Chapter

7.2

Molecular Basis of Inheritance

Nucleic acids

Two types of nucleic acids are found in the cells of all living organisms. These are DNA (Deoxyribonucleic acid) and RNA (Ribonucleic acid). The nucleic acid was first isolated (reported) by Friedrich Miescher in 1869 from the nuclei of pus cells and was named nuclein. The term nucleic acid was given by Altman (1899).

DNA (Deoxyribonucleic Acid)

Term was given by Zacharis, which is found in the cells of all living organisms except plant viruses,where RNA forms the genetic material and DNA is absent. In bacteriophages and viruses there is a single molecule of DNA, which remains coiled and is enclosed in the protein coat. In bacteria, mitochondria, plastids and other prokaryotes, DNA is circular and lies naked in the cytoplasm but in eukaryotes it is found in nucleus and known as carrier of genetic information and capable of self replication. Isolation and purification of specific DNA segment from a living organism achieved by Nirenberg. H.Harries is associated with DNA-RNA hybridization technique.

Chemical composition

The chemical analysis has shown that DNA is composed of three different types of compound.

(i) **Sugar molecule :** Levene identified a five carbon sugar, ribose in nucleic acid in 1910. It is represented by a pentose sugar the deoxyribose or 2-deoxyribose which is derived from ribose due to the deletion of oxygen from the second carbon.

(ii) **Phosphoric acid :** H_3PO_4 that makes DNA acidic in nature.

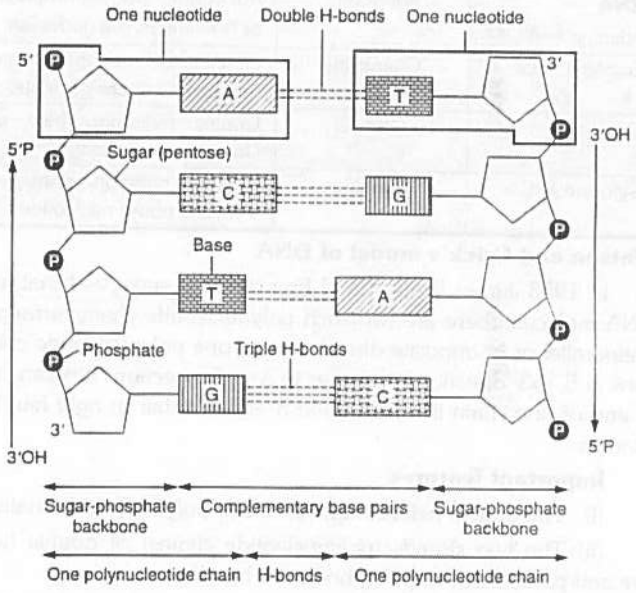


Fig : 7.2-1 Diagrammatic representation of Watson's and Crick's model of DNA

(iii) **Nitrogenous base :** Kossel demonstrated the presence of two pyrimidines (cytosine and thymine) and two purines (adenine and guanine) in DNA and he was awarded Nobel Prize in 1910. These are nitrogen containing ring compound which are classified into two groups:

(a) **Purines :** Two ring compound namely as Adenine and Guanine.

(b) **Pyrimidine :** One ring compound included Cytosine and Thymine. In RNA Uracil is present instead of Thymine.

Nucleosides : Nucleosides are formed by a purine or pyrimidine nitrogenous base and pentose sugar. DNA nucleosides are known as deoxyribosenucleosides.

Nucleotides : In a nucleotide, purine or pyrimidine nitrogenous base is joined by deoxyribose pentose sugar (D), which is further linked with phosphate (P) group to form nucleotides.

Table : 7.2-1

Nitrogenous base	Nucleoside (Base + Sugar)	Nucleotide (Base + Sugar + Phosphate)
DNA Adenine = A	Deoxyadenosine	Deoxyadenosine monophosphate or Adenine deoxyribose nucleotide
Guanine = G	Deoxyguanine	Deoxyguanine monophosphate or Guanine deoxyribose-nucleotide
Thymine = T	Thymidine	Deoxythymidine monophosphate or Thymidine deoxyribose nucleotide
Cytosine = C	Deoxycitidine	Deoxycytidine monophosphate or Cytosine deoxyribose nucleotide
RNA Adenine = A	Adenosine	Adenosine monophosphate or Adenine ribose nucleotide
Guanine = G	Guanosine	Guanosine monophosphate or Guanine ribose nucleotide
Uracil = U	Uridine	Uridine monophosphate or Uracil ribose nucleotide
Cytosine = C	Cytidine	Cytidine monophosphate or Cytosine ribose nucleotide

Watson and Crick's model of DNA

In 1953 James Watson and Francis Crick suggested that in a DNA molecule there are two such polynucleotide chains arranged antiparallel or in opposite directions *i.e.*, one polynucleotide chain runs in 5' →3' direction, the other in 3'→ 5' direction. It means the 3' end of one chain lies beside the 5' end of other in right handed manner.

Important features

(i) The double helix comprises of two polynucleotide chains.

(ii) The two strands (polynucleotide chains) of double helix are anti-parallel due to phosphodiester bond.

(iii) Each polynucleotide chain has a sugar-phosphate 'backbone' with nitrogenous bases directed inside the helix.

(iv) The nitrogenous bases of two antiparallel polynucleotide strands are linked through hydrogen bonds. There are two hydrogen bonds between A and T, and three between G and C. The hydrogen bonds are the only attractive forces between the two polynucleotides of double helix. These serve to hold the structure together.

The two polynucleotides in a double helix are complementary. The sequence of nitrogenous bases in one determines the sequence of the nitrogenous bases in the other. Complementary base pairing is of fundamental importance in molecular genetics.

Erwin Chargaff (1950) made quantitative analysis of DNA and proposed "base equivalence rule" stating that molar concentration of A = T & G ≡ C or $\frac{A+G}{C+T}=1$ & $\frac{A+T}{G+C}$ which is constant for a species. Sugar deoxyribose and phosphate occur in equimolar proportion.

Ten base pairs occur per turn of helix (abbreviated 10bp). The spacing between adjacent base pairs is 3.4Å. The helix is 20Å (19.8Å) in diameter and DNA molecule found 360° in a clockwise.

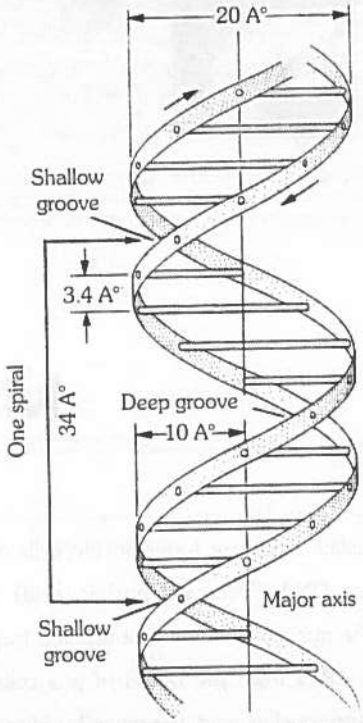


Fig : 7.2-2 Double helical structure of DNA

Forms of DNA

Five different morphological forms of DNA double helix have been described. These are A, B, C, D and Z forms. Most of these forms (except B, and Z) occur in rigidly controlled experimental conditions. Watson and crick model represents commonest form, Biotic-form (B-form or B-DNA) of DNA. Some DNA forms are inter convertible also. The differences in these DNA forms are associated with :

(i) The numbers of base pairs, present in each turn of DNA helix.

(ii) The pitch or angle between each base pair.

(iii) The helical diameter of DNA molecule.

(iv) The handedness of double helix. Which is mentioned in table.

Table : 7.2-2 Comparison of different types of DNA

Characters	*A*-DNA	*B*-DNA	*C*-DNA	*D*-DNA	*Z*-DNA
Base pair per turn of the helix	11	10	9.33	8	12
Tilt of pairs (γ) base	20.2°	6.3°	– 7.8°	– 16.7°	7 Å
Axial rise (h)	2.56 Å	3.37 Å	3.32 Å	3.03 Å	3.7 Å
Helical diameter	23 Å	20 Å	19 Å	–	18 Å
Handedness of the double helix	Right handed	Right handed	Right handed	Right handed	Left handed

Promiscuous DNA : Special type of DNA which makes movement between mitochondria, chloroplast and nucleus. It was discovered in 1983 in cambridge university in maize. It was later reported in yeast, mungbean, spinach and peas.

Repetitive DNA : Multiple copies of DNA having same or almost same base pair sequence constitute repetitive DNA. In higher organisms 20% – 90% DNA is of this type.

Satellite DNA : In some eukaryotes small highly repetitive DNA sequences have been found called satellite DNA, which differ in base composition.

Characteristics of DNA

Denaturation or melting : The phenomenon of separating of two strand of DNA molecule by breaking of hydrogen bond at the temp. 90^0C. In prokaryotes and human mitochondria G ≡ C are more because this melting point is more. In eukaryotes the amount of A = T are more because melting point is less.

Renaturation or annealing : Separated strands reunite to form double helix molecule of DNA by cooling at the room temp. *i.e.*, 25^0C.

These properties help to form hybrid from different DNA or with RNA.

Evidences of DNA as the genetic material

The following experiments conducted by the molecular biologists provide direct evidences of DNA being the genetic material.

Bacterial transformation or Griffith's Experiments : Griffith (1928) injected into mice with virulent and smooth (S-type, smooth colony with mucilage) form of *Diplococcus pneumoniae*. The mice died due to pneumonia. No death occurred when mice were injected with nonvirulent or rough (R-type, irregular colony without mucilage) form or heat- killed virulent form. However, in a combination of heat killed S-type and live R-type bacteria, death occurred in some mice. Autopsy of dead mice showed that they possessed S-type living bacteria, which could have been produced only by transformation of R-type bacteria. The transforming chemical was found out by O.T.Avery, C.M. Mc. leod and M. Mc. Carty (1944). They fractionated heat-killed S-type bacteria into DNA, carbohydrate and protein fractions. DNA was divided into two parts, one with DNAase and the other without it. Each component was added to different cultures of R-type bacteria. Transformation was found only in that culture which was provided with intact DNA of S-type. Therefore, the trait of virulence is present in DNA. Transformation involves transfer of a part of DNA from surrounding medium or dead bacteria (donor) to living bacteria (recipient) to form a recombinant.

Evidence from genetic recombination in bacteria or bacterial conjugation : Lederberg and Tatum (1946) discovered the genetic recombination in bacteria from two different strains through the process of conjugation. Bacterium *Escherichia coli* can grow in minimal culture medium containing minerals and sugar only. It can synthesize all the necessary vitamins from these raw materials. But its two mutant strains were found to lack the ability to synthesize some of the vitamins necessary for growth. These could not grow in the minimal medium till the particular vitamins were not supplied in the culture medium.

Mutant strain A : It (used as male strain) had the genetic composition Met^-, Bio^-, Thr^+, Leu^+, Thi^+. It lacks the ability to manufacture vitamins methionine and biotin and can grow only in a culture medium which contains these vitamins in addition to sugar and minerals.

Mutant strain B : It (used as female strain or recipient) has a genetic composition Me^{++}, Bio^+, Thr^-, Leu^-, Thi^-. It lacks the ability to manufacture threonine, leucine and thionine and can grow only when these vitamins are added to the growing medium.

These two strains of *E.coli* are, therefore, unable to grow in the minimal culture medium, when grow separately. But when a mixture of these two strains was allowed to grow in the same medium a number of colonies were formed. This indicates that the portion of donor DNA containing information to manufacture threonine, leucine and thionine had been transferred and incorporated in the recipient's genotype during conjugation.

This experiment of Lederberg and Tatum shows that the conjugation results in the transfer of genetic material DNA from one bacterium to other. During conjugation a cytoplasmic bridge is formed between two conjugating bacteria.

Evidence from bacteriophage infection

- Hershey and Chase (1952) by his Wareing-blender experiment confirmed that DNA of bacteriophage (virus, infecting bacteria) enters into host (bacterial) cell and carries the necessary information for formation of new phages.
- Two types of phage particles, *i.e.*, S^{35} and P^{32} types, were produced by growing in bacteria with radioactive S^{35} and P^{32}. These two types were separately made to infect normal bacterial cells. When these normal bacterial cells were analysed for radioactivity, no S^{35} was reported and only P^{32} was reported in bacterial cells, which were infected with P^{32} phage.
- This is because sulphur (*S*) does not form part of DNA and phosphorus (*P*) only forms part of DNA, hence P^{32} radioactivity was found in bacterial cell infected with P^{32} phage, which confirms DNA to be the genetic material.

DNA replication

Watson and Crick suggested a very simple mechanism of DNA replication or DNA transcription on the basis of its double helical structure. During replication the weak hydrogen bonds between the nitrogenous bases of the nucleotides separate so that the two polynucleotide chains of DNA also separate and uncoil. The chains thus separated are complementary to one another. Because of the specificity of base pairing, each nucleotide of separated chains attracts complementary nucleotide from the cell cytoplasm. Once the nucleotides are attached by their hydrogen bonds, their sugar radicals unite through their phosphate components, completing the formation of a new polynucleotide chain.

The method of DNA replication is semi-discontinuous and described as semi-conservative method, because each daughter DNA molecule is a hybrid conserving one parental polynucleotide chain and the other one newly synthesized strand. DNA replication occur in S-phage in cell cycle.

Mechanism of DNA replication

The entire process of DNA replication involves following steps in *E.coli* :

Recognition of the initiation point : First, DNA helix unwind by the enzyme "Helicase" (Breaks H_2 bond) which use the energy of ATP and replication of DNA begin at a specific point, called initiation point or origin where replication fork begins.

Unwinding of DNA : The unwinding proteins bind to the nicked strand of the duplex and separate the two strands at DNA duplex. Topoisomerase (Gyrase is a type of topoisomerase in E.coli) helps in unwinding of DNA.

Single stranded binding protein (SSB) : Which remain DNA in single stranded position and also known as helix destabilising protein (HDP).

RNA Priming : The DNA directed RNA polymerase now synthesizes the primer strands of RNA (RNA primer). The priming RNA strands are complementary to the two strands of DNA and are formed of 50 to 100 nucleotides.

Formation of DNA on RNA primers : The new strands of DNA are formed in the 5′ → 3′ direction from the 3′→5′ template DNA by the addition of deoxyribonucleotides to the 3′ end of primer RNA.

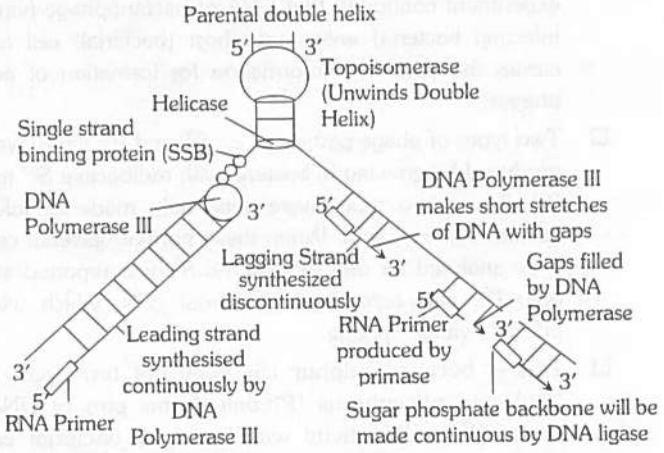


Fig : 7.2-3 Showing continuous replication of a daughter DNA strand on leading strand and discontinuous replication of lagging strand

Addition of nucleotide is done by DNA polymerase III. The leading strand of DNA is synthesized continuously in 5′→3′ direction as one piece. The lagging strand of DNA is synthesized discontinuously in its opposite direction in short segments. These segments are called Okazaki fragments.

Excision of RNA primers : Once a small segment of an okazaki fragment has been formed, the RNA primers are removed from the 5′ by the action of 5′→3′ exonuclease activity of DNA polymerase I.

Joining of okazaki fragments : The gaps left between Okazaki fragments are filled with complementary deoxyribonucleotide residues by DNA polymerase-I. Finally, the adjacent 5′ and 3′ ends are joined by DNA ligase.

DNA polymerase enzymes

There are three DNA polymerase enzymes that participate in the process of DNA replication.

(i) **DNA polymerase-I :** This enzyme has been studied in *E. coli* in detail. It possesses a sulphydryl group, single interchain disulphide and one zinc molecule at the active site. DNA polymerase-I was discovered by Kornberg and his colleagues in 1955. It was considered to carry out DNA replication and also participates in the repair and proof reading of DNA by catalyzing the addition of mononucleotide units (the deoxyribonucleotide residues) to the free 3′-hydroxyl end of DNA chain. A pure DNA polymerase-I can add about 1,000 nucleotide residues per minute per molecule and catalyses 5′→3′ exonuclease activity and removes nucleotide residues of primer RNA at 3′.

(ii) **DNA polymerase-II :** The biological role of polymerase II is not yet known.

(iii) **DNA polymerase-III :** This enzyme was discovered by T. Kornberg and M.L. Gefter (1972). It is the most active enzyme and responsible for DNA chain elongation.

DNA repair : When DNA is damaged by mutagen, a system is activated to repair damaged DNA. Say for example UV light induced thymidine dimers in DNA and repair mechanism of that DNA is called photoreactivation. Many enzyme are involved in repair mechanism in which endonuclease (Chemical knives) cut the defective part of DNA then gap is filled with DNA polymerase I and finally DNA ligase seals that repaired part.

