
 (c) the DNA double helix is exposed (d) transcription is occurring
17. In operon concept, regulator gene functions as  
 (a) inhibitor (b) repressor (c) regulator (d) all of these
18. Initiation codon in eukaryotes is  
 (a) GAU (b) AGU (c) AUG (d) UAG
19. DNA is mainly found in  
 (a) nucleolus (b) nucleus only (c) cytoplasm only (d) none of these
20. In prokaryotes, the genetic material is  
 (a) linear DNA without histones (b) circular DNA without histones  
 (c) linear DNA with histones (d) circular DNA with histones
21. In DNA, when AGCT occurs, their association is as per which of the following pair?  
 (a) ATGC (b) AGCT (c) ACGT (d) All of these
22. The eukaryotic genome differs from the prokaryotic genome because  
 (a) the DNA is complexed with histone in prokaryotes  
 (b) the DNA is circular and single stranded in prokaryotes  
 (c) repetitive sequences are present in eukaryotes  
 (d) genes in the former case are organized into operons

23. What base is responsible for hot spots for spontaneous point mutations?  
 (a) 5bromouracil (b) 5methylcytosine (c) Guanine (d) Adenine
24. Genes that are involved in turning on or off the transcription of a set of structural genes are called  
 (a) redundant genes (b) regulatory genes (c) polymorphic genes (d) operator genes
25. DNA elements, which can switch their position, are called  
 (a) cistrons (b) transposons (c) exons (d) introns
26. The codons causing chain termination are  
 (a) AGT, TAG, UGA (b) UAG, UGA, UAA (c) TAG, TAA, TGA (d) GAT, AAT, AGT
27. The equivalent of a structural gene is  
 (a) muton (b) cistron (c) operon (d) recon
28. Which of the following rRNAs acts as structural RNA as well as ribozyme in bacteria?  
 (a) 5S rRNA (b) 18S rRNA (c) 23S rRNA (d) 5.8S rRNA
29. A molecule that can act as a genetic material must fulfill the traits given below, except  
 (a) it should be able to express itself in the form of 'Mendelian characters'  
 (b) it should be able to generate its replica  
 (c) it should be unstable structurally and chemically  
 (d) it should provide the scope for slow changes that are required for evolution
30. DNA dependent RNA polymerase catalyses transcription on one strand of the DNA which is called the  
 (a) template strand (b) coding strand (c) alpha strand (d) antistrand
31. There are special proteins that help to open up DNA double helix in front of the replication fork. These proteins are  
 (a) DNA ligase (b) DNA topoisomerase I (c) DNA gyrase (d) DNA polymerase I
32. In protein synthesis, the polymerisation of amino acids involves three steps. Which one of the following is not involved in the polymerisation of protein?  
 (a) Termination (b) Initiation (c) Elongation (d) Transcription
33. Nucleosome core is made of  
 (a) H1, H2A, H2B and H3 (b) H1, H2A, H2B, H4  
 (c) H1, H2A, H2B, H3 and H4 (d) H2A, H2B, H3 and H4
34. Initiation codon of protein synthesis (in eukaryotes) is  
 (a) GUA (b) GCA (c) CCA (d) AUG
35. The transforming principle of *Pneumococcus* as found out by Avery, MacLeod and McCarty was  
 (a) mRNA (b) DNA (c) protein (d) polysaccharide
36. Which one of the following is the starter codon?  
 (a) UAA (b) UAG (c) AUG (d) UGA
37. Which of the following is required as inducer for the expression of Lac operon?  
 (a) Lactose (b) Lactose and Galactose (c) Glucose (d) Galactose
38. A complex of ribosomes attached to a single strand of RNA is known as  
 (a) polypeptide (b) Okazaki fragment (c) polysome (d) polymer
39. Which one of the following is not applicable to RNA?  
 (a) Heterocyclic nitrogenous bases (b) Chargaff's rule  
 (c) Complementary base pairing (d) 5' phosphoryl and 3' hydroxyl ends
40. Identify the correct order of organisation of genetic material from largest to smallest.  
 (a) Genome, chromosome, gene, nucleotide (b) Chromosome, genome, nucleotide, gene  
 (c) Chromosome, gene, genome, nucleotide (d) Genome, chromosome, nucleotide, gene