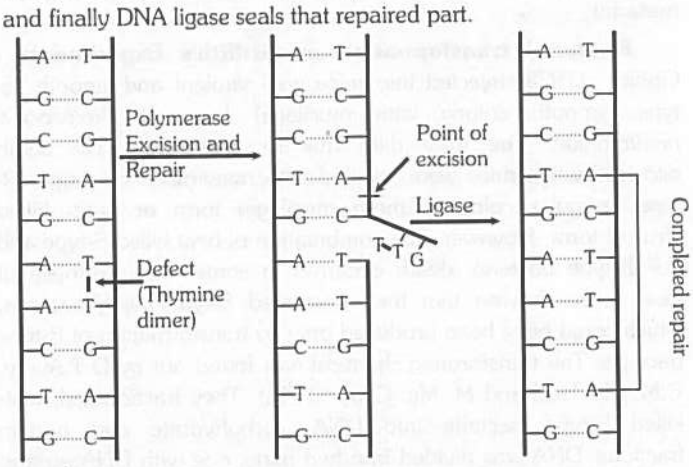


Fig : 7.2-4 Repair of ultraviolet-induced thymine dimer which prevents replication

Evidence in support of semiconservative mode of DNA replication (Meselson and Stahl's experiment)

(1) Meselson and Stahl (1958) cultured (*Escherichia coli*) bacteria in a culture medium containing N^{15} which were isotopes of nitrogen. After these had replicated for a few generations in that medium both the strands of their DNA contained N^{15} as constituents of purines and pyrimidines. When these bacteria with N^{15} were transferred in cultural medium containing N^{14}, it was found that DNA separated from fresh generation of bacteria possesses one strand heavier than the other. The heavier strand represents the parental strand and lighter one is the new one synthesized from the culture indicating semiconservative mode of DNA replication. Circular form of replication on as characteristic of prokaryotes is theta replication discovered by J. Cairns.

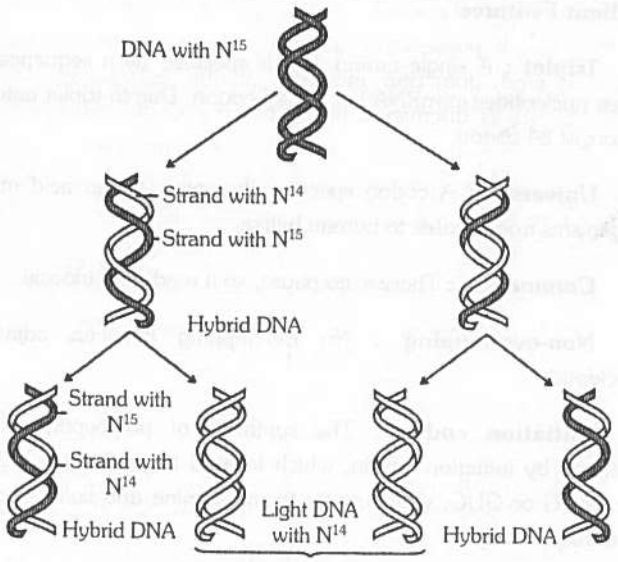


Fig : 7.2-5 Second generation daughter molecules after DNA replication

(2) Evidence from Taylor's experiment on *Vicia faba* (Broad Bean) root tips using autoradiography technique and further he used tritiated thymidine (H^3-tdR).

(3) Evidence from Cairn's autoradiography experiment in bacteria. He used tritiated thymidine (H^3-tdR).

RNA (Ribonucleic acid)

RNA is found in the cytoplasm and nucleolus. Inside the cytoplasm it occurs freely as well as in the ribosomes. RNA can also be detected from mitochondria, chloroplasts and associated with the eukaryotic chromosomes. In some plant viruses RNA acts as hereditary material. S. Ochoa got nobel prize for artificial synthesis of RNA.

Structure of RNA

More commonly RNA is a single stranded structure consisting of an unbranched polynucleotide chain, but it is often folded back on itself forming helices. DNA is a double stranded structure and its two polynucleotide chains are bounded spirally around a main axis. It is made up by :

(1) **Sugar :** Ribose

(2) **Phosphate :** In the form of H_3PO_4.

(3) **Nitrogenous base :** Two types:

(a) Purine,

(b) Pyrimidine

(i) **Purine** is further divided into Adenine and Guanine.

(ii) **Pyrimidine** divided into Cytosine and Uracil.

Types of RNA

RNA can be classified into two types.

(1) **Genetic RNA :** Which established by Conrat. In most of the plant viruses, some animal viruses and in many bacteriophages DNA is not found and RNA acts as hereditary material. This RNA may be single stranded or double stranded.

(2) **Nongenetic RNA :** In all other organisms where DNA is the hereditary material, different types of RNA are nongenetic. The nongenetic RNA is synthesized from DNA template.

In general, three types of RNAs have been distinguished :

Messenger RNA or Nuclear RNA (mRNA) : mRNA is a polymer of ribo-nucleotide as a complementary strand to DNA and carries genetic information in cytoplasm for the synthesis of proteins. For this reason only, it was named messenger RNA (mRNA) by Jacob and Monod (1961). It is 5% of total RNA. It acts as a template for protein synthesis and has a short life span.

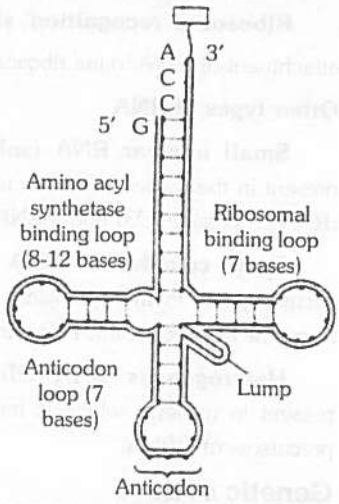


Fig : 7.2-6 Clover leaf model of t-RNA structure

Ribosomal RNA (rRNA) : rRNA constitutes rebundant nature upto 80% of total RNA of the cell. It occurs in ribosomes, which are nucleoprotein molecules.

Inside the ribosomes of eukaryotic cells rRNA occurs in the form of the particles of four different dimensions. These are designated 28S, 18S, 5.8S and 5S.

The 28S and 5S molecules occur in large subunit (60S subunit) of ribosome, whereas 18S molecules is present in the small subunit (40S subunit) of ribosome. In prokaryotic cells there are only 23S, 16S and 5S rRNA are found. Which are synthesized in nucleolus / SAT region.

Transfer RNA (tRNA) : The transfer RNA is a family of about 60 small sized ribonucleic acids which can recognize the codons of mRNA and exhibit high affinity for 21 activated amino acids, combines with them and carry them to the site of protein synthesis. tRNA molecules have been variously termed as soluble RNA or supernatant RNA or adapter RNA. It is about 0-15% of RNA of the cell.

tRNA molecules are smallest, containing 75 to 80 nucleotides. The 3′ end of the polynucleotide chain ends in CCA base sequence. This represents site for the attachment of activated amino acid. The end of the chain terminates with guanine base. The bent in the chain of each tRNA molecule contains a definite sequence of three nitrogenous bases, which constitute the anticodon. It recognizes the codon on mRNA.

Most accepted model for t-RNA structure is clover leaf model, which way given by Robert Holley (1965) along with H.G. Khorana and Nirenberg (for yeast alanyl t-RNA) and for this work, they were awarded Nobel prize in 1968.

Four different region or special sites can be recognised in the molecule of tRNA.These are :

Amino acid attachment site : It occurs at the 3′ end of tRNA chain and has OH group combined with specific amino acid in the presence of ATP forming amino acyl tRNA.

Site for activating enzymes : Dihydrouridine or DHU loop dictate activation of enzymes.

Anticodon or codon recognition site : This site has three unpaired bases (triplet of base) whose sequence is complementary with a codon in mRNA.

Ribosome recognition site ($T_\psi C$) : This helps in the attachment of tRNA to the ribosome.

Other types of RNA

Small nuclear RNA (snRNA) : It is a small sized RNA present in the nucleus. SnRNA takes part in splicing (U1 and U2), rRNA processing (U3) and mRNA processing.

Small cytoplasmic RNA (scRNA) : It is small sized RNA occurring free in the cytoplasm. It helps in taking and binding a ribosome to endoplasmic reticulum for producing secretory proteins.

Heterogenous RNA (HnRNA) : This type of RNA is present in nucleus, which is having larger molecules and act as precursors of mRNA.

Genetic code

Defined as structure of nitrogen bases(nucleotides) in mRNA molecule which contain the information for the synthesis of protein molecule. It is discovered by frame shift mutation by Crick.

Codon is the sequence of nitrogen bases (nucleotides) in mRNA, which codes for a single amino acid. Nirenberg and Mathaei (1961) experimentally proved that a single amino acid is determined by a sequence of three nitrogen bases which is known as triplet code. Khorana has got Nobel prize on genetic code.

Salient Features

Triplet : A single amino acid is specified by a sequence of three nucleotides in mRNA *i.e.*, called codon. Due to triplet nature, it consist 64 codon.

Universal : A codon specifies the same amino acid in all organisms from viruses to human beings.

Commaless : There is no pause, so it reads continously.

Non-overlapping : No overlapping between adjacent nucleotide.

Initiation codon : The synthesis of polypeptide chain initiated by initiation codon, which located beginning the cistron *i.e.*, AUG or GUG, which codes to *methionine* and *valine* amino acid respectively.

Termination codon : Termination is done by codon. These are **UAA, UGA** or **UAG** which does not code to any amino acid. These are also called nonsense codon.

Degeneracy : A single amino acid may be specified by many codon *i.e.*, called degeneracy. Degeneracy is due to the last base in codon, which is known as wobble base. Thus first two codon are more important to determining the amino acid and third one differ without affecting the coding *i.e.*, known wobble hypothesis, (proposed by Crick) which establishes a economy of tRNA molecule and put forwarded by Crick. Degeneracy of genetic code was discovered by Berrfield and Nirenberg.

Table : 7.2-3 The Genetic Code Dictionary

First Letter	Second Letter U	Second Letter C	Second Letter A	Second Letter G	Third Letter
U	UUU, UUC — Phenylalanine	UCU, UCC, UCA, UCG — Serine	UAU, UAC — Tyrosine	UGU, UGC — Cystine	U, C
	UUA, UUG — Leucine		UAA — Ochre (Terminator); UAG — Amber (Terminator)	UGA — Opal (Terminator); UGG — Tryptophan	A, G
C	CUU, CUC, CUA, CUG — Leucine	CCU, CCC, CCA, CCG — Proline	CAU, CAC — Histidine; CAA, CAG — Glutamine	CGU, CGC, CGA, CGG — Arginine	U, C, A, G
A	AUU, AUC, AUA — Isoleucine	ACU, ACC, ACA, ACG — Threonine	AAU, AAC — Asparagine; AAA, AAG — Lysine	AGU, AGC — Serine; AGA, AGG — Arginine	U, C, A, G
	AUG — Methionine				
G	GUU, GUC, GUA, GUG — Valine	GCU, GCC, GCA, GCG — Alanine	GAU, GAC — Aspartic acid; GAA, GAG — Glutamic acid	GGU, GGC, GGA, GGG — Glycine	U, C, A, G

Central dogma

Central dogma of molecular biology proposes a unidirectional or one way flow of information from DNA to RNA (transcription) and from RNA to protein (translation). The concept was given by Watson and Crick.

$$DNA \xrightarrow{\text{Transcription}} mRNA \xrightarrow{\text{Translation}} Protein$$

As mentioned above the first step of central dogma is transcription (synthesis of mRNA from DNA), but in case of reverse transcription DNA is synthesized from RNA in *retrovirus*. That concept is given by Temin and Baltimore in *Rous sarcoma* virus, also known as teminism or reverse transcription and enzyme which catalyze this reaction is reverse transcriptase or RNA dependent DNA polymerase. For this work, Temin, Baltimore and Dulbecco were given Nobel prize (1975).

$$DNA \underset{\text{Reverse Transcription}}{\overset{\text{Transcription}}{\rightleftharpoons}} RNA \longrightarrow Protein$$

Transcription

Formation of mRNA from DNA is called as Transcription. It is heterocatalytic function of DNA. Template of DNA called sense strand (Master Strand) is involved. The segment of DNA involved in transcriptions is cistron, which have a promoter region where initiation is started and terminator region where transcription ends. Enzyme involved in transcription is RNA polymerase-II. Which consist five polypeptide $\alpha, \beta, \beta', \omega$ (constitute core enzyme) and σ (sigma factor). Sigma (σ) factor recognise promoter site while remaining core enzymes takes part in chain elongation. After transcription, DNA molecule reassociates to form its original structure. In eukaryotes hn RNA (heterogenous nuclear RNA) which consist exon (coded region) and introns (non coded region or intervening sequences) formed in nucleus and diffuse in cytoplasm is also known as split gene which goes to transcription changes for removing the introns and later formed mRNA.

It consist of three phenomenon

(1) **Initiation :** Initiation start with the help of σ (sigma) factor of RNA polymerase enzyme. At the cap region which have 7 methyl guanosine residue at the 5′.

(2) **Elongation :** Elongation is done by core enzyme, which moves along the sense strand.

(3) **Termination :** In prokaryotes termination is done by rho (ρ) factor while in eukaryotes poly A tail is responsible for termination at the 3′.

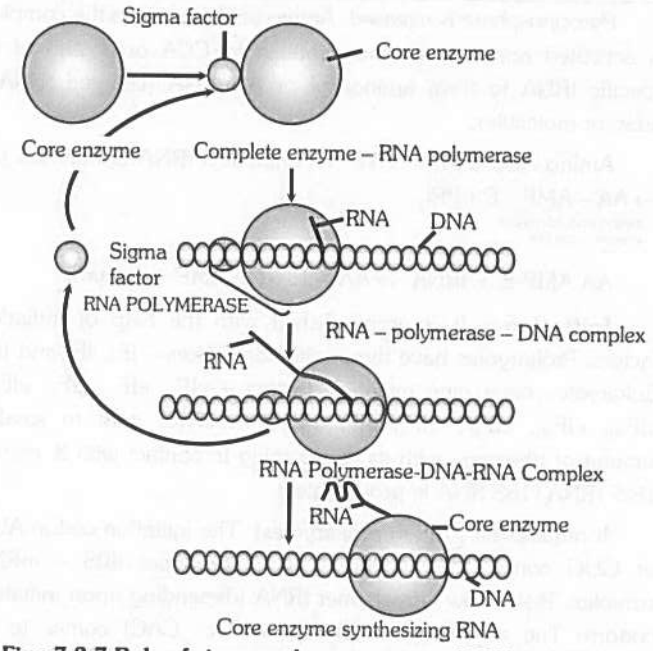


Fig : 7.2-7 Role of sigma and core enzyme of RNA polymerase enzyme during transcription of mRNA

Translation or Protein synthesis

Formation of protein from mRNA is called translation it is also known as polypeptide synthesis or protein synthesis. It is unidirectional process. The ribosomes of a polyribosome are held together by a strand of mRNA. Each eukaryotic ribosome has two parts, smaller 40S subunit (30S in prokaryotes) and larger 60S subunit (50S in prokaryotes).

Larger subunit has a groove for protection and passage of polypeptide, site A (acceptor or aminoacyl site), enzyme peptidyl transferase and a binding site for tRNA. The smaller subunit has a point for attachment of mRNA. Along with larger subunit, it forms a P-site or peptidyl transfer (donor site).

There are binding sites for initiation factors, elongation factors, translocase, GTPase, etc. The raw materials for protein synthesis are amino acids, mRNA, tRNAs and amino acyl tRNA synthetases.

Amino acids : Twenty types of amino acids and amides constitute the building blocks of proteins.

mRNA : It carries the coded information for synthesis of one (monocistronic) or more polypeptides (polycistronic). Its codons are recognised by tRNAs.

tRNAs : They pick up specific amino acid from amino acid pool and carry over the mRNA strand.

Amino Acyl tRNA Synthetases : The enzymes are specific for particular amino acids and their tRNAs.

Activation of Amino Acids : An amino acid combines with its specific aminoacyl tRNA synthetase enzyme (AA-activating enzyme) in the presence of ATP to form aminoacyl adenylate enzyme complex (AA-AMP-E).

Pyrophosphate is released. Amino acid present in the complex is activated amino acid. It can attach to CCA or 3′ end of its specific tRNA to form aminoacyl or AA-tRNA (charged tRNA / adaptor molecule).

Amino Acid (AA) + ATP + Aminoacyl tRNA Synthetase (E) $\rightarrow$ AA – AMP – E + PPi
amino acid adenylate enzyme complex

AA-AMP-E + tRNA $\rightarrow$ AA—tRNA + AMP + Enzyme.

Initiation : It is accomplished with the help of initiation factors. Prokaryotes have three initiation factors – IF_3, IF_2 and IF_1. Eukaryotes have nine initiation factors – eIF_1, eIF_2, eIF_3, eIF_{4A}, eIF_{4B}, eIF_{4C}, eIF_{4D}, eIF_5, eIF_6,mRNA attaches itself to smaller subunit of ribosome with its cap coming in contact with 3′ end of 18 S rRNA (16S RNA in prokaryotes).

It requires eIF_2 (IF_3 in prokaryotes). The initiation codon AUG or GUG comes to lie over P-site. It produces 40S – mRNA complex. P-site now attracts met tRNA (depending upon initiation codon). The anticodon of tRNA (UAC or CAC) comes to lie opposite initiation codon. Initiation factor eIF_3 (IF_2 in prokaryotes) and GTP are required. It gives rise to 40S-mRNA - $tRNA^{Met}$. Methionine is nonformylated ($tRNA_m^{Met}$) in eukaryotic cytoplasm and formylated ($tRNA_f^{Met}$) in case of prokaryotes.

The larger subunit of ribosome now attaches to 40S-mRNA-$tRNA^{Met}$ complex to form 80S mRNA -tRNA complex. Initiation factors eIF_1 and eIF_4 (A, B and C) are required in eukaryotes and IF_1 in prokaryotes. Mg^{2+} is essential for union of the two subunit of ribosomes. A-site becomes operational. Second codon of mRNA lies over it.

Elongation/chain formation : A new AA-tRNA comes to lie over the A site codon by means of GTP and elongation factor (eEF_1 in eukaryotes, EF-Tu and EF-Ts in prokaryotes). Peptide bond (–CO.NH–) is established between carboxyl group (–COOH) of amino acid of P-site and amino group ($–NH_2$) of amino acid at A-site with the help of enzyme peptidyl transferase/synthetase.

Connection between tRNA and amino acid of P-site and A-site tRNA comes to bear a dipeptidyl. Free tRNA of P-site slips away. By means of translocase (eEF_2 in eukaryotes and EF-G in prokaryotes) and GTP, ribosome moves in relation to mRNA so that peptidyl carrying tRNA comes to lie on P-site and a new codon is exposed at A-site.Incorporation of an amino acid in polypeptide chain thus requires one ATP and two GTP molecules. Peptide formation and translocation continue uninterrupted till the whole m-RNA code is translated into polypeptide. In a polyribosome, when a number of ribosomes are helping in translation of same mRNA code, the ribosome nearest the 5′ end of mRNA carries the smallest polypeptide and the one towards the 3′ end the longest. Of course, ultimately the whole polypeptide is formed by each.

Termination : Polypeptide synthesis stops when a nonsense or termination codon [UAA, (ochre), UAG (Amber) or UGA (opal)] reaches A-site. It does not attract any AA-tRNA, P-site tRNA separates from its amino acid in the presence of release factor eRF_1 in eukaryotes ($RF_1$for UAG and UAA, RF_2 for UAA and UGA in prokaryotes). The completed polypeptide is released, mRNA and ribosome separate. The two subunits of ribosome also dissociate with the help of dissociation factor.

Modification : Formylated methionine present at the beginning of polypeptide in prokaryotes and organelles is either deformylated (enzyme deformylase) or removed from chain (enzyme exopeptidase). Initially the polypeptide is elongated having only primary structure. As soon as the polypeptide comes out the groove of larger ribosome sub-unit, it forms α-helix (secondary structure) which coils further forming a number of linkages (tertiary structure). Two or more polypeptides may get associated to become β-pleated which then coil to produce tertiary and quaternary structure.

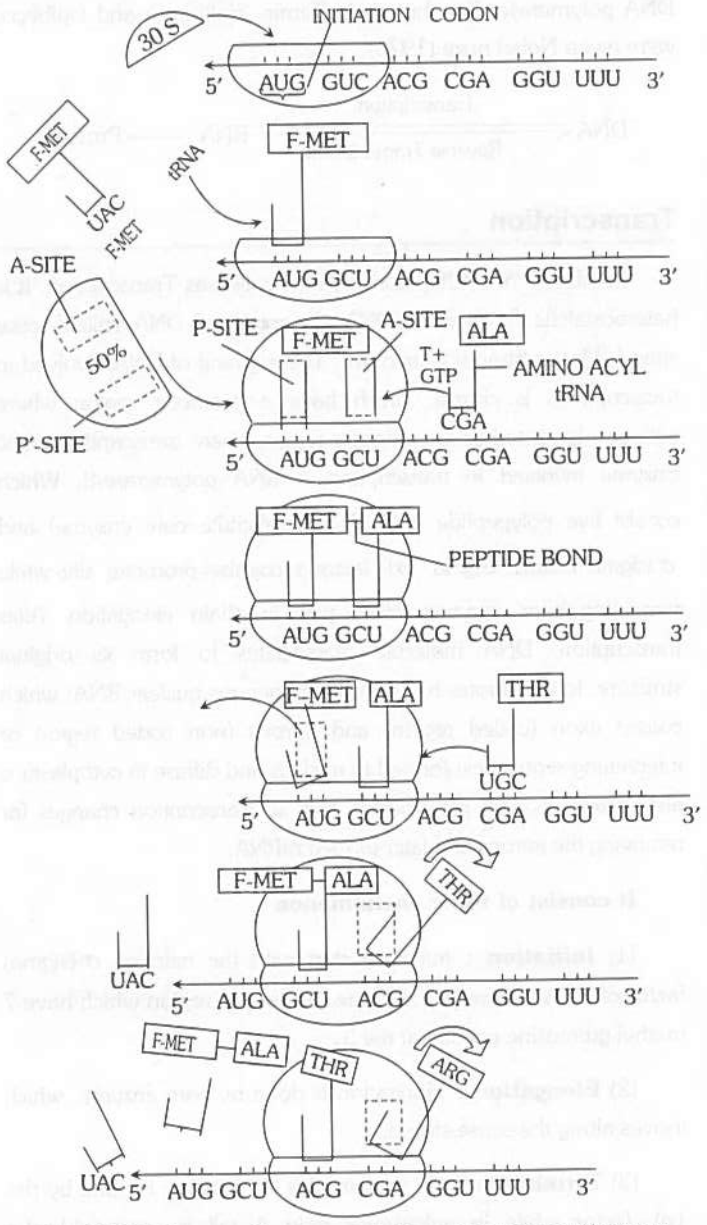


Fig : 7.2-8 Diagramatic representation of protein synthesis in prokaryotes

Genes expression and its regulation

Gene expression in prokaryotes

Gene expression refers to the molecular mechanism by which a gene expresses a phenotype by synthesizing a protein or an enzyme, which determines the character. The gene contains the blue print or the information for the protein or an enzyme.

The category includes mechanism involved in the rapid turn-on and turn-off gene expression in response to environmental changes. Regulatory mechanism of this type is very important in microorganisms, because of the frequent exposure of these organisms to sudden changes in environment.

Gene concept can be studied by operon model. Operon are segment of genetic material which function as regulated unit that can be switched on and switched off, which was given by French scientist Jacob and Monod (1961) working at Pasteur institute. They were studying lactose utilization in mutants of *E.coli*. An operon consists of one to several structural genes (three in lac operon and five in tryptophan operon of *Escherichia coli*, nine in histidine operon of *Salmonella typhimurium*), an operator gene a promoter gene a regulator gene, a repressor and inducer or corepressor. Operons are of two types, inducible and repressible.

(1) **Inducible operon system /lac operon system :** An inducible operon system is that regulated genetic material which remains switched off normally but becomes operaticnal in the presence of an inducer. It occurs in catabolic pathways. The components are :

Structural genes : They are genes, which produce mRNAs for forming polypeptides/proteins/enzymes. Lac operon of *Escherichia coli* has three structural genes-Z (produces enzyme β-galactosidase for splitting lactose/galactoside into glucose and galactose) Y (produces enzyme galactoside permease required in entry of lactose/galactoside) and A (produces enzyme galactoside acetylase/transacetylase without any function in *E.coli*). The three structural genes of lac operon produce a single polycistronic mRNA. The three enzymes are, however, produced in different concentration.

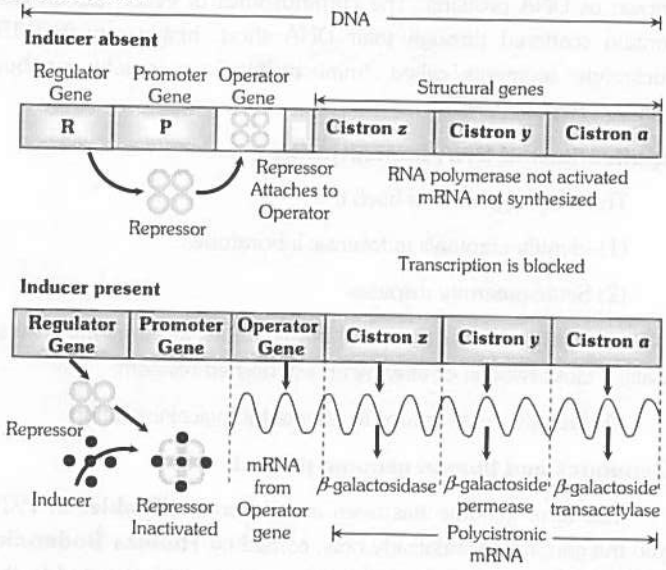


Fig : 7.2-9 Diagram representing the function of lac operon in Escherichia coli

Operator gene (O) : It gives passage to RNA polymerase when the structural genes are to express themselves. Normally, it is covered by a repressor. Operator gene of lac operon is small, made of 27 base pairs.

Promoter gene (P) : It is recognition centre / initiation point for RNA polymerase of the operon.

Regulator gene (i Gene) : It produces a repressor that binds to operator gene for keeping it nonfunctional (preventing RNA polymerase to pass from promoter to structural genes).

Repressor : It is a small protein formed by regulator gene which binds to operator gene and blocks passage of RNA polymerase towards structural enzymes. Repressor has two allosteric sites, one for attaching to operator gene and second for binding to inducer. Repressor of lac operon has a molecular weight of 160,000 and 4 subunit of 40,000 each.

Inducer : It is a chemical which attaches to repressor, changes the shape of operator binding site so that repressor no more remain attached to operator.

Table : 7.2-4 Differences between induction and repression

Induction	Repression
It turns the operon on.	It turns the operon off.
It starts transcription and translation.	It stops transcription and translation.
It is caused by a new metabolite which needs enzymes to get metabolised.	It is caused by an excess of existing metabolite
It operates in a catabolic pathway.	It operates in an anabolic pathway.
Repressor is prevented by the inducer from joining the operator gene.	Aporepressor is enabled by a corepressor to join the operator gene

Lactose/galactoside is inducer of lac operon. As soon as the operator gene becomes free, RNA polymerase is recognised by promoter gene. cAMP is required, RNA polymerase passes over the operator gene and then reaches the area of structural genes. Here it catalyses transcription of mRNAs.

(2) **Repressible operon system/tryptophan operon system :** A repressible operon system is that regulated genetic material, which normally remains active/operational and enzymes formed by its structural genes present in the cell till the operon is switched off when concentration of an end product crosses a threshold value. Repressible operon system usually occurs in anabolic pathways, *e.g.*, tryptophan operon, arginine operon. Each has the following parts.

Structural genes : They are genes, which take part in synthesis of polypeptides/proteins/enzymes through the formation of specific mRNAs. Tryptophan operon has five structural genes – E, D, C, B and A.

Operator gene : It provides passage to RNA polymerase moving from promoter to structural genes. Operator gene of repressible operon is normally kept switched on as aporepressor formed by regulator gene is unable to block the gene.

Promoter gene : It is initiation/recognition point for RNA polymerase.

Regulator gene : The gene produces an aporepressor.

Aporepressor : It is a proteinaceous substance formed through the activity of regulator gene. It is able to block operator gene only when a corepressor is also available.

Corepressor : The nonproteinaceous component of repressor, which can be end product (feed back inhibition/repression) of the reaction mediated through enzymes synthesized by structural genes. Corepressor of tryptophan operon is tryptophan. It combines with aporepressor, form repressor which then blocks the operator gene to switch off the operon.

Gene expression in eukaryotes

In regulation of gene expression in eukaryotes the chromosomal proteins play important role. The chromosomal proteins are of two types. They are histones and non-histones. The regulation of gene expression involves an interaction between histones and non-histones. Histones inhibit protein synthesis and non-histones induce RNA synthesis. There are four main steps in the expression of genes. Hence regulation is brought about by the regulation and modification of one or more of these steps. They are :

Regulation of replication : Differential gene expression is achieved by gene amplification.

Regulation of transcription : The regulation of the expression of gene is mainly done at transcription. Hybridization experiments clearly show that production of specialised protein is due to differential gene transcription.

Regulation of the processing level : Some of the RNA synthesized in the nucleus are destroyed without leaving the nucleus. 80% of the nuclear RNA has no equivalent in the cytoplasm and only 20% of the nuclear RNA is identical in the cytoplasm. All the genes in a cell are transcribed into mRNA at all times, but the mRNA produced by some genes is destroyed rapidly. But the mRNA modeled on other genes are stabilized and only these mRNAs are passed into the cytoplasm.

Regulation of translation : The control of mRNA-translation is a fundamental phenomenon. In sea-urchin eggs fertilisation is followed by a tremendous increase in protein synthesis; but in the unfertilised egg, there is no protein synthesis. Still the unfertilised egg has complete machinery (*i.e.*, amino acids, ribosomes, mRNA) for protein synthesis. There are two model for regulation in eukaryotes.

(a) **Frenster's model (1965) :** According to this the histones act as repressor during protein synthesis.

(b) **Britten Davidson model :** This is also called gene battery model or operon-operator model. It was proposed by Britten and Davidson in 1969. They have been proposed four type of genes namely integrator sensor, producer and receptor.

Gene libraries

A gene library is a collection of gene clones that contains all the DNA present in some source. If the original source of the DNA was original DNA from a living organism, then the library seek to include clones of all that DNA, it is called a genomic gene library. Gene libraries can also be created by using RNA.

cDNA

If a gene library is created by enzymatic copying of RNA by reverse transcriptase (RNA-dependent DNA polymerase), it would be called c-DNA library. c-DNA stands for complimentary DNA or copy DNA. c-DNA is made to use PCR to amplify an RNA. PCR does not work on RNA, so one can copy it to DNA using reverse transcriptase and then PCR amplify the c-DNA; this is called RT-PCR (reverse transcriptase PCR).

Gene bank

A gene bank is repository of clones of known DNA fragments, genes, gene maps, seeds, spores, frozen sperms or eggs or embryos. These are stored for possible use in genetic engineering and breeding experiment where species have become extinct.

DNA finger printing

Alec Jeffreys et al (1985) developed the procedure of genetic analysis and forensic medicine, called DNA finger printing. It is individual specific DNA identification which is made possible by the finding that no two people are likely to have the same number of copies of repetitive DNA sequences of the regions. It is also known as DNA profiling. The chromosomes of every human cell contain scattered through their DNA short, highly repeated 15 nucleotide segments called "mini-satellites" or variable-number Tandem Repeat (VNTR).

Applications of DNA fingerprinting

This technique is now used to :

(1) Identify criminals in forensic laboratories.

(2) Settle paternity disputes.

(3) Verify whether a hopeful immigrant is, as he or she claims, really a close relative of already an established resident.

(4) Identify racial groups to rewrite biological evolution.

Genomics and human genome project

The term genome has been introduced by **Winkler** in 1920 and the genomics is relatively new, coined by **Thomas Rodericks** in 1986. Genomics is the subdiscipline of genetics devoted to the mapping, sequencing and functional analysis of genomes.

Two important scientist associated with human genome are **Francis Collins**, director of the Human Genome Project and **J. Craig Venter**, founding president of Celera genomics. The complete sequencing of the first human chromosome, small chromosome 22, was published in December 1999.

Table : 7.2-5 Genome of Model organisms

Organism	No. of base pair	No. of genes
Bacteriophage	10 thousand	–
E. coli	4.7 million	4000
Saccharomyces cerevisiae	12 million	6000
Caenorhabditis elegans	97 million	18,000
Drosophila melanogaster	180 million	13,000
Human	3 billion	30,000
Lily	106 billion	–

Prospects and implications of human genome project

(1) The genome project is being compared to the discovery of antibiotics.

(2) Efforts are in progress to determine genes that will revert cancerous cells to normal.

(3) The human genome sequencing not only holds promise for a healthier living. It also holds the prospects of vast database of knowledge about designer drugs, genetically modified diets and finally our genetic identity.

Tips & Tricks

✍ M.H.F. Wilkins and his associates supported DNA double helical structure using X-ray crystallography technique.

✍ Fisher discovered purine and pyramidine bases in DNA.

✍ Repetitive DNA or Satelite DNA It is found in eukaryotes only.

✍ Palindromic DNA are inverted repetitions of bases in double stranded DNA

$$5' \xrightarrow[ATCGAT]{} 3' \; ; \; 3' \xleftarrow[TAGCTA]{} 5'$$

✍ Nucleotide ATP is always found free in cell.

✍ RNA is single stranded but it is double stranded in reovirus and wound tumour plant and Rice dwarf Virus.

✍ In vitro synthesis of DNA, RNA and Gene were done by Korenberg, Ochoa and Khorana respectively.

✍ Ribozyme : RNA acts as an enzyme having catalytic activity, discovered by Altman and Cock.

✍ Circular flow of information→DNA→RNA→Protein→RNA → DNA (commoner).

✍ Eukaryotic mRNA can be modified by the addition (at their 5′ end) of methylated arginine.

✍ Actinomycin D prevents transcription.

✍ The transcription of genes is increased by Glucocorticoid.

✍ When a particular gene codes for a m-RNA strand, it is said to be monocistronic or monogenic. When several genes (Cistrons) transcribe one m-RNA molecule it is called as polycistronic polygenic.

✍ **Informososmes :** In eukaryotes mRNA is associated with protein forming ribonucleoprotein complex. The name is given by Spirin and ratio of protein and mRNA is 4 : 1.

✍ UUU was first triplet codon discovered.

✍ Puromycin antibiotic inhibits translation.

✍ Pallindromic DNA is a segment of DNA in which the base pair sequence reads the same in both directions from a point of symmetry.

✍ Western blotting is the technique used to detect specific proteins.

✍ Northern blotting is the technique used to blot transfer of RNAs.

✍ Southern blotting technique is used for separating DNA fragments and identification of cloned genes.

✍ Gel electrophoresis and autoradiography are employed in nucleic and blotting.

✍ H_1, H_2A and H_2B proteins are lysine rich (H_1 is very lysine rich) while H_3 and H_4 are arginine rich polypeptide chains.