41. Satellite DNA is important because it
- does not code for proteins and is same in all members of the population
  - codes for enzymes needed for DNA replication
  - codes for proteins needed in cell cycle
  - shows high degree of polymorphism in population and also the same degree of polymorphism in an individual, which is heritable from parents to children
42. Out of 64 codons, 61 codons code for 20 types of amino acid. It is called
- degeneracy of genetic code
  - overlapping of gene
  - wobbling of codon
  - universality of codons
43. Which of the following reunites the exon segments after RNA splicing?
- RNA polymerase
  - RNA primase
  - RNA ligase
  - RNA proteases
44. Which of the following enzymes are used to join bits of DNA?
- Ligase
  - Primase
  - DNA polymerase
  - Endonuclease
45. Exon part of mRNAs have code for
- protein
  - lipid
  - carbohydrate
  - phospholipid
46. Change in sequence of nucleotide in DNA is called
- mutagen
  - mutation
  - recombination
  - translation
47. mRNA is synthesised on DNA template in the direction
- 5' → 3'
  - 3' → 5'
  - both (a) and (b)
  - any one
48. In negative operon,
- corepressor binds with repressor
  - corepressor does not bind with repressor
  - corepressor binds with inducer
  - campressor has negative effect on lac operon
49. Which one of the following pairs of codons is correctly matched with their function or the signal for the particular amino acid?
- AUG, ACG Start/methionine
  - UUA, UCA Leucine
  - GUU, GCU Alanine
  - UAG, UGA Stop
50. One turn of the helix in a B-form DNA is approximately
- 2 nm
  - 20 nm
  - 0.34 nm
  - 3.4 nm
51. Antiparallel strands of a DNA molecule means that
- one strand turns clockwise
  - one strand turns anticlockwise
  - the phosphate groups of two DNA strands, at their ends, share the same position
  - the phosphate groups at the start of two DNA strands are in opposite position (pole)
52. Which antibiotic inhibits interaction between tRNA and mRNA during bacterial protein synthesis?
- Tetracycline
  - Erythromycin
  - Neomycin
  - Streptomycin
53. Amino acid sequence, in protein synthesis is decided by the sequence of
- rRNA
  - tRNA
  - mRNA
  - cDNA
54. *E. coli* cells with a mustard z gene of the lac operon cannot grow in medium containing only lactose as the source of energy because
- the lac operon is constitutively active in these cells
  - they cannot synthesise functional beta galactosidase
  - in the presence of glucose, *E. coli* cells do not utilise lactose
  - they cannot transport lactose from the medium into the cell



55. Telomerase is an enzyme which is a  
 (a) simple protein (b) RNA (c) ribonucleoprotein (d) repetitive DNA
56. Using imprints from a plate with complete medium and carrying bacterial colonies, you can select streptomycin resistant mutants and prove that such mutations do not originate as adaptation. These imprints need to be used  
 (a) on plates with and without streptomycin (b) on plates with minimal medium  
 (c) only on plates with streptomycin (d) only on plates without streptomycin
57. Gene and cistron words are sometimes used synonymously because  
 (a) one cistron contains many genes (b) one gene contains many cistrons  
 (c) one gene contains one cistron (d) one gene contains no cistron
58. Types of RNA polymerase required in nucleus of eukaryotes for RNA synthesis  
 (a) 1 (b) 2 (c) 3 (d) 4
59. Method of DNA replication in which two strands of DNA separate and synthesise new strands  
 (a) dispersive (b) conservative (c) semiconservative (d) non conservative
60. Gene regulation governing lactose operon of *E. coli* that involves the lac I gene product is  
 (a) negative and repressible because repressor protein prevents transcription  
 (b) feedback inhibition because excess of  $\beta$ -galactosidase can switch off transcription  
 (c) positive and inducible because it can be induced by lactose  
 (d) negative and inducible because repressor protein prevents transcription
61. Which one of the following is wrongly matched?  
 (a) Transcription—writing information from DNA to tRNA.  
 (b) Translation—using information in mRNA to make protein.  
 (c) Repressor—protein binds to operator to stop enzyme synthesis.  
 (d) Operon—structural genes, operator and promoter.
62. Transformation was discovered by  
 (a) Meselson and Stahl (b) Hershey and Chase (c) Griffith (d) Watson and Crick
63. Select the correct option. Direction of RNA synthesis and direction of reading of the template DNA strand.
- | Direction of RNA synthesis | Direction of reading of the template DNA strand |
|----------------------------|---|
| (a) 5' - 3'                | 3' - 5'   |
| (b) 3' - 5'                | 5' - 3'   |
| (c) 5' - 3'                | 5' - 3'   |
| (d) 3' - 5'                | 3' - 5'   |
64. Which of the following statements is not true of two genes that show 50% recombination frequency?  
 (a) The gene show independent assortment.  
 (b) If the genes are present on the same chromosome, they undergo more than one crossovers in every meiosis.  
 (c) The genes may be on different chromosomes.  
 (d) The genes are tightly linked.
65. The diagram given below shows an important concept in the genetic implication of DNA. Fill in the blanks A to C.
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- (a) A = Transcription, B = Translation, C = Francis Crick  
 (b) A = Translation, B = Extension, C = Rosalind Franklin  
 (c) A = Transcription, B = Replication, C = James Watson  
 (d) A = Translation, B = Transcription, C = Ervin Chargaff