Ordinary Thinking

Objective Questions

Nucleic acid (DNA/RNA)

1. A complex of ribosomes attached to a single strand of RNA is known as **[NEET (Phase-I) 2016]**
   (a) Polysome (b) Polymer
   (c) Polypeptide (d) Okazaki fragment

2. Isolation and purification of specific DNA segment from a living organism was achieved by **[CBSE PMT 1993]**
   (a) Crick
   (b) Nirenberg
   (c) Khorana
   (d) Beckwith and his colleagues

3. Cyclic adenosine monophosphate was discovered by **[DPMT 1993]**

Or

caMP mediated 'Cascade model' of enzyme regulation was proposed by

(a) Bekhor *et al* (b) E.W. Sutherland
(c) Beerman (d) Weismann

4. Genetic information in a DNA molecule is coded in the **[Odisha JEE 2008]**

(a) No of bases (b) Sequence of nucleotides
(c) Length of DNA (d) Number of nucleosides

5. Prokaryotic genetic system has **[RPMT 2005]**

Or

The bacterial genome contains **[MP PMT 1996; BHU 2002]**

(a) DNA and histone (b) DNA and no histone
(c) No DNA and histone (d) No DNA and no histone

6. The polymerase chain reaction is a technique that **[Odisha JEE 2008]**

(a) Is used for in vivo replication of DNA
(b) Is used for in vivo synthesis of mRNA
(c) Is used for in vitro synthesis of mRNA
(d) Used for in vitro replication of specific DNA sequence using thermostable DNA polymerase

7. If an isolated strain of DNA is kept at 82–90° *C*, then **[CPMT 1995]**

(a) It changes into RNA
(b) It divides into one million pieces
(c) No effect
(d) It uncoils into helixes

8. Antiparallel strands of a DNA molecule means that **[CBSE PMT 2006]**

(a) The phosphate groups at the start of two DNA strands are in opposite position (pole)
(b) One strand turns clockwise
(c) One strands turns anti-clockwise
(d) The phosphate groups of two DNA strands, at their ends, share the same position

9. Which site of a t-RNA molecule hydrogen bonds to a m-RNA molecule **[NCERT; MP PMT 1993, 2002; AMU (Med.) 2006]**

(a) Codon
(b) Anticodon
(c) 5′ end of the t-RNA molecule
(d) 3′ end of the t-RNA molecule

10. Nucleotide arrangement in DNA can be seen by **[VITEEE 2008]**

(a) X-ray crystallography (b) Electron microscope
(c) Ultracentrifuge (d) Light microscope

11. RNA interference is essential for the **[AIIMS 2012]**

(a) Cell proliferation (b) Cell defence
(c) Cell differentiation (d) Micropropagation

12. Who was awarded Nobel Prize for synthesis of RNA in 1959 **[BVP 2003]**

(a) S. Ochoa (b) A. Kornberg
(c) H. Khorana (d) Nirenberg

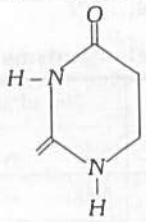
13. Break through of the year 2002 **[Kerala CET 2003]**

(a) cDNA (b) 16 *S*rRNA
(c) *r*DNA (d) *mi*RNA

14. Uridine, present only in RNA is **[Kerala CET 2002; NEET (Karnataka) 2013]**

(a) Nucleoside (b) Nucleotide
(c) Purine (d) Pyrimidine

15. Identify this structure



[KCET 2015]

(a) Adenylic acid (b) Uracil
(c) Cholesterol (d) Adenosine

16. Feulgen reaction is a special test for **[MP PMT 2000]**

(a) RNA (b) DNA
(c) Protein (d) Carbohydrate

17. There is no DNA in **[CBSE PMT 2009]**

(a) An enucleated ovum (b) Mature RBCs
(c) A mature spermatozoan (d) Hair root

18. Removal of introns and joining the exons in a defined order in a transcription unit is called **[NCERT; CBSE PMT 2009; Kerala PMT 2010; CBSE PMT (Pre.) 2012]**

(a) Splicing (b) Tailing
(c) Transformation (d) Capping

19. Semiconservative model of DNA replication was proposed by which workers in eukaryotes **[NCERT; MP PMT 1993, 94, 96, 97, 99; DPMT 1996; AMU (Med.) 1997; BHU 1997; CPMT 2010]**

(a) Taylor, Woods and Hughes, 1957
(b) Messelson and Stahl, 1957
(c) Nirenberg and Khorana, 1967
(d) Watson and Crick, 1952

20. Semiconservative replication of DNA was first demonstrated in **[CBSE PMT 2009]**

(a) *Drosophila melanogaster*
(b) *Escherichia coli*
(c) *Streptococcus pneumoniae*
(d) *Salmonella typhimurium*

21. Which one of the following pairs of nitrogenous bases of nucleic acids, is wrongly matched with the category mentioned against it **[CBSE PMT 2008]**

(a) *Guanine, Adenine – Purines*
(b) *Adenine, Thymine – Purines*
(c) *Thymine, Uracil - Pyrimidines*
(d) *Uracil, Cytosine - Pyrimidines*

22. Which one of the following is called polynucleotide joining enzyme **[CBSE PMT 2002]**

Or

Okazaki fragments are linked by **[J & K CET 2010]**

Or

A foreign DNA and plasmid cut by the same restriction endonuclease can be joined to form a recombinant plasmid using **[NEET (Phase-II) 2016]**

(a) Polymerase I (b) Polymerase II
(c) Ligase (d) Ribonuclease

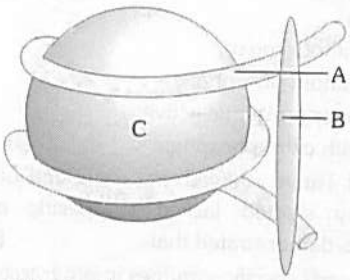
23. One turn of the helix in a B-form DNA is approximately **[CBSE PMT 2006]**
(a) 3.4 *nm* (b) 2 *nm*
(c) 20 *nm* (d) 0.34 *nm*

24. A–DNA is **[WB JEE 2012]**
(a) Left handed helix with 12 nucleotide pair per turn
(b) Right handed helix with 11 nucleotide pairs per turn
(c) Right handed helix with 12 nucleotide pairs per turn
(d) Left handed helix with 11 nucleotide pairs per turn

25. Which form of RNA is most heterogeneous **[Haryana PMT 2005]**
(a) tRNA (b) mRNA
(c) rRNA (d) hnRNA

26. The name "mRNA" was given by
(a) Kornberg and Khorana (b) Khorana and Nirenberg
(c) Jacob and Monad (d) Messelson and Stahl

27. Study the given figure of Nucleosome (structural unit of chromatin). Identify its componental parts indicated by A, B and C **[NCERT]**



(a) A - DNA, B - Non histone, C - Histone
(b) A - RNA, B - Histone octamer, C - H1 histone
(c) A - DNA, B - H1 histone, C - Histone octamer
(d) A - RNA, B - Non histone, C – Histone

28. In the double helix model of DNA, how far is each base pair from the next base pair **[NCERT; Kerala PMT 2006; WB JEE 2010]**
(a) 3.4 nm (b) 0.34 nm
(c) 2.0 nm (d) 34 nm
(e) 0.034 nm

29. The nitrogen base found only in DNA is also called **[KCET 2015]**
(a) Uracil (b) 5-methyl uracil
(c) Guanine (d) NH_4CL

30. 3' AAA TGC GCG ATA 5' is the sequence of nucleotides on a gene; after transcription the mRNA formed against it and the sequence of bases in the corresponding binding anticodons will be **[KCET 2012]**
(a) 5' UUU ACG CGC UAU 3' and 3' AAA–UGC–GCG–AUA 5'
(b) 5' UAU CGC GCA UUU 3' and 3' AUA–GCG–CGU–AAA 5'
(c) 5' UUU ACC TUG UAU 3' and 3' AAA–UGG–UAC–AUA 5'
(d) 5' UAU GUT CCA UUU 3' and 3' AUA–CAU–GGU–AAA 5'

31. The enzyme, which helps to cut one strand of *DNA* duplex to release tension of coiling of two strands is **[Kerala PMT 2006; AFMC 2006; WB-JEE 2016]**
(a) *DNA* ligase
(b) *DNA* polymerase *I*
(c) Topo-isomerase
(d) Swielases (helicase or unwindases)

32. In the DNA molecule **[CBSE PMT 2008]**
(a) The proportion of Adenine in relation to thymine varies with the organism
(b) There are two strands which run antiparallel-one in 5'→3' direction and other in 3'→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'→3' direction

33. Which enzyme is responsible for linking the fragments of DNA **[NCERT; CBSE PMT 1996; Kerala PMT 2005, 09]**

Or

The DNA joining enzyme, required in recombinant DNA technology **[WB-JEE 2016]**
(a) DNA polymerase III (b) Endonuclease
(c) DNA polymerase I (d) DNA ligase

34. The double helical model of the DNA was proposed by Watson and Crick based on what data produced by Wilkins and Franklin **[Kerala PMT 2011]**
(a) Hybridization (b) DNA sequencing
(c) Southern blotting (d) Fourier's transformation
(e) X-ray diffraction

35. DNA polymerase helps in **[CPMT 2003]**
(a) Joining bits of DNA
(b) Splitting or separation of two strands of DNA
(c) Renaturation
(d) Denaturation

36. In a 3.2 Kbp long piece of DNA, 820 adenine bases were found. What would be the number of cytosine bases **[KCET 2015]**
(a) 780 (b) 1560
(c) 740 (d) 1480

37. Histone occupies the major grooves of DNA at an angle of **[CBSE PMT 2002]**
(a) 15° (b) 90°
(c) 45° to the helix axis (d) 30° to the helix axis

38. For transformation, micro-particles coated with DNA to be bombarded with gene gun are made up of **[NCERT; CBSE PMT (Pre.) 2012]**
(a) Silver or Platinum (b) Platinum or Zinc
(c) Silicon or Platinum (d) Gold or Tungsten

39. What is antisense technology **[CBSE PMT 2008]**
(a) When a piece of RNA that is complementary in sequence is used to stop expression of a specific gene
(b) RNA polymerase producing DNA
(c) A cell displaying a foreion antigen used for synthesis of antigens
(d) Production of somaclonal variants in tissue cultures

40. Which one of the following is not applicable to RNA **[AIPMT 2015]**
(a) 5' phosphoryl and 3' hydroxyl ends
(b) Heterocyclic nitrogenous bases
(c) Chargaff's rule
(d) Complementary base pairing

41. The prokaryotic enzymes with 5'→3' exonuclease property is/are **[BHU 2012]**
(a) DNA polymerase I (b) DNA polymerase II
(c) DNA polymerase III (d) Both (a) and (c)

42. A 340 Å long segment of DNA molecules has 20 thymine nitrogenous bases, what will be the number of guanine nitrogen bases in the same segment **[MHCET 2015]**
(a) 10 (b) 40
(c) 80 (d) 160

43. Which one of the following pair is correctly matched **[MP PMT 1993; CBSE PMT 2014]**

(a) Frederick Griffith	Discovered the phenomenon of transformation
(b) Linus Pauling	Isolated the DNA for the first time
(c) Francis Crick	Proposed one gene one polypeptide hypothesis
(d) George Beadle	Proposed the concept of inborn errors

44. Chargaff's rule states **[VITEEE 2006, 08; RPMT 2006]**
Or
Which one of the following ratio is constant in DNAs of different species **[NCERT]**
(a) A+G = T+C (b) A+T=G+C
(c) A+C = T+C (d) All of the above

45. The method developed by Matthew Meselson and Franklin Stahl to separate heavy DNA with ^{15}N from DNA with ^{14}N, for providing evidence for semi-conservative replication of DNA is **[MP PMT 1993; Kerala PMT 2008]**
(a) Ion exchange chromatography
(b) Density gradient centrifugation
(c) Buoyant density centrifugation
(d) Gel filtration
(e) Isopycnic centrifugation

46. The haploid content of human DNA is **[Kerala PMT 2008, 11]**
(a) 3.3×10^9 *bp* (b) 3.3×10^9 *kbp*
(c) 4.6×10^6 *bp* (d) 48502 *bp*
(e) 1.65×10^9 *bp*

47. True replication of DNA is possible due to **[Odisha JEE 2009]**
(a) Hydrogen bonding
(b) Phosphate backbone
(c) Complementary base pairing rule
(d) None of the above

48. Replication of DNA is in **[Pb. PMT 1999; MP PMT 2001; Haryana PMT 2005]**
(a) 3' → 5' direction
(b) 2' → 5' direction
(c) Both 3' → 5' and 5' → 3' direction
(d) None of these

49. DNA replication is aided by **[NCERT; AFMC 1995; BCECE 2005; MP PMT 2007]**
(a) DNA polymerase only
(b) DNA ligase only
(c) Both DNA polymerase and ligase
(d) RNA polymerase

50. If the DNA codons are ATG ATG ATG and a cytosine base is inserted at the beginning, which of the following will result **[NCERT; CBSE PMT 1995]**
(a) A non-sense mutation (b) CA TGA TGA TG
(c) CAT GAT GAT G (d) C ATG ATG ATG

51. Melting of DNA at an elevated temperature (70°C) is primarily due to the breakdown of **[WB JEE 2012]**
(a) Phosphodiester bonds (b) Glycosidic bonds
(c) Disulphide (d) Hydrogen bonds

52. The part of DNA molecule that varies among DNA molecule is **[Odisha JEE 2009]**
(a) Phosphate molecule (b) Nitrogen base
(c) Sugar molecule (d) All of these

53. Ribozyme is **[BHU 1995]**
(a) RNA without sugar
(b) RNA without phosphate
(c) RNA having enzymic activity
(d) RNA with extra phosphate

54. Beadle and Tatum showed that each kind of mutant bread mould they studied lacked a specific enzyme. Their experiments demonstrated that **[DUMET 2009]**
(a) Cells needs specific enzymes in order to function
(b) Genes are made of DNA
(c) Enzymes are required to repair damage
(d) Genes carry information for making proteins

55. DNA is methylated at **[Odisha JEE 2005]**
(a) A-residue (b) G-residue
(c) T-residue (d) C-residue

56. Purines of DNA are represented by **[CBSE PMT 1996; MP PMT 1999; J & K CET 2002]**
(a) Uracil and thymine (b) Guanine and adenine
(c) Uracil and cytosine (d) Thymine and cytosine

57. A nucleoside differs from a nucleotide in not having **[MP PMT 1995, 98; J & K CET 2002; BVP 2002; DUMET 2010]**
(a) Phosphate (b) Sugar
(c) Nitrogen base (d) Phosphate and sugar

58. Watson and Crick are known for their discovery that DNA **[MP PMT 1995; EAMCET 1996; BCECE 1996; J & K CET 2002, 10; BVP 2004]**
(a) Is a single stranded helix (b) Contains deoxyribose only
(c) Is a double stranded helix (d) Synthesizes rRNA

59. The anti-parallel nature of DNA refers to **[DUMET 2009]**
(a) Its charged phosphate groups
(b) The formation of hydrogen bonds between bases from opposite strands
(c) The opposite direction of the two strands
(d) The pairing of bases on one strand with bases on the other strand

60. Phosphorus is present in **[J & K CET 2005]**
(a) Protein (b) DNA
(c) RNA (d) Both DNA and RNA

61. The enzyme which can cut molecules of DNA into segments is known as **[CPMT 1995; MP PMT 1995; BHU 1995; CBSE PMT 2001; Odisha PMT 2002; Kerala CET 2003; J & K CET 2008, 12; Odisha JEE 2009; AIPMT 2015]**
(a) DNA polymerase (b) DNA ligase
(c) Restriction enzyme (d) DNA gyrase

62. DNA consists of two complementary nucleotide chains. If the sequence of nucleotide in one of the chains is AGCTTCGA, then the nucleotide sequence in the other chain shall be **[BHU 1994, 04; MP PMT 1995, 2000; DPMT 2003; Odisha JEE 2011]**
(a) TAGCATAT (b) GATCCTAG
(c) TCGAAGCT (d) GCTAAGCT

63. Eukaryotes differ from prokaryotes in the mechanism of DNA replication due to **[BHU 1994]**
(a) Different enzymes (instead of same enzyme) for synthesis of lagging and leading strands
(b) Discontinuous rather than semidiscontinuous replication
(c) Use of DNA primers rather than RNA primers
(d) Unidirectional rather than bidirectional replication

64. Mode of DNA replication in *E. coli* is **[CPMT 2005]**
(a) Conservative and unidirectional
(b) Semi conservative and unidirectional
(c) Conservative and bidirectional
(d) Semi conservative and bidirectional

65. If there are 120 adenine molecules in a *bDNA* double helical structure showing 20 coils, what is the number of pyrimidine nucleotides forming three hydrogen bonds in it **[EAMCET 2009]**
(a) 80 (b) 100
(c) 120 (d) 140

66. Okazaki segments are formed during **[NCERT; CBSE PMT 1996; DUMET 2007, 10]**

Or

DNA multiplication is called **[NCERT; CPMT 1998, 2003; KCET 1999; MP PMT 2003; BHU 2006]**
(a) Replication (b) Transduction
(c) Transcription (d) Translation

67. Ribosomal RNA is synthesised in **[NCERT; MP PMT 1996]**
(a) Nucleolus (b) Nucleosome
(c) Ribosome (d) Lysosome

68. DNA is transcribed by some viral RNA using the enzyme **[MP PMT 1996, 2012]**

Or

Information transfer from RNA to DNA is called **[NCERT]**

Or

Which one of the following makes use of RNA as a template to synthesize DNA **[CBSE PMT 2005]**
(a) DNA polymerase (b) Reverse transcriptase
(c) Endonuclease (d) Ligase

69. The characteristics of a molecular probe are
(I) Very long molecule
(II) double stranded
(III) DNA or RNA
(IV) Complementary to a part of desired gene
The correct pair is **[EAMCET 2009]**
(a) I, II (b) II, III
(c) III, IV (d) IV, I

70. Transcription of DNA is aided by **[NCERT; MP PMT 1996, 2001; CPMT 2001, 03]**
(a) RNA polymerase (b) DNA polymerase
(c) Exonuclease (d) Recombinase

71. Which of the endonuclease is mostly used in Genetic Engineering **[VITEEE 2006]**
(a) Type I (b) Type II
(c) Type III (d) (a) & (c)

72. When DNA replication starts **[KCET 2009]**
(a) The leading strand produces Okazaki fragments
(b) The hydrogen bonds between the nucleotides of two strands break
(c) The phosphodiester bonds between the adjacent nucleotides break
(d) The bonds between the nitrogen base and deoxyribose sugar break

73. Okazaki fragments are synthesised on **[CPMT 2005]**
(a) Leading strands of DNA only
(b) Lagging strands of DNA only
(c) Both leading and lagging strands of DNA
(d) Complementary DNA

74. mRNA is a polymer of **[MP PMT 1997]**
(a) Deoxyribonucleosides (b) Ribonucleosides
(c) Deoxyribonucleotides (d) Ribonucleotides