66. Which enzyme will be produced in a cell if there is a nonsense mutation in the lac Y gene?  
 (a) Transacetylase (b) Lactose permease and transacetylase  
 (c)  $\beta$  galactosidase (d) Lactose permease
67. Satellite RNAs are present in some  
 (a) viroids (b) prions (c) bacteriophages (d) plant viruses
68. In mutational event, when adenine is replaced by guanine, it is a case of  
 (a) frame shift mutation (b) transcription  
 (c) transition (d) transversion
69. The following ratio is generally constant for a given species  
 (a)  $A + G / C + T$  (b)  $T + C / G + A$  (c)  $G + C / A + T$  (d)  $A + C / T + G$
70. What would happen if in a gene encoding a polypeptide of 50 amino acids, 25th codon (UAU) is mutated to UAA ?  
 (a) A polypeptide of 24 amino acids will be formed.  
 (b) Two polypeptides of 24 and 25 amino acids will be formed.  
 (c) A polypeptide of 49 amino acids will be formed.  
 (d) A polypeptide of 25 amino acids will be formed
71. What does "lac" refer to in what we call the lac operon?  
 (a) Lactose (b) Lactase  
 (c) Lac insect (d) The number 1,00,000
72. During translation initiation in prokaryotes, a GTP molecule is needed in  
 (a) formation of formylmet-tRNA  
 (b) binding of 30S subunit of ribosome with mRNA  
 (c) association of 30S mRNA with formylmet- tRNA  
 (d) association of 50S subunit of ribosome with initiation complex
73. Which one of the following triplet codes, is correctly matched with its specificity for an amino acid in protein synthesis or as 'start' to 'stop' codon?  
 (a) UCG – start (b) UUU – stop (c) UGU – leucine (d) UAC – tyrosine
74. During transcription, the DNA site at which RNA polymerase binds is called  
 (a) promoter (b) regulator (c) receptor (d) enhancer
75. Degeneration of a genetic code is attributed to the  
 (a) first member of a codon (b) second member of a codon  
 (c) entire codon (d) third member of a codon
76. In the genetic code dictionary, how many codons are used to code for all the 20 essential amino acids?  
 (a) 20 (b) 64 (c) 61 (d) 60
77. Which of the following is not a property of the genetic code?  
 (a) Nonoverlapping (b) Ambiguous (c) Degeneracy (d) Universal
78. Genes of interest can be selected from a genomic library by using  
 (a) cloning vectors (b) DNA probes (c) gene targets (d) restriction enzymes
79. In an inducible operon, the genes are  
 (a) usually not expressed unless a signal turns them "on"  
 (b) usually expressed unless a signal turns them "off"  
 (c) never expressed  
 (d) always expressed

80. One of the most frequently used techniques in DNA fingerprinting is  
 (a) VNTR (b) SSCP (c) SCAR (d) AFLP
81. Removal of introns and joining of exons in a defined order during transcription is called  
 (a) looping (b) inducing (c) slicing (d) splicing
82. If one strand of DNA has the nitrogenous base sequence as ATCTG, what would be the complementary RNA strand sequence?  
 (a) TTAGU (b) UAGAC (c) AACTG (d) ATCGU
83. Ribosomal RNA is actively synthesised in  
 (a) lysosomes (b) nucleolus (c) nucleoplasm (d) ribosomes
84. Which one of the following is not a part of a transcription unit in DNA?  
 (a) The inducer (b) A terminator (c) A promoter (d) The structural gene
85. Removal of RNA polymerase III from nucleoplasm will affect the synthesis of  
 (a) tRNA (b) hnRNA (c) mRNA (d) rRNA
86. What are the structures called that give an appearance as 'beads on string' in the chromosomes when viewed under electron microscope?  
 (a) Genes (b) Nucleotides (c) Nucleosomes (d) Base pairs
87. The unequivocal proof of DNA as the genetic material came from the studies on a  
 (a) bacterium (b) fungus (c) viroid (d) bacteriophage
88. Which one of the following does not follow the central dogma of molecular biology?  
 (a) Pea (b) *Mucor* (c) *Chlamydomonas* (d) HIV
89. The one aspect which is not a silent feature of genetic code, is its being  
 (a) degenerate (b) ambiguous (c) universal (d) specific
90. Semiconservative replication of DNA was first demonstrated in  
 (a) *Escherichia coli* (b) *Streptococcus pneumoniae*  
 (c) *Salmonella typhimurium* (d) *Drosophila melanogaster*
91. In Lac-operon, the gene 'a' codes for the enzyme  
 (a) lactase (b) beta-galactosidase (c) permease (d) transacetylase
92. What is not true for genetic code?  
 (a) It is nearly universal.  
 (b) It is degenerate.  
 (c) It is unambiguous.  
 (d) A codon in mRNA is read in a non-contiguous fashion.
93. In the DNA molecule,  
 (a) the proportion of adenine in relation to thymine varies with the organism  
 (b) there are two strands which run antiparallel one in 5' to 3' direction and other in 3' to 5'  
 (c) the total amount of purine nucleotides and pyrimidine nucleotides is not always equal  
 (d) there are two strands which run parallel in the 5' to 3' direction
94. Which one of the following pairs of nitrogenous bases of nucleic acids, is wrongly matched with the category mentioned against it?  
 (a) Guanine, Adenine = Purines (b) Adenine, Thymine = Purines  
 (c) Thymine, Uracil = Pyrimidines (d) Uracil, Cytosine = Pyrimidines

**95. Polysome is formed by**

- (a) a ribosome with several subunits
- (b) ribosomes attached to each other in a linear arrangement
- (c) several ribosomes attached to a single mRNA
- (d) many ribosomes attached to a strand of endoplasmic reticulum

**INPUT-TEXT BASED QUESTIONS**

**Read the following paragraphs and answer the following questions.**

I. DNA as an acidic substance present in nucleus was first identified by Friedrich Meischer in 1869. He named it as 'Nuclein'. However, due to technical limitation in isolating such a long polymer intact, the elucidation of structure of DNA remained elusive for a very long period of time. It was only in 1953 that James Watson and Francis Crick, based on the X-ray diffraction data produced by Maurice Wilkins and Rosalind Franklin, proposed a very simple but famous Double Helix model for the structure of DNA.

1. On the basis of above, some statements are given as follows:

- (i) If the sequence of bases of one strand is known, the sequence in other strand can be predicted.
- (ii) The backbone of DNA is constituted by sugar phosphate and bases.
- (iii) The two chains of DNA are antiparallel and complementary to each other.
- (iv) The bases in both the strands are joined by phosphodiester bond.

Which of the following is/are correct statement(s)?

- (a) (i) and (ii)
- (b) (i), (ii) and (iv)
- (c) (ii), (iii) and (iv)
- (d) (i), (ii) and (iii)

2. Four kinds of bases are found in DNA. Still it is called an acid. It is because of

- (a) Presence of phosphodiester bonds between sugars
- (b) Presence of hydrogen bonds
- (c) Presence of phosphoric acid
- (d) Presence of pentose sugar

3. In DNA, two hydrogen bonds are found between

- (a) Adenine and thymine
- (b) Adenine and guanine
- (c) Guanine and cytosine
- (d) Cytosine and uracil

4. Which of the following statement(s) is/are correct?

- (i) The two chains are coiled in a left sided fashion.
- (ii) A purine comes opposite to the pyrimidine in DNA helix.
- (iii) Adenine forms two hydrogen bonds between Thymine.
- (iv) The two chains are coiled in a right sided fashion.

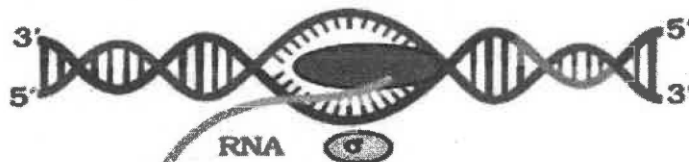
- (a) (i), (ii) and (iv)
- (b) (iii) and (iv)
- (c) (ii), (iii) and (iv)
- (d) (i) and (ii)

5. Nucleoside includes

- (a) Nitrogenous base and pentose sugar
- (b) Phosphate group and pentose sugar
- (c) Nitrogenous base and phosphate
- (d) Phosphate group only

II. The process of copying genetic information from one strand of the DNA into RNA is termed as transcription. The principle of complementarity governs the process of transcription, except the adenosine complements now forms base pair with uracil instead of thymine. However, unlike in the process of replication, which once set in, the total DNA of an organism gets duplicated, in transcription only a segment of DNA and only one of the strands is copied into RNA. There are three major types of RNAs: mRNA (messenger RNA), tRNA (transfer RNA), and rRNA (ribosomal RNA). All three RNAs are needed to synthesise a protein in a cell.