75. Non-genetic RNA is of **[MP PMT 1999, 2000]**
(a) Two types (b) Three types
(c) Only one type (d) None of these

76. What is the type of coiling in DNA **[MP PMT 1999]**
(a) Right-handed (b) Left-handed
(c) Zig-Zag (d) Opposite

77. The successive nucleotides of RNA are covalently linked through or antiparallal **[CPMT 1999; JIPMER 2001; MP PMT 2001]**
(a) Glycosidic bonds (b) Phosphodiester bonds
(c) Hydrogen bonds (d) None of these

78. During DNA replication, the addition of nucleotides on the lagging strand occurs **[MHCET 2015]**
(a) Towards the replicating fork
(b) At a faster rate than leading strand
(c) Continuously
(d) Discontinuously

79. Recombinant DNA is achieved by cleaving the pro-DNAs by **[CBSE PMT 1998; RPMT 2006]**

Or

DNA finger printing is based on DNA segments formed by **[NCERT]**
(a) Primase (b) Exonucleases
(c) Ligase (d) Restriction endonuclease

80. The chemical knives of DNA are **[NCERT; CBSE PMT 1998; VITEEE 2008; BHU 2008]**

Or

Enzyme that cleaves nucleic acids within the polynucleotide chain is known as **[DUMET 2010]**

(a) Ligases (b) Polymerases
(c) Endonucleases (d) Transcriptases

81. In sea urchin DNA, which is double stranded, 17% of the bases were shown to be cytosine. The percentages of the other three bases expected to be present in this DNA are **[AIPMT (Cancelled) 2015]**

(a) G 17%, A 16.5%, T 32.5%
(b) G 17%, A 33%, T 33%
(c) G 8.5%, A 50%, T 24.5%
(d) G 34%, A 24.5%, T 24.5%

82. Which of the following RNAs picks up specific amino acid (from amino acid pool) in the cytoplasm to ribosome during protein synthesis **[NCERT; CBSE PMT 1997; AIIMS 1998]**

Or

Which form of RNA has a structure resembling clover leaf **[CBSE PMT 2004]**

(a) *t*RNA (b) *m*RNA
(c) *r*RNA (d) All of these

83. Read the following statements and choose the correct option

A. Nitrogenous base is linked to the pentose sugar through a N-glycosidic linkage
B. Phosphate group is linked to 5'-OH of a nucleoside through phosphoester linkage
C. Two nucleosides are linked through 3'-5' N-glycosidic linkage
D. Negatively charged DNA is wrapped around positively charged histone octamer to form nucleosome
E. The chromatin that is more densely packed and stains dark is called euchromatin **[Kerala PMT 2012]**

(a) A, B and C alone are wrong
(b) D alone is wrong
(c) C and E alone are wrong
(d) A alone is wrong
(e) A, B and D alone are wrong

84. The substance that acts as connecting link between two generations is **[RPMT 1997]**

(a) Ribonucleic acid
(b) Deoxyribonucleic acid
(c) Nucleoplasm
(d) Ribonucleic acid + Deoxyribonucleic acid

85. Which one of the following peak absorption of ultraviolet light by heterocyclic bases (Nitrogen bases) **[BHU 2000]**

(a) 1500 *nm* (b) 26 *nm*
(c) 75 *nm* (d) 260 *nm*

86. The enzyme that breaks H_2 bonds in DNA is **[Kerala CET 2002]**

(a) Helicase (b) Topoisomerase
(c) Ligase (d) Polymerase

87. Exon part of *m*-RNAs has code for **[CBSE PMT 2002; WB JEE 2009]**

(a) Protein (b) Lipid
(c) Phospholipid (d) Carbohydrate

88. It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for genetic material. This is written by **[Kerala CET 2003]**

(a) Meselson and Stahl (b) Archibold Garrod
(c) Severo Ochoa (d) Watson and Crick

89. DNA elements, which can switch their position, are called **[CBSE PMT 1998; MP PMT 2004; BHU 2005, 06; VITEEE 2006; CPMT 2009; Odisha JEE 2010, 12; WB JEE 2010]**

(a) Exons
(b) Introns
(c) Cistrons
(d) Transposons/Jumping genes

90. The specific DNA sequence where Eco R1 cuts is **[Kerala CET 2003; Odisha JEE 2004; AMU (Med.) 2012]**

Or

Which of the following palindromic sequence is recognized by EcoRI **[NCERT]**

(a) ATTCGA / TAAGCT (b) GAATTC / CTTAAG
(c) GCTTAA / CGAATT (d) GTTCAA / CAAGTT

91. The enzyme DNA polymerase was discovered by **[Kerala CET 2003; Kerala PMT 2003]**

(a) Kornberg (b) Okazaki
(c) Waston and Crick (d) Jacob and Monod

92. What is false about *t* RNA **[AIIMS 2003]**

(a) It binds with an amino acid at it 5' end
(b) It has five double stranded regions
(c) It has a codon at one end which recognizes the anticodon on messenger RNA
(d) It looks like clover leaf in the three dimensional structure

93. c-DNA can be formed by **[DPMT 2003; Odisha JEE 2011]**

(a) Transaminase
(b) DNA ligase
(c) RNA dependent DNA polymerase (Reverse Transcriptase)
(d) DNA dependent DNA polymerase

94. Which of the following is not correct **[DPMT 2003; Haryana PMT 2005]**

(a) $\frac{A}{T}=1$ (b) $A+T=G+C$
(c) $A+G=C+T$ (d) None of these

95. Which is not correctly matched **[BHU 2003]**

(a) Lipase - Hydrolysis of fats
(b) Isomerases - Joining of similar substrate and management of substrate
(c) Polymerase - Chain elongation
(d) DNA ligase - Breaks DNA strand into two segments

96. In a mutational event, when adenine is replaced by guanine, it is a case of **[CBSE PMT 2004]**

Or

A mutation which substitutes one purine base with another purine base is called **[VITEEE 2008]**

(a) Transition (b) Transversion
(c) Frameshift mutation (d) Transcription

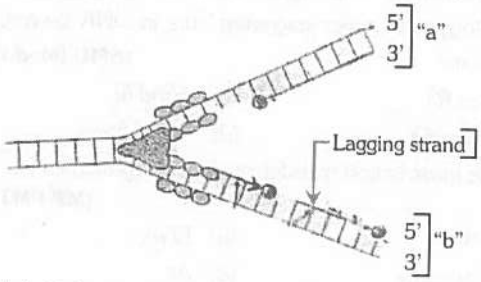
97. During transcription, if the nucleotide sequence of the DNA strand that is being coded is ATACG; then the nucleotide sequence in the *m*RNA would be **[NCERT; Manipal 1995; CBSE PMT 2004; Kerala PMT 2004; RPMT 2006; Odisha JEE 2008; WB JEE 2011; CBSE PMT (Pre.) 2012]**

(a) UAUGC (b) UATGC
(c) TATGC (d) TCTGG

98. During replication of a bacterial chromosome DNA synthesis starts from a replication origin site and **[CBSE PMT 2004]**

(a) Moves in one direction of the site
(b) Moves in bi-directional way
(c) RNA primers are involved
(d) Is facilitated by tolemerase

99. Which option shows correctly labelled region in the given diagram of DNA replication **[GUJCET 2014]**



(a) Only c (b) a, c
(c) a, b (d) b,c

100. Removal of *RNA* polymerase III from nucleoplasm will affect the synthesis of **[CBSE PMT (Pre.) 2012]**

Or

Eukaryotic RNA polymerase III catalyse the synthesis of **[Kerala CET 2003]**

(a) *tRNA* (b) *hnRNA*
(c) *mRNA* (d) *rRNA*

101. DNA repairing is done by **[NCERT; Kerala CET 2002; AFMC 2004; Odisha JEE 2004, 05; MP PMT 2006]**

(a) Ligase (b) DNA polymerase III
(c) DNA polymerase II (d) DNA polymerase I

102. Transforming principle in Griffith's experiment was DNA. It was discovered by **[MHCET 2004]**

(a) Zinder and Lederberg
(b) Avery, McLeod and McCarthy
(c) Lederberg and Tatum
(d) Zinder and Tatum

103. The enzyme required to catalyze the polymerization of deoxynucleotides is **[Kerala PMT 2012]**

(a) DNA ligase (b) DNA polymerase
(c) β-galactosidase (d) Transacetylase
(e) RNases

104. The bacterium used in Griffith's experiment was **[MHCET 2004]**

(a) Bacillus (b) Monococcus
(c) Diplococcus (d) Spirillum

105. Which RNA carries information from DNA in protein synthesis **[CPMT 1995; AIIMS 1998; BVP 2000]**

Or

In biotechnical processes cDNA is prepared from **[BHU 2012]**

(a) *s*-RNA (b) *t*-RNA
(c) *r*-RNA (d) *m*-RNA

106. New strand on a DNA template is initiated by **[MHCET 2002]**

(a) RNA polymerase
(b) DNA polymerase
(c) DNA ligase
(d) None of the above

107. During DNA replication, the strands separate by **[MHCET 2002]**

(a) DNA polymerase (b) Unwindase
(c) Gyrase (d) Topoisomerase

108. Select the correct option **[CBSE PMT 2014]**

	Direction of RNA synthesis	Direction of reading of the template DNA strand
(a)	5' – 3'	5' – 3'
(b)	3' – 5'	3' – 5'
(c)	5' – 3'	3' – 5'
(d)	3' – 5'	5' – 3'

109. There are special proteins that help to open up DNA double helix in front of the replication fork. These protein are **[MHCET 2003]**

(a) DNA ligase (b) DNA gyrase
(c) DNA polymerase I (d) None of these

110. In a hair pin model of RNA which nitrogen base is present at the short end **[MHCET 2002]**

(a) Adenine (b) Guanine
(c) Thymine (d) Cytosine

111. The end of fragments of DNA molecule are sticky due to **[Odisha JEE 2011]**

(a) Free methylation (b) Endonuclease
(c) Unpaired bases (d) Calcium ions

112. Choose the correct statement about the direction of DNA strand **[MHCET 2004; BVP 2004]**

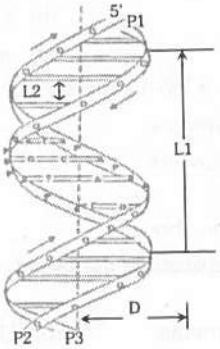
(a) 5' → 3' takes place on template strand
(b) 3' → 5' takes place on new strand
(c) 5' → 3' takes place on leading strand
(d) None of these

113. Which one of the following hydrolyses internal phosphodiester, bonds in a polynucleotide chain **[CBSE PMT 2005]**

(a) Lipase (b) Exonuclease
(c) Endonuclease (d) Protease

114. Nucleotides are building blocks of nucleic acids. Each nucleotide is a composite molecule formed by
[NCERT; AIIMS 1993; MP PMT 2000, 09; BVP 2001; CBSE PMT 2005; AMU (Med.) 2012]
(a) (Base-sugar)*n* (b) Base-sugar-OH
(c) Base-sugar-phosphate (d) Sugar-phosphate

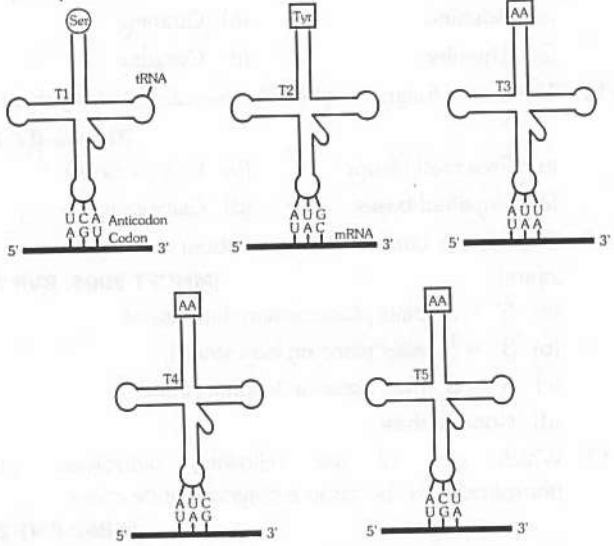
115. The adjoining figure given below shows DNA double helix. Which one of the following option gives the correct information about the DNA **[NCERT]**



	P1	P2	P3	L1	L2	D
(a)	3'	5'	3'	3.4 Å	34 Å	20 Å
(b)	3'	5'	3'	34 Å	3.4 Å	20 Å
(c)	3'	5'	3'	3.4 Å	34 Å	10 Å
(d)	3'	5'	3'	34 Å	3.4 Å	10 Å

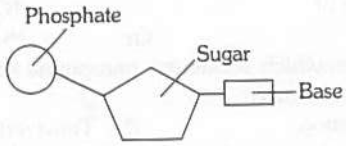
116. What would be the correct base sequence in mRNA for the given DNA strand **[Kerala PMT 2009]**
5' – AATGCCTTAAGC – 3'
(a) 5' – GCUUAAGGCAUU – 3'
(b) 5' – UUACGGAATTCG – 3'
(c) 3' – UUACGGAAUUCG – 5'
(d) 3' – AAUGCCUUAUCG – 5'
(e) 5' – UUACCGAUUUCG – 3'

117. Study the following tRNA molecules related with their anti codon pairing with respective codons. Which types of tRNA is impossible **[NCERT]**

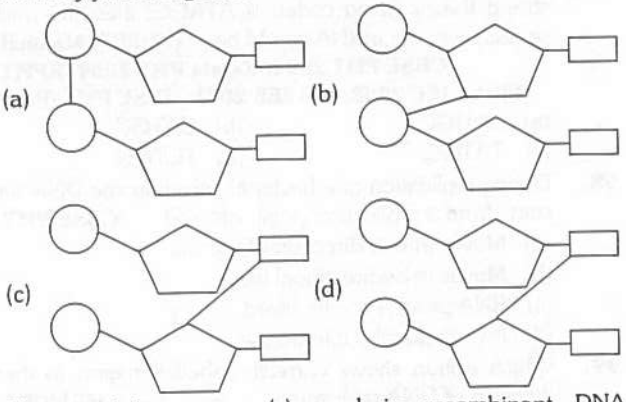


(a) T1 and T2 (b) T1, T2 and T3
(c) T1 and T4 (d) T3, T4 and T5

118. The structure of one nucleotide is given below **[NCERT]**



Which of the following figure shows two nucleotides correctly joined together



119. The restriction enzyme(s) used in recombinant DNA technology that make staggered cuts in DNA leaving sticky ends is/are **[AMU (Med.) 2012]**
(a) *Eco R I* (b) *Hind III*
(c) *Bam H I* (d) All of these

120. Genetic information transfer nucleus to cytoplasm by **[MP PMT 2005]**
(a) DNA (b) RNA
(c) Lysosome (d) All

121. Supercoiled DNA can be traced in **[Wardha 2005]**
(a) Prokaryotes and eukaryotes
(b) Eukaryotes only
(c) Prokaryotes only
(d) None of these

122. DNA is double helix and **[NCERT; Wardha 2005]**
(a) Right handed complementary and parallel
(b) Right handed complementary and antiparallel
(c) Without super coils
(d) Always circular

123. Degeneration of DNA after heating can be studied by comparing **[Wardha 2005]**
(a) A : T ratio (b) G : C ratio
(c) Sugar : Phosphate (d) Number of nucleotides

124. Major difference between *DNA* and *c DNA* is **[VITEEE 2006]**
(a) Exons absent in *DNA* (b) Introns absent in *c DNA*
(c) Introns present in *c DNA* (d) Both (a) and (b)

125. If a length of *DNA* has 45,000 base pairs, how many complete turns will the *DNA* molecule take **[NCERT; KCET 2007]**
(a) 4,500 (b) 45,000
(c) 45 (d) 450

126. Amino acid binding site of *tRNA* is **[Odisha JEE 2012]**
(a) 5'*end* (b) *T ψ C* loop
(c) *DHU* loop (d) 3' end

127. Which of the following is not relevant to the structure of double helical *DNA* **[Kerala PMT 2007]**
(a) The helix makes one complete spiral turn every 34Å
(b) The diameter of the helix is 20Å
(c) The distance between adjacent nucleotide is 3.4Å
(d) Each strand of helix has a backbone made up of alternating ribose sugar and phosphate
(e) The two adjacent sugar molecules joined with phosphate by phosphodiester bond

128. Which is the initial step in *m-RNA* maturation process **[Kerala PMT 2007]**
(a) Polyadenylation
(b) 5' capping
(c) Splicing
(d) Endonucleolytic cleavage
(e) Sealing by ligase

129. Statements
A. The four nucleotide bases are not necessarily present in *DNA* in exact equal proportions
B. The total amount of purines are equal to the total amount of pyrimidines
C. *DNA* ligase enzyme act to hydrolyse or breakdown a polynucleotide chain into its component nucleotides
D. Nuclease enzymes are capable of restoring an intact *DNA* duplex
Of the above statements **[Kerala PMT 2007]**
(a) *B* is correct but *A*, *C* and *D* are wrong
(b) *A* and *B* are wrong but *C* and *D* are correct
(c) *A*, *B* and *C* are correct but *D* is wrong
(d) *A* and *B* are correct but *C* and *D* are wrong
(e) *B*, *C* and *D* are correct but *A* is wrong

130. Which one of the following is correct **[KCET 2011]**
(a) Introns are present in *m*RNA and exons are present in *t*RNA
(b) Codons are present in *m*RNA and anticodons in *t*RNA
(c) Every intron is a set of three terminator codons
(d) Exons are present in eukaryotes while introns are present in prokaryotes

131. In prokaryotes, the process of replication is catalysed by the following enzymes. Identify which of the enzymes is best coordinate with the role **[NCERT; AIIMS 2009]**
(a) Helicase – Joins the ends of DNA segments
(b) DNA polymerase-I – Synthesises DNA
(c) DNA polymerase-II – Erases primer and fills gaps
(d) Primase – Synthesises RNA primers

132. The eukaryotic genome differs from the prokaryotic genome because **[CBSE PMT 1999; MP PMT 2006]**
(a) Repetitive sequences are present in eukaryotes
(b) Genes in the former case are organized into operons
(c) The DNA is complexed with histones in prokaryotes
(d) The DNA is circular and single stranded in prokaryotes