- During transcription, both strands are not copied because
  - This would prevent RNA from being translated into protein.
  - Both strands would code for RNA molecule with different sequences.
  - A double stranded RNA would form.
  - All the above
- A transcription unit is defined by three regions of DNA. Which is not the correct region?
  - Promoter
  - Structural gene
  - Operator
  - Terminator
- Look at the diagram.



This stage is called

- Elongation
  - Initiation
  - Termination
  - Translation
- Which of the following is the function of t-RNA?
    - It provides template for transcription.
    - It brings amino acids and reads the genetic code.
    - It has the catalytic role during translation.
    - It helps in initiating the process of transcription.
  - Which of the following is/are true?
    - Sigma factor is related to initiation phase.
    - DNA dependent RNA polymerase binds to promoter to start transcription.
    - Sigma factor has the role of both initiation and termination.
    - Messenger RNA provides the template for transcription.
    - (i), (iii) and (iv)
    - (i), (ii) and (iv)
    - (ii), (iii) and (iv)
    - (i), (ii) and (iii)

### ANSWERS

1. (c)	2. (c)	3. (b)	4. (b)	5. (b)	6. (d)	7. (b)	8. (d)	9. (b)	10. (d)
11. (a)	12. (b)	13. (c)	14. (d)	15. (c)	16. (b)	17. (b)	18. (c)	19. (b)	20. (b)
21. (a)	22. (b)	23. (a)	24. (d)	25. (b)	26. (b)	27. (b)	28. (c)	29. (c)	30. (a)
31. (b)	32. (d)	33. (d)	34. (d)	35. (b)	36. (c)	37. (a)	38. (c)	39. (b)	40. (c)
41. (c)	42. (a)	43. (c)	44. (a)	45. (a)	46. (b)	47. (a)	48. (a)	49. (d)	50. (d)
51. (d)	52. (a)	53. (c)	54. (b)	55. (c)	56. (c)	57. (c)	58. (c)	59. (c)	60. (d)
61. (a)	62. (c)	63. (a)	64. (d)	65. (a)	66. (c)	67. (d)	68. (c)	69. (c)	70. (a)
71. (a)	72. (c)	73. (d)	74. (a)	75. (d)	76. (b)	77. (b)	78. (b)	79. (a)	80. (a)
81. (d)	82. (b)	83. (b)	84. (a)	85. (a)	86. (c)	87. (d)	88. (d)	89. (b)	90. (a)
91. (d)	92. (d)	93. (b)	94. (b)	95. (c)					

### EXPLANATION

- The deletion occurs at 901 position so that the remaining 98 bases specifying 33 codons of amino acids will be altered.
- In DNA, AGCT is associated with pair ATGC because in a DNA molecule, the purine adenine in either chain is associated with the pyrimidine thymine on the other. Similarly, purine guanine in either chain is associated with pyrimidine cytosine on the other.

30. The DNA-dependent RNA polymerase catalyse the polymerisation in only one direction that is 5→3, the strand with polarity 5→3 act as template and known as template strand.
42. There are 64 codons. Out of 64, 3 are stop codons or nonsense codons, i.e., these do not code for any amino acid and rest 61 code for one of the 20 amino acids. Neither of them code for more than one amino acids except GUG which normally code for valine but in certain conditions it also codes for N-formyl methionine as initiation codon.
52. Neomycin is a broad spectrum antibiotic effective against gram positive as well as gram negative bacteria. It's mechanism of action is by selective inhibition of protein synthesis on the 70s (prokaryotic) ribosome by inhibiting the interaction of mRNA and tRNA during translation process.
63. RNA polymerase initiates and extends the RNA (chain elongation) in the direction always in 5' to 3'.
68. In case of transition, purine base is replaced by another purine (e.g, A G) and pyrimidine is replaced by another pyrimidine (e.g, C T)
70. If in a gene encoding a polypeptide of 50 amino acid, 25th codon is mutated to UAA or any of the termination codon, then the chain will be terminated at that place.
78. Molecular probes are small DNA segments that are used to detect the presence of complementary sequences in nucleic acid samples in genomic library. These are usually formed of 200–500 nucleotide sequences. These segments or probes are labelled either with radioactive or with nonradioactive compound.

**Input-Text Based Answers**

- |            |        |        |        |        |        |
|------------|--------|--------|--------|--------|--------|
| <b>I.</b>  | 1. (d) | 2. (c) | 3. (a) | 4. (c) | 5. (a) |
| <b>II.</b> | 1. (d) | 2. (c) | 3. (a) | 4. (b) | 5. (b) |