133. The double helix model of Watson and Crick is known as **[CPMT 2004]**
(a) C-DNA (b) B-DNA
(c) Z-DNA (d) D-DNA

134. Find out the wrong statement **[Kerala PMT 2007]**
(a) Mobile genetic elements, transposons were visualized by Barbara McClintock
(b) Udder cell, a somatic cell is used to produce the cloned sheep by nuclear transplantation method
(c) In pedigree analysis, a person immediately affected by an action is called propositus
(d) Dr. Ian Wilmut produced a cloned sheep called Dolly
(e) *DNA* ligases are used to cleave a *DNA* molecule

135. Who among the following did not provide experimental proof for the semiconservative model of DNA replication **[DPMT 2007]**
(a) Meselson & Stahl (b) Cairns
(c) Watson & Crick (d) Taylor

136. *mRNA* carries the genetic information from *DNA* to the **[J & K CET 2010]**
Or
Which of the following is the site of translation of the mRNA **[J & K CET 2012]**
(a) Chloroplasts (b) Ribosomes
(c) Mitochondria (d) Lysosomes

137. During DNA replication in prokaryotes DNA is anchored **[MP PMT 2007]**
(a) Chromosome (b) Mesosome
(c) Nucleolus (d) Ribosome

138. DNA is acidic due to **[MP PMT 2007]**
(a) Sugar (b) Phosphoric acid
(c) Purine (d) Pyrimidine

139. RNA is not found in **[MHCET 2003; MP PMT 2007]**
(a) Chromosome (b) Plasmmalemma
(c) Nucleolus (d) Ribosome

140. The length of DNA molecule greatly exceeds the dimensions of the nucleus in eukaryotic cells. How is this DNA accommodated **[CBSE PMT 2007]**
(a) Deletion of non-essential genes
(b) Super-coiling in nucleosomes
(c) DNAase digestion
(d) Through elimination of repetitive DNA

141. The two polynucleotide chains in DNA are **[CBSE PMT 2007]**
(a) Parallel (b) Discontinuous
(c) Antiparallel (d) Semiconservative

142. In DNA of certain organisms, guanine constitutes 20% of the bases. What percentage of the bases would be adenine **[NCERT; Kerala PMT 2009; WB JEE 2012]**
(a) 0% (b) 10%
(c) 20% (d) 30%
(e) 40%

143. Base composition in RNA is **[BHU 2008]**
(a) A + T = G + C (b) A + G = T + C
(c) A + U = G + C (d) A + G = U + C

144. Left handed DNA among following is **[BHU 2008]**
(a) Z DNA (b) A DNA
(c) C DNA (d) B DNA

145. Which of the following be named for DNA produced from RNA **[WB JEE 2008]**
(a) A–DNA (b) B–DNA
(c) C-DNA (d) Z–DNA

146. *hn*-RNA undergoes two additional processing. Out of which, in one of them an unusual nucleotide (methyl guanosine triphosphate) is added to the 5'-end of *hn*RNA. This is known as **[AIIMS 2009, 13; AMU (Med.) 2010; Kerala PMT 2011]**

(a) Capping (b) Tailing
(c) Splicing (d) Termination

147. If a segment of an *m*RNA molecule has the sequence 5' GUACCGAUCG 3', which of the following could have been the template DNA molecule **[AIIMS 2010]**

(a) 5' GCUAGCCAUG 3'
(b) 5' GUACCGAUCG 3'
(c) 5' CATGGCTAGC 3'
(d) 5' CGATCGGTAC 3'

148. Clover leaf model of *tRNA* was suggested by **[J & K CET 2010]**

(a) Went (b) Flemming
(c) Holley (d) Messelson

149. Width of DNA molecule is **[MP PMT 2009; J & K CET 2010]**

(a) 15 Å (b) 20 Å
(c) 25 Å (d) 34 Å

150. Z-DNA and B-DNA differ in **[BHU 2012]**

(a) Constitution of bases (b) Conformation
(c) Number of helix (d) Base pairing

151. Match the following

(a) tRNA	1. Linking of amino acids
(b) mRNA	2. Transfer of genetic information
(c) rRNA	3. Nucleolar organising region
(d) Peptidyl transferase	4. Transfer of amino acid from cytoplasm of ribosome

Codes **[AIIMS 2007]**

	A	B	C	D
(a)	4	2	3	1
(b)	1	4	3	2
(c)	1	2	3	4
(d)	1	3	2	4

152. If percentage of cytosine is 18%, then percentage of adenine will be **[NCERT; Haryana PMT 2005; AFMC 2009, 10]**

(a) 32% (b) 64%
(c) 36% (d) 23%

153. DNA nucleotides are attached by **[AFMC 2009; PET (Pharmacy) 2013]**

(a) Hydrogen bond (b) Covalent bond
(c) Van der waals bond (d) Electrovalent Bond

154. During Meselson and Stahl's experiments, heavy DNA was distinguished from normal DNA by centrifugation in **[Kerala PMT 2010]**

(a) *CsOH* gradient
(b) $^{14}NH_4Cl$
(c) $^{15}NH_4Cl$
(d) $^{35}SO_2$
(e) *CsCl* gradient

155. Consider the following statements

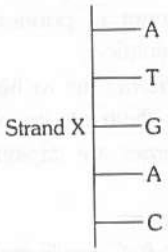
(A) *r*-RNA provides the template for synthesis of proteins
(B) *t*-RNA brings amino acids and reads the genetic code
(C) RNA polymerase binds to promoter and initiates transcription
(D) A segment of DNA coding for polypeptide is called intron **[Kerala PMT 2010]**

(a) (A) and (C) are correct
(b) (A) and (B) are correct
(c) (A), (B) and (C) are correct
(d) (B) and (C) are correct
(e) (A),(B) and (D) are correct

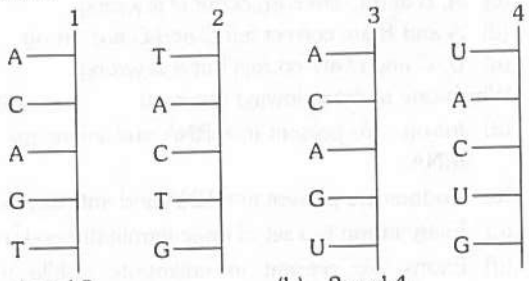
156. Locations or sites in the human DNA where single base DNA differences occurs are called **[Kerala PMT 2010]**

(a) Repetitive DNA (b) VNTR
(c) SNP (d) SSCP
(e) Expressed sequence tags

157. Strand X in the figure shows a small part of a nucleic acid molecule **[NCERT]**



Which pair of the following strands are complementary to strand X



(a) 1 and 3 (b) 2 and 4
(c) 1 and 2 (d) 3 and 4

158. If the total amount of adenine and thymine in a double-stranded DNA is 45%, the amount of guanine in this DNA will be **[DUMET 2010]**

(a) 22.5% (b) 27.5%
(c) 45% (d) 55%

159. The 3' –5' phosphodiester linkages inside a polynucleotide chain serve to join **[CBSE PMT (Mains) 2010]**

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

160. DNA synthesis during replication is **[MP PMT 2010]**

(a) Discontinuous (b) Continuous
(c) Semi-discontinuous (d) None of the above

161. Purines possess nitrogen at **[WB JEE 2010]**

(a) 1, 2, 4 and 6 position (b) 1, 3, 5 and 7 position
(c) 1, 3, 7 and 9 position (d) 1, 2, 6 and 8 position

162. Which of the following is structural subunit of DNA **[WB JEE 2010]**

Or

Nucleic acid are polymer of **[NCERT; BCECE 2005]**

(a) Protein (b) Carbohydrate
(c) RNA (d) Nucleotides

163. DNA gyrase, the enzyme that participates in the process of DNA replication is a type of **[KCET 2010]**

(a) DNA topoisomerase (b) Reverse transcriptase
(c) DNA ligase (d) DNA polymerase

164. The 5' end of polynucleotide chain is attached to **[Odisha JEE 2010]**

(a) Hydroxyl group (b) Carboxyl group
(c) Methyl group (d) Phosphate group

165. Which one of the following palindromic base sequences in DNA can be easily cut at about the middle by some particular restriction enzyme **[NCERT; CBSE PMT (Pre.) 2010, 12; Kerala PMT 2012]**

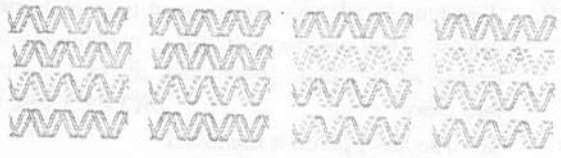
(a) 5' ——CACGTA——3'
3' ——CTCAGT——5'
(b) 5' ——CGTTCG——3'
3' ——ATGGTA——5'
(c) 5' ——GATATG——3'
3' ——CTACTA——5'
(d) 5' GAATTC 3'
3' CTTAAG 5'

166. DNA or RNA segment tagged with a radioative molecule is called **[CBSE PMT (Pre.) 2010, 12]**

(a) Plasmid (b) Vector
(c) Probe (d) Clone

167. A cell is grown in a solution which contain radioactive nucleotides, so that its DNA is labelled with radioactivity. It is isolated from the radioactive solution and grown in a normal medium, so that any new DNA strands it makes will not be radioactive. The cell replicates its DNA and divides in the normal medium. The two daughter cells also replicate their DNA and divide, producing a total of four cells. If a dotted line represents a radioactive DNA strand and a solid line represents a nonradioactive DNA strand, which of the following depicts the DNA of the four cells **[NCERT]**

(a)
(b)
(c)
(d)



168. The unequivocal proof of DNA as the genetic material came from the studies on a **[NCERT; CBSE PMT (Mains) 2011]**

(a) Viroid (b) Bacterial virus
(c) Bacterium (d) Fungus

169. Which one of the following also acts as a catalyst in a bacterial cell **[NCERT; CBSE PMT (Pre.) 2011]**

Or

Which one of the following rRNAs acts as structural RNA as well as ribozyme in bacterial **[NEET (Phase-II) 2016]**

(a) 23 sr RNA (b) 5 sr RNA
(c) sn RNA (d) hn RNA

170. Automated *DNA* sequencers, work on the principle of the method developed by **[Kerala PMT 2011]**

(a) Erwin Chargaff (b) Maurice Wilkins
(c) Frederick Sanger (d) Francis Crick
(e) Alec Jeffreys

171. Which of the following statements are correct

(i) *RNA* polymerase I transcribes *rRNAs*
(ii) *RNA* polymerase II transcribes *snRNAs*
(iii) *RNA* polymerase III transcribes *hnRNA*
(iv) *RNA* polymerase II transcribes *hnRNA*

[Kerala PMT 2011]

(a) (i) and (ii) are correct (b) (i) and (iii) are correct
(c) (i), (ii) and (iv) are correct (d) (ii) and (iii) are correct
(e) (i) and (iv) are correct

172. In Hershey and Chase experiments, radioactive ^{32}P was used to culture bacteriophages which resulted in radioactive **[Kerala PMT 2011]**

(a) Viral *DNA* (b) Bacterial Capsule
(c) Viral proteins (d) Plasmamembrane of bacteria

173. DNA-dependent RNA polymerase catalyzes transcription on one strand of the DNA which is called the **[NEET (Phase-II) 2016]**

(a) Antistrand (b) Template strand
(c) Coding strand (d) Alpha strand

174. Taylor conducted the experiments to prove semiconservative mode of chromosome replication on **[NEET (Phase-II) 2016]**

(a) *E. coli* (b) *Vinca rosea*
(c) *Vida faba* (d) *Drosophila melanogaster*

175. Initiation of DNA strand synthesis is performed by **[WB-JEE 2016]**

(a) DNA polymerase 1 (b) DNA Helicase
(c) DNA Primase (d) DNA Topoisomerase

176. During DNA replication, Okazaki fragments are used to elongate **[NEET 2017]**

(a) The leading strand towards replication fork
(b) The lagging strand towards replication fork
(c) The leading strand away from replication fork
(d) The lagging strand away from the replication fork

177. The final proof for DNA as the genetic material came from the experiments of **[NEET 2017]**

(a) Griffith
(b) Hershey and Chase
(c) Avery, Mcleod and McCarty
(d) Hargobind Khorana

178. The association of histone H1 with a nucleosome indicates **[NEET 2017]**

(a) Transcription is occurring
(b) DNA replication is occurring
(c) The DNA is condensed into a Chromatin Fibre
(d) The DNA double helix is exposed

Gene regulation and Genetic code

1. There are 64 types of codons in genetic code dictionary because **[CBSE PMT 1990]**

(a) There are 64 types of tRNA's found in cell
(b) There are 44 meaningless and 20 codons for amino acids
(c) There are 64 amino acids for coding
(d) Genetic code is triplet

2. Barbara McClintock is famous for her work on **[HPMT 2001]**
(a) Wheat (b) Rice
(c) Maize (d) *Pisum*

3. Which one of the following group of codons is called as degenerate codons **[Kerala PMT 2006; WB JEE 2011]**
(a) UAA, UAG and UGA
(b) GUA, GUG, GCA, GCG and GAA
(c) UUC, UUG, CCU, CAA and CUG
(d) UUA, UUG, CUU, CUC and CUG
(e) AAC, AAG, GAC and CGG

4. The codons causing chain termination (stop codons) are **[NCERT; CBSE PMT 1997; BVP 2001, 02; Kerala CET 2003; MHCET 2003; Pb. PMT 2004; Bihar CECE 2006; DPMT 2006]**
(a) TAG, TAA, TGA (b) GAT, AAT, AGT
(c) AGT, TAG, UGA (d) UAG, UGA, UAA

5. Which one of the following is the starter codon **[NEET (Phase-I) 2016]**
(a) AUG (b) UGA
(c) UAA (d) UAG

6. Genetic code consists of **[AFMC 1993]**
(a) 4 codons, each with two nucleotides
(b) 16 codons, each with four nucleotides
(c) 64 codons, each with two nucleotides
(d) 64 codons, each with three nucleotides

7. The sequence of nitrogen bases in a particular region of the non- coding strand of a DNA molecule was found to be CAT GTT TAT CGC. What would be the sequence of nitrogen bases in the *m*RNA that is synthesized by the corresponding region of the coding strand in that DNA **[KCET 2006]**
(a) GUA CAA AUA GCC (b) GTA CAA ATA GCC
(c) CAU GUU UAU CGC (d) CAA GAA TAU GCC

8. In 125 amino acid sequence if the codon for 25th amino acid is mutated to UAA, then **[KCET 2015]**
(a) A polypeptide of 24 amino acids is formed
(b) A polypeptide of 124 amino acids is formed
(c) No polypeptide are formed
(d) A polypeptide of 25 amino acids is formed

9. Whose experiments cracked the DNA and discovered unequivocally that a genetic code is a "triplet" **[CBSE PMT 2009]**
(a) Nirenberg and mathaei
(b) Hershey and Chase
(c) Morgan and Sturtevant
(d) Beadle and Tatum

10. What is not true for genetic code **[CBSE PMT 2009]**
(a) A codon in mRNA is read in a non-contiguous fashion
(b) It is nearly universal
(c) It is degenerate
(d) It is unambiguous

11. All the terminator codons begin with the nucleotide of **[KCET 2006]**
(a) Adenine (b) Uracil
(c) Guanine (d) Cytosine

12. Which one of the following pairs of codons is correctly matched with their function or the signal for the particular amino acid **[CBSE PMT 2008]**
(a) AUG, ACG – Start/Methionine
(b) UUA, UCA – Leucine
(c) GUU, GCU – Alanine
(d) UAG, UGA – stop

13. Read the following four statements (*A-D*)
(A) In transcription, adenosine pairs with uracil
(B) Regulation of *lac* operon by repressor is referred to as positive regulation
(C) The human genome has approximately 50,000 genes
(D) Haemophilia is a sex-linked recessive disease
How many of the above statements are right **[NCERT; CBSE PMT (Mains) 2012]**
(a) Two (b) Three
(c) Four (d) One

14. Transcription of genetic code occurs from DNA molecule to a **[NCERT; Odisha JEE 2009]**
(a) DNA molecule (b) RNA molecule
(c) Protein (d) Both DNA and RNA

15. The arrangement of three bases in the genetic code signifies a specific **[MP PMT 1994; WB JEE 2009; AFMC 2012]**
(a) Protein (b) Amino acid
(c) Plasmid (d) Nucleic acid

16. *m*RNA directs the building of proteins through a sequence of **[DUMET 2009]**
(a) Exons (b) Introns
(c) Codons (d) Anticodons

17. The codon which has dual function is **[Kerala PMT 2012]**

Or

Polypeptide synthesis in prokaryotes is initiated by **[BHU 2012]**
(a) UGA (b) UUU
(c) AUG (d) AAA
(e) GUC

18. Wild type *E.coli* cells are growing in normal medium with glucose. They are transferred to a medium containing only lactose as the sugar. Which one of the following changes take place **[NCERT; CBSE PMT 1995]**
(a) The lac–Operon is repressed
(b) All Operons are induced
(c) *E. coli* cells stop dividing
(d) The lac–Operon is induced

19. Khorana got the Nobel Prize on **[CPMT 1995; Pb. PMT 1999]**
(a) DNA synthesis (b) Genetic code
(c) Protein synthesis (d) Enzyme synthesis

20. A specific nucleotide sequence to which RNA polymerase attaches to initiate transcription of mRNA from a gene **[NCERT; EAMCET 2009]**
(a) Promoter gene (b) Structural gene
(c) Operon (d) Regulator gene

21. Which of the following codons has no tRNA **[Kerala PMT 2009, 12]**

(a) UAA (b) UAU
(c) UGU (d) UGC
(e) UGG

22. Who was awarded Nobel prize for the synthesis of an artificial gene **[Kerala PMT 2004]**

(a) Hargovind Khorana (b) M.S. Swaminathan
(c) B.P. Pal (d) P. Maheshwari

23. 'Operon model' for gene regulation in bacteria was proposed by **[NCERT; DPMT 2007]**

(a) Jacob and Monad (b) Barry Commoner
(c) Crick (d) Watson and Crick

24. What is the correct sequence of processes involved in central dogma **[BHU 2008]**

(a) Replication, transcription, translation
(b) Replication, translation, transcription
(c) Translation, replication, transcription
(d) Transcription, replication, translation

25. Pleitropy is a condition in which a single gene **[AMU (Med.) 2005, 06; DPMT 2006; MP PMT 2013; AIPMT 2015]**

(a) Controls only one phenotype
(b) Controls more than one phenotype
(c) Does not control any phenotype
(d) None of these

26. In lac operon, the genes *a*, *i*, *y* and *z* code respectively for **[BHU 2005; AMU (Med.) 2010; Kerala PMT 2010, 12]**

(a) Repressor protein, permease, β – galactosidase, transacetylase
(b) Transacetylase, permease, β – galactosidase, repressor protein
(c) Permease, transacetylase, repressor protein, β – galactosidase
(d) β – galactosidase, transacetylase, repressor protein, permease
(e) Transacetylase, repressor protein, permease, β – galactosidase

27. In Operon concept, regulator gene functions as **[NCERT; CBSE PMT 1999; KCET 2004]**

(a) Repressor (b) Regulator
(c) Inhibitor (d) All of these

28. Genes that are involved in turning on or off the transcription of a set of structural genes are called **[CBSE PMT 1998]**

Or

Functioning of structural genes is controlled by **[MP PMT 2001]**

(a) Polymorphic genes (b) Operator genes
(c) Redundant genes (d) Regulatory genes

29. The codon AUG has dual function. It is an initiation codon and also codes for **[KCET 2015]**

(a) Phenylalanine (b) Formaldehyde
(c) Serine (d) Methionine

30. Wobble hypothesis was given by **[AIIMS 2002; MH CET 2006]**

(a) R. W. Holley (b) H. G. Khorana
(c) M. Nirenberg (d) F. H. C. Crick

31. Out of 64 codons, 61 codons code for 20 types of amino acid. It is called **[CBSE PMT 2002; MH CET 2005; MP PMT 2007; KCET 2011]**

(a) Wobbling of codon (b) Overlapping of gene
(c) Universility of codons (d) Degeneracy of genetic code

32. The regulatory genes are located **[Kerala CET 2003]**

(a) Along with the structural genes
(b) In between operator and the structural genes
(c) In the middle of structural genes
(d) At the end of structural genes

33. Which one of the following codons codes for the same information as UGC **[AIIMS 2003]**

(a) UGU (b) UGA
(c) UAG (d) UGG

34. Identify the correct match between the codons and coding functions **[Kerala PMT 2004; Odisha JEE 2004; AMU (Med.) 2009]**

	Column I	Column II
A.	AUG	1. Phenylalanine
B.	UAA	2. Methionine
C.	UUU	3. Tryptophan
D.	UGG	4. Termination

(a) A-1, B-4, C-2, D-3 (b) A-2, B-4, C-1, D-3
(c) A-4, B-3, C-2, D-1 (d) A-4, B-1, C-3, D-2
(e) A-2, B-3, C-4, D-1

35. Which one of the following pairs is correctly matched **[Kerala PMT 2004]**

(a) Ribosomal RNA-carries aminoacids to the site of protein synthesis
(b) Transcription-process by which protein is synthesized
(c) Translation-process by which *mRNA* carries the information from nucleus to the ribosome
(d) Anticodon-site of *t*RNA molecule that contains complementary bases to the triple code on the *m* RNA
(e) Cistron-is a unit of mutation

36. A naturally occurring coding strand composed of alternating C and U residues would result in the formation of **[Kerala PMT 2004]**

(a) A polypeptide containing alternating leu and ser residues
(b) A polypeptide containing either leu or ser residues
(c) A polypeptide containing only leu residues
(d) A polypeptide containing only ser residues
(e) A polypeptide containing only phe residues

37. Which one of the following pairs is correctly matched with regard to the codon and the amino acid coded by it **[AIIMS 2004, 08]**

(a) UUA-Valine (b) AAA-Lysine
(c) AUG-Cysteine (d) CCC-Alanine

38. A sequence of how many nucleotides in messenger RNA makes a codon for an amino acid **[CBSE PMT 2004]**

(a) One (b) Two
(c) Three (d) Four

39. In *E.coli* an operator gene combine with **[AFMC 2006]**

(a) Inducer gene to switch on structural gene action
(b) Inducer gene to switch off structural gene action
(c) Regulator protein (repressor) to switch off structural gene action
(d) Regulator protein to switch on gene action

40. Operon is **[Kerala PMT 2004]**
(a) A set of closely linked genes regulating a metabolic pathways in prokaryotes
(b) The sequence of three nitrogen bases determining a single amino acid
(c) The sequence of nitrogen bases in *m*RNA which codes for a single amino acid
(d) A gene responsible for switching on or off other genes
(e) A segment of DNA specifying one polypeptide chain in protein synthesis

41. Code of $m-$ RNA and proteins are **[DPMT 2004]**
(a) Coplanar (b) Colinear
(c) Nonlinear (d) Irregular

42. Which of the following cartoon characters does not share its name with that of a gene **[AIIMS 2012]**
(a) Tintin (b) Popeye
(c) Asterix (d) Obelix

43. Which of the following is the simplest amino acid **[CBSE PMT 2005]**
(a) Tyrosine (b) Asparagine
(c) Glycine (d) Alanine

44. Gene regulation governing lactose operon of *E.coli* that involves the lac I gene product is **[AIPMT (Cancelled) 2015]**
(a) Negative and inducible because repressor protein prevents transcription
(b) Negative and repressible because repressor protein prevents transcription
(c) Feedback inhibition because excess of $\beta-$ galactosidase can switch off transcription
(d) Positive and inducible because it can be induced by lactose

45. Terminator gene **[BHU 2005]**
(a) Help in terminating flowering
(b) Help in terminating seed germination
(c) Used in hybridisation
(d) None of these

46. In the lac operon, the structural genes are switched off when **[Kerala CET 2005; Manipal 2005; KCET 2006]**
(a) Repressor binds to operator
(b) Repressor binds to promotor
(c) Repressor binds to regular
(d) Repressor binds to inducer
(e) Repressor binds to allolactose

47. In a given DNA segment ATGACC AGG ACC CCA ACA, the first base gets mutated. The effect of this on coding by this DNA segment will result in **[Kerala CET 2005]**
(a) Complete change in the type as well as sequence of amino acids
(b) Change in the first amino acid only
(c) No change in the sequence
(d) One amino acid less in the protein
(e) No coding

48. Which one of the following is common to both prokaryotes and eukaryotes **[Kerala CET 2005]**
(a) Mitotic apparatus (b) Histones
(c) Mitochondria (d) Genetic code
(e) Endoplasmic reticulum

49. Triplet codon in genetics is **[Wardha 2005]**
(a) Fixed (b) Degenerate
(c) Ambiguous (d) Non-wobbly

50. The *lac* operon is turned on when allolactose molecules bind to **[KCET 2012]**
(a) Promoter site (b) Operator site
(c) *m*RNA (d) Repressor protein

51. Jacob and Monad studied lactose metabolism in *E.coli* and proposed operon concept, which is applicable for **[CBSE PMT 2002]**
(a) Prokaryotes (b) Eukaryotes
(c) Protozoanes (d) All of these

52. Anticodon is **[CBSE PMT 1995]**
(a) Paired triplet of bases on messenger RNA
(b) Unpaired triplet of bases on rRNA
(c) Paired triplet of bases on rRNA
(d) An unpaired triplet of bases in an exposed position of tRNA

53. A triplet codon means **[NCERT; KCET 1994; J & K CET 2002]**
(a) A sequence of three nitrogen bases on mRNA
(b) A sequence of three nitrogen bases in tRNA
(c) A sequence of three bases in rRNA
(d) The presence of only three bases in mRNA

54. Two or more codons coding for one amino acid **[NCERT; JIPMER 1994; MP PMT 1998; DPMT 2006; AMU (Med.) 2012]**
(a) Non-ambiguous (b) Degeneracy of codon
(c) Non-overlapping of codon (d) Non-sense codon

55. The sequence of structural gene in lac operon concept is **[NCERT; KCET 2007]**
(a) Lac *A*, Lac *Y*, Lac *Z* (b) Lac *A*, Lac *Z*, Lac *y*
(c) Lac *Y*, Lac *Z*, Lac *A* (d) Lac *Z*, Lac *Y*, Lac *A*

56. In regulation of gene expression in prokaryotes
A. Lactose acts as the suppressor for gene expression
B. Tryptophan acts as the inducer for gene expression
C. Regulator gene is the one that produces the repressor molecule **[Kerala PMT 2007]**
(a) *A* alone correct (b) *B* alone correct
(c) *C* alone correct (d) *B* and *A* are correct
(e) *B* and *C* are correct

57. Which of the following group of codons code for amino acid serine **[Kerala PMT 2007]**
(a) *CUU, CUC, CUA* and *CUG*
(b) *UAU, UAC, UGU* and *UGC*
(c) *UCU, UCC, UCA* and *UCG*
(d) *UGU, UGC, UGA* and *UAG*
(e) *GUU, GUC, GCU* and *GCC*

58. Which conserved motifs are found in *E.coli* genes **[DPMT 2007]**

(a) TATA box (b) CAAT box
(c) Pribnow box (d) All of these

59. Differentiation of organs and tissues in a developing organism, is associated with **[CBSE PMT 2007]**

(a) Developmental mutations
(b) Differential expression of genes
(c) Lethal mutations
(d) Deletion of genes

60. Select the incorrect statement(s)

1. Six codons do not code for any amino acid
2. Codon is read in *mRNA* in a contiguous fashion
3. Three codons function as stop codons
4. The initiator codon AUG codes for methionine

[Kerala PMT 2011]

(a) 1, 2 and 4 are incorrect (b) 1, 2 and 3 are incorrect
(c) 2, 3 and 4 are incorrect (d) 2 alone is incorrect
(e) 1 alone is incorrect

61. Out of 64 codons, the number of codons with GGG is **[NCERT; AMU (Med.) 2012]**

(a) 1 (b) 2
(c) 4 (d) 6

62. Select the correct bases of DNA, RNA and amino acid of beta chain resulting in sickle cell anaemia **[Kerala PMT 2009]**

	DNA	RNA	Amino acid
(a)	CTC/GAG	GUG	Glutamic acid
(b)	CAC/GTG	GUG	Valine
(c)	CAC/GTG	GAG	Valine
(d)	CTC/GAG	GUG	Valine
(e)	CAC/GUG	GAG	Glutamic acid

63. Which of the following amino acid has hydroxyl methyl group as its R group **[DUMET 2010]**

(a) Serine (b) Proline
(c) Alanine (d) Arginine

64. The lac operon consists of **[CBSE PMT (Mains) 2010]**

(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

65. Which one is diaminodicarboxylic amino acid **[WB JEE 2010]**

(a) Cystine (b) Lysine
(c) Cysteine (d) Aspartic acid

66. Which one of the following statement is not correct **[KCET 2010]**

(a) Cysteine is coded by UGU and UGC codons
(b) Tyrosine is coded by UAU and UAC codons
(c) UAA codon codes for lysine
(d) UGG codon codes for tryptophan

67. Select the two correct statements out of the four (*A* – *D*) given below about lac operon

(A) Glucose or galactose may bind with the repressor and inactivate it
(B) In the absence of lactose the repressor binds with the operator region
(C) The z-gene codes for permease
(D) This was elucidated by Francois Jacob and Jacque Monod

The correct statements are **[CBSE PMT (Pre.) 2010]**

(a) (A) and (B) (b) (B) and (C)
(c) (A) and (C) (d) (B) and (D)

68. The one aspect which is not a salient feature of genetic code, is its being **[NCERT; CBSE PMT (Pre.) 2010; NEET (Karnataka) 2013]**

(a) Specific (b) Degenerate
(c) Ambiguous (d) Universal

69. How many effective codons are there for the synthesis of twenty amino acids **[NCERT; WB JEE 2010; AMU (Med.) 2012; MH CET 2015]**

(a) 64 (b) 32
(c) 60 (d) 61

70. Dr. Hargovind Khorana deduced the code for which of the following amino acids **[BHU 2012]**

(a) Serine and leucine
(b) Phenylalanine and methionine
(c) Isoleucine and leucine
(d) Valine and glutamic acid

71. Given below is a sample of a portion of DNA strand giving the base sequence on the opposite strands. What is so special shown in it **[EAMCET 2009; DUMET 2010; CBSE PMT (Pre.) 2011]**

5'_____GAATTC_____3'
3'_____CTTAAG_____5'

(a) Palindromic sequence of base pairs
(b) Replication completed
(c) Deletion mutation
(d) Start codon at the 5' end

72. The inducer for switching 'on' the *lac* operon in bacteria is **[Kerala PMT 2011]**

(a) Presence of lactose
(b) Number of bacteria
(c) Presence of structural genes in the bacteria
(d) Presence of sucrose
(e) Presence of *RNA* polymerase

73. Operon contains **[MP PMT 2013]**

(a) Operator + Regulator genes
(b) Operator + Regulator + Structural genes
(c) Operator + Regulator + Repressor genes
(d) Operator + Regulator + Structural + Repressor + Promoter genes

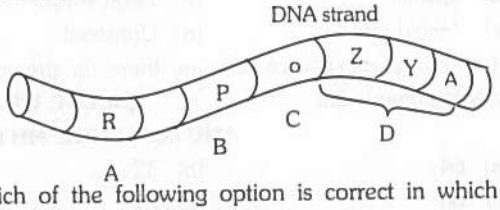
74. Which enzyme/s will be produced in a cell in which there is a nonsense mutation in the lac Y gene **[NEET 2013]**

(a) Lactose permease and transacetylase
(b) β – galactosidase
(c) Lactose permease
(d) Transacetylase

75. In an inducible operon, the genes are **[NEET (Karnataka) 2013]**

(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

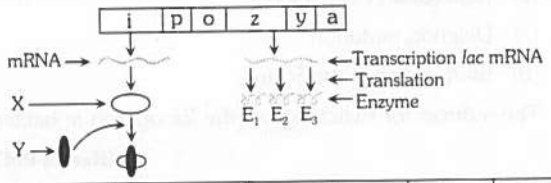
76. The figure of the lac operon from *E. coli* is shown below. Each alphabets indicates its components may be used more than once **[NCERT]**



Which of the following option is correct in which all the alphabets are matched with their functions

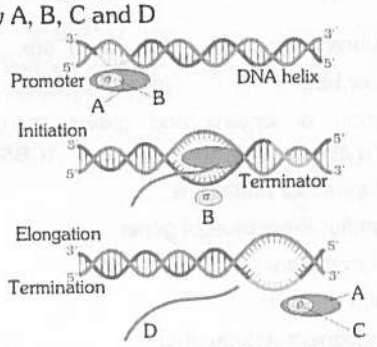
(a) D - the binding site for the repressor protein, C - the binding site for RNA polymerase, B - the structural genes, A - the gene that codes for the repressor protein
(b) A - the binding site for the repressor protein, D - the binding site for RNA polymerase, B - the structural genes, C - the gene that codes for the repressor protein
(c) A - the binding site for the repressor protein, B - the binding site for RNA polymerase, C - the structural genes, D - the gene that codes for the repressor protein
(d) C - the binding site for the repressor protein, B - the binding site for RNA polymerase, D - the structural genes, A - the gene that codes for the repressor protein

77. In the given figure of the *lac* operon, an operon for inducible enzymes, Identify components and enzymes **[NCERT]**



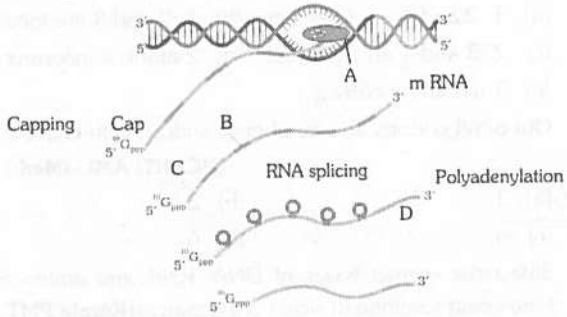
	X	Y	E_1	E_2	E_3
(a)	Repressor protein	Inducer (lactose)	Permease	Trans acetyl ase	β-Galacto sidase
(b)	Repressor protein	Inducer (lactose)	β-Galactosidase	Trans acetyl ase	Permea se
(c)	Inducer (lactose)	Repressor protein	β-Galactosidase	Perm ease	Transace tylase
(d)	Repressor protein	Inducer (lactose)	β-Galactosidase	Perm ease	Transace tylase

78. The following figure refers to transcription in prokaryote. Identify A, B, C and D **[NCERT]**



(a) RNA polymerase, Sigma factor, Rho factor, RNA
(b) DNA polymerase, Initiation factor, Rho factor, RNA
(c) RNA polymerase, Rho factor, Sigma factor, RNA
(d) DNA polymerase, Sigma factor, Rho factor, RNA

79. The given figure refers to the process of transcription in Eukaryotes. A, B, C and D are respectively **[NCERT]**



(a) A - RNA polymerase II, B - Intron, C - Exon, D - Poly G tail
(b) A - RNA polymerase II, B - Intron, C - Exon, D - Poly A tail
(c) A - DNA polymerase II, B - Intron, C - Exon, D - Poly A tail
(d) A - RNA polymerase II, B - Exon, C - Intron, D - Poly A tail

80. Which one of the following is **wrongly** matched **[CBSE PMT 2014]**

(a) Repressor protein-Binds to operator to stop enzyme synthesis
(b) Operon-Structural genes, operator and promoter
(c) Transcription-Writing information from DNA to t-RNA
(d) Translation-Using information in m-RNA to make protein

81. In lac-operon if mutation occurs in the middle gene of the 'structural gene' then **[GUJCET 2014]**

(a) Permease will not be synthesized
(b) β-Galactosidase will not be synthesized
(c) Transacetylase will not be synthesized
(d) Lactose digestion will be rapid

82. Which option is correct for the aminoacid and the total number of their genetic code **[GUJCET 2014]**

(a) Arg = 6, His = 6 (b) Val = 6, Pro = 6
(c) Pro = 4, Thr = 4 (d) Thr = 4, Arg = 4

83. Which amino acid determines by four genetic codes **[GUJCET 2015]**

(a) Leucine (Leu) (b) Proline (Pro)
(c) Serine (Ser) (d) Tyrosine (Tyr)

84. Which of the following is required as inducer(s) for the expression of Lac operon **[NEET (Phase-I) 2016]**
(a) Glucose (b) Galactose
(c) Lactose (d) Lactose and galactose

85. The amino acid tryptophan is the precursor for the synthesis of **[NEET (Phase-I) 2016]**
(a) Melatonin and Serotonin
(b) Thyroxine and Triiodothyronine
(c) Estrogen and Progesterone
(d) Cortisol and Cortisone

86. Which of the following pair of amino acids are acidic **[WB-JEE 2016]**
(a) Glycine and glutamate
(b) Aspartate and valine
(c) Alanine and methionine
(d) Glutamate and aspartate

87. If there are 999 bases in RNA that codes 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 **[NEET 2017]**
(a) 1 (b) 11
(c) 33 (d) 333

Protein Synthesis

1. The process by which DNA of nucleus passes genetic information to mRNA **[MHCET 2004; HPMT 2005; BCECE 2005; MH CET 2005; J & K CET 2008; CPMT 2009; Kerala PMT 2010]**

Or

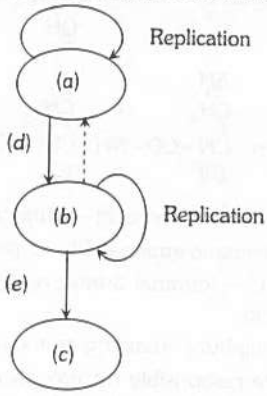
What is transfer of DNA → RNA called **[MP PMT 2005, 11]**
(a) Translocation
(b) Transcription
(c) Translation
(d) Transportation

2. Translation is called **[NCERT; CPMT 1996; MP PMT 2001]**
(a) Formation of RNA from DNA
(b) Formation of DNA from DNA
(c) Formation of DNA from RNA
(d) Protein formation

3. Who discovered "Reverse transcription" **[NCERT; MP PMT 1999; Pb. PMT 1999, 2000; Kerala PMT 2006]**
(a) Watson and Crick
(b) Beadle and Tatum
(c) Temin and Baltimore
(d) Khorana

4. Repressor protein is formed from **[MP PMT 1996, 2007]**
(a) Repressor gene
(b) Structural gene
(c) Operator gene
(d) Regulatory gene

5. The diagram represents the "central dogma" of molecular biology. Choose the correct combination of labelling **[Kerala PMT 2006; NEET 2013; NEET (Karnataka) 2013]**



(a) (*A*) Protein (*B*) RNA (*C*) DNA (*D*) Translation (*E*) Transcription
(b) (*A*) RNA (*B*) DNA (*C*) Protein (*D*) Transcription (*E*) Translation
(c) (*A*) Transcription (*B*) Translation (*C*) Protein (*D*) DNA (*E*) RNA
(d) (*A*) DNA (*B*) RNA (*C*) Protein (*D*) Translation (*E*) Transcription
(e) (*A*) DNA (*B*) RNA (*C*) Protein (*D*) Transcription (*E*) Translation

6. Which one of the following sequence represents m–RNA coded from a DNA segment with base pairs as **[Kerala PMT 2006]**

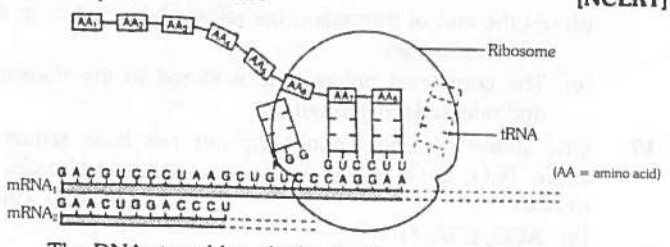
GA GC GCACA
CT CG CGTGT

(a) GAGCGCACA (b) CUCCGCUGU
(c) CTCGCGTGT (d) CUCCGCUCC
(e) CUCGUGUGU

7. In processing of eukaryotic hn RNA, during protein synthesis tailing involves _____ of RNA **[MHCET 2015]**
(a) Addition of adenylate residues at 3' end
(b) Addition of methyl guanosine triphosphate at 3' end
(c) Addition of methyl guanosine triphosphate at 5' end
(d) Removal of introns

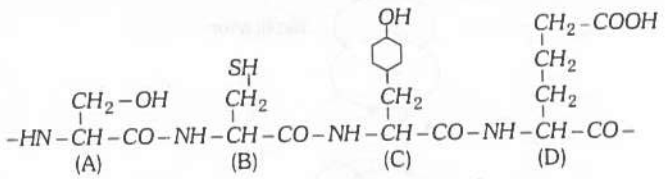
8. The sequence of nitrogen bases (triplet) on tRNA is **[EAMCET 2009]**
(a) Anticodon (b) Terminating codon
(c) Degenerate codon (d) Initiating codon

9. Study the following figure which shows the synthesis of part of a protein molecule **[NCERT]**



The DNA strand by which $mRNA_2$ was synthesised is
(a) CUUGACCUGGGA (b) GAACUGGACCCU
(c) CTTGACCTGGGA (d) GAACTGGACCCT

10. The figure shows a hypothetical tetrapeptide portion of a protein with parts labelled A-D. Which one of the following option is correct **[NEET (Karnataka) 2013]**



(a) D is the acidic amino acid – glutamic acid
(b) C is an aromatic amino acid – tryptophan
(c) A is the C – terminal amino acid and D is N terminal amino acid
(d) A is the sulphur containing amino acid-methionine

11. The genes are responsible for growth and differentiation in an organism through regulation of **[MP PMT 1994]**
(a) Translocation
(b) Transformation
(c) Transduction and translation
(d) Translation and transcription

12. The transcription unit is **[DPMT 2006]**
(a) TATA box to start point
(b) TATA box to stop codon
(c) Start point to stop codon
(d) 35 sequence to start point

13. Teminism is also called as **[BHU 2008]**
(a) Reverse transcription (b) Transcription
(c) Translation (d) Replication

14. RNA interference involves **[NEET (Karnataka) 2013]**
(a) Synthesis of cDNA from RNA using reverse transcriptase
(b) Silencing of specific mRNA due to complementary RNA
(c) Interference of RNA in synthesis of DNA
(d) Synthesis of mRNA from DNA

15. Which one-of the following is not a part of a transcription unit in *DNA* **[NCERT; CBSE PMT (Pre.) 2012]**
(a) The inducer (b) A terminator
(c) A promoter (d) The structural gene

16. Select the correct statement regarding protein synthesis **[Kerala PMT 2012]**
(a) When the small subunit of the ribosome encounters an mRNA the process of translation begins
(b) Peptidase catalyses the formation of peptide bond
(c) UTRs are present between the start codon and stop codon
(d) At the end of translation the release factor binds to the initiation codon
(e) The completed polypeptide is stored in the ribosome and released when required

17. One strand of DNA (non template) has base sequence CAG, TCG, GAT. What will be the sequence of bases in *m*-RNA **[MP PMT 2006]**
(a) AGC, CTA, CTA
(b) GTC, AGC, CTC
(c) CAG, UCG, GAU
(d) GAC, TAG, CTA

18. The Okazaki fragments in DNA chain growth **[NCERT; CBSE PMT 2007; WB JEE 2009; Odisha JEE 2012]**
(a) Result in transcription
(b) Polymerize in the 3' - to 5' direction and forms replication fork
(c) Prove semi-conservative nature of DNA replication
(d) Polymerize in the 5' - to 3' direction and explain 3' - to - 5' DNA replication

19. Molecular basis of organ differentiation depends on the modulation in transcription by **[CBSE PMT 2007]**
(a) RNA polymerase (b) Ribosome
(c) Transcription factor (d) Anticodon

20. Length of mRNA that carries information for complete polypeptide synthesis is **[DPMT 2007]**
(a) Muton (b) Codon
(c) Operon (d) Cistron

21. 'Central Dogma' was proposed by **[RPMT 1995; MP PMT 2011]**
(a) Crick (b) Beadle and Tatum
(c) Temin and Baltimore (d) Klug

22. Transcription is a process by which **[MP PMT 1994, 97, 98, 2002, 07; Manipal 1995]**
(a) Amino acids are joined to form polypeptides
(b) An RNA molecule is synthesized on a DNA template
(c) An RNA molecule is synthesized within a ribosome
(d) Two daughter strands of DNA are synthesized

23. Balbiani rings are sites of **[WB JEE 2010; AIPMT 2015]**
(a) DNA replication
(b) RNA and protein synthesis
(c) Synthesis of lipids
(d) Synthesis of polysaccharides

24. The presence and position of which one of the following defines the template and coding strands in a transcription unit **[Kerala PMT 2012]**
(a) Repressor (b) Operator
(c) Structural gene (d) Promoter
(e) Inducer

25. Which of the following step of translation does not consume a high energy phosphate bond **[CBSE PMT 1997]**
(a) Translocation
(b) Amino acid activation
(c) Peptidyl transferase reaction
(d) Aminoacyl *t*RNA binding to *A*–site

26. Post transcriptional modification in Eukaryotes is referred as **[VITEEE 2006]**
(a) Translation (b) Splicing
(c) Sequencing (d) Restriction

27. The processes by which mRNA is made by DNA and protein by mRNA are respectively called as **[MP PMT 1998]**
(a) Transcription and translation
(b) Translation and transcription
(c) Synthesis of mRNA and protein
(d) Replication of mRNA and protein

28. In protein synthesis, the polymerization of amino acids involves three steps. Which of the following is not involved in protein synthesis **[BHU 2000]**

(a) Elongation (b) Transcription

(c) Termination (d) Initiation

29. Who proposed the 'Signal hypothesis' meant for the biosynthesis of secretory type of proteins **[AFMC 2000]**

(a) Baltimore (b) Camillio Golgi

(c) Blobel and Sabatini (d) Sheeler and Bianchi

30. Which amino acids are present in histones **[Odisha JEE 2004; Kerala PMT 2010; WB-JEE 2016]**

(a) Lysine and histidine

(b) Valine and Histidine

(c) Arginine and lysine

(d) Arginine and histidine

31. After a mutation at a genetic locus the character of an organism changes due to the change in **[CBSE PMT 2004]**

(a) Protein synthesis pattern (b) RNA transcription pattern

(c) Protein structure (d) DNA replication

32. DNA is not directly involved with the synthesis of the following **[MHCET 2002; KCET 2006]**

(a) *m*-RNA (b) *r*-RNA

(c) *t*-RNA (d) Protein

33. Choose the wrong statement in the process of protein synthesis **[Kerala PMT 2007]**

(a) After uncoiling of *DNA* molecule, one strand acts as a template for the formation *m-RNA*

(b) In the presence of *DNA* polymerase enzyme the *m-RNA* is formed based on the triplet codes

(c) The *m-RNA* that leaves nucleus reaches cytoplasm and gets attached with 30*S* ribosomal subunit

(d) The amino acids are transferred from the intracellular amino acid pool to the active ribosomes by the *t-RNA*

(e) Translation is the process in which proteins are synthesized from the *RNA*

34. During protein denaturation which of the following is disrupted **[BVP 2004]**

(a) 2D structure (b) 3D structure

(c) Peptide bond (d) AA sequence

35. Protein synthesis in an animal cell occurs **[CBSE PMT 2005]**

(a) Only on the ribosomes present in cytosol

(b) On ribosomes present in cytoplasm as well as in mitochondria

(c) Only on ribosomes attached to the nuclear envelope and endoplasmic reticulum

(d) On ribosomes present in the nucleolus as well as in cytoplasm

36. Which antibiotic inhibits interaction between tRNA and mRNA during bacterial protein synthesis **[CBSE PMT 2006]**

(a) Streptomycin (b) Tetracycline

(c) Erythromycin (d) Neomycin

37. Which of the following is not correct about translation **[BCECE 2005]**

(a) It starts with AUG

(b) Stopped at termination codon

(c) Based on operon model

(d) Occurs in nucleus

38. Amino acid sequence, in protein synthesis is decided by the sequence of **[CBSE PMT 2006]**

(a) cDNA (b) rRNA

(c) tRNA (d) mRNA

39. Which of the following inhibits protein synthesis by binding to 50 S ribosome **[Odisha JEE 2005]**

(a) Tetracycline (b) Streptomycin

(c) Erythromycin (d) Penicillin

40. Portion of gene which is transcribed but not translated is **[CPMT 2005]**

(a) Exon (b) Intron

(c) Cistron (d) Codon

41. The central dogma of protein synthesis in teminious is **[NCERT; MHCET 2002; KCET 2007; Odisha JEE 2011]**

(a) $g.RNA \rightarrow DNA \rightarrow m-RNA \rightarrow protein$

(b) $DNA \rightarrow G-RNA \rightarrow m-RNA \rightarrow protein$

(c) $DNA \rightarrow DNA \rightarrow m-RNA \rightarrow protein$

(d) $m-RNA \rightarrow g.RNA \rightarrow DNA \rightarrow protein$

42. The enzyme responsible for reverse transcription is **[Odisha JEE 2011]**

(a) RNA polymerase (b) Reverse transcriptase

(c) DNA polymerase (d) Transcriptase

43. Select the incorrect statement **[Kerala PMT 2011]**

(a) Protein are heteropolymers made of amino acids

(b) Ribozymes are nucleic acids with catalytic power

(c) Nucleic acids serve as genetic material

(d) Proteins, nucleic acids and polysaccharides are the only three types of macromolecules found in the living system

(e) Collagen is the most abundant protein in the whole of the biosphere and *RuBisCo* is the most abundant proteins in animal world

44. The enzyme reverse transcriptase is **[Odisha JEE 2010; BHU 2012]**

(a) RNA dependent RNA polymerase

(b) RNA dependent DNA Polymerase

(c) DNA dependent DNA polymerase

(d) DNA dependent RNA polymerase

45. Initiation of polypeptide chain in eukaryotic protein synthesis is induced by **[NCERT; J & K CET 2008; AMU (Med.) 2010]**

(a) Methionine (AUG) (b) Leucine

(c) Lysine (d) Glycine

46. The most commonly used enzyme for polymerase chain reaction is **[MP PMT 2001; Odisha JEE 2010]**
(a) DNA polymerase-II (b) Reverse transcriptase
(c) Klenow fragment (d) Taq polymerase

47. To which of the following factors, RNA polymerase binds transiently to initiate transcription **[Kerala PMT 2012]**
(a) Rho (b) Beta
(c) Gamma (d) Sigma
(e) Alpha

48. In bacteria, the formation of peptide bond during translation is effected by **[Kerala PMT 2010]**
(a) Lysozyme (b) Ribozyme
(c) Nucleosome (d) Microsome
(e) Peroxisome

49. What will be the correct gene expression pathway **[DUMET 2010]**
(a) Gene–mRNA–transcription–translation–protein
(b) Transcription–Gene–translation–mRNA–protein
(c) Gene– transcription –mRNA–translation–protein
(d) Gene–translation–mRNA–transcription–protein

50. In eukaryotic cell transcription, RNA splicing and RNA capping take place inside the **[CBSE PMT (Mains) 2010]**

Or

Messenger RNA is produced in **[CPMT 2005]**
(a) Ribosomes (b) Nucleus
(c) Dictyosomes (d) ER

51. Hargovind Khorana is known for **[MP PMT 2010]**
(a) Discovery of DNA structure
(b) Synthesis of protein
(c) Discovery of DNA ligase enzyme
(d) Discovery of tRNA

DNA Finger Printing

1. Transfer of DNA bands from an agrose gel to a nitrocellulose or nylon membrane is referred to as **[Haryana PMT 2005; Kerala PMT 2006; KCET 2011]**

Or

DNA finger printing is done by a technique called **[NCERT]**
(a) Western transfer (b) Northern transfer
(c) Eastern transfer (d) Gene transfer
(e) Southern transfer

2. The main aim of the human genome project is ..... **[KCET 2010]**
(a) To introduce new genes into humans
(b) To identify and sequence all the genes present in human DNA
(c) To develop better techniques for comparing two different human DNA samples
(d) To remove disease causing genes from human DNA

3. Human genome project was discovered by **[AMU (Med.) 2006]**
(a) Francis Collins and Roderick
(b) Watson and Crick
(c) Beadle and Tatum
(d) Paul Berg and Wollman

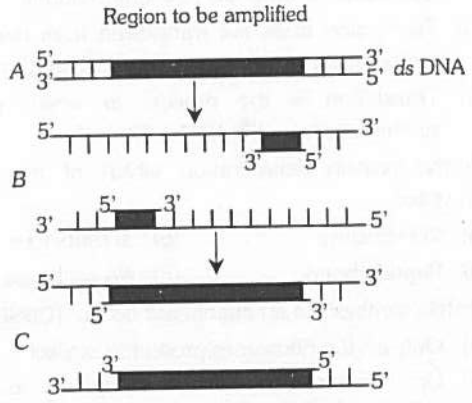
4. Polyethylene glycol method is used for **[CBSE PMT 2009]**
(a) Gene transfer without a vector
(b) Biodiesel production
(c) Seedless fruit production
(d) Energy production from sewage

5. The Human Genome Project (HGP) was initiated in **[MHCET 2015]**
(a) 1988 (b) 1990
(c) 1992 (d) 1994

6. EcoRI is an example of **[AMU (Med.) 2006]**
(a) Exonuclease
(b) Endonuclease
(c) Specific site of restriction endonuclease
(d) RNA polymerase

7. Which of the following is used to select genes of interest from a genomic library **[J & K CET 2012]**
(a) Restriction enzymes
(b) Cloning vectors
(c) Gene targets
(d) DNA probes

8. The figure below shows three steps (A, B, C) of Polymerase Chain Reaction (PCR). Select the option giving correct identification together with what it represents



Options **[NCERT; CBSE PMT (Mains) 2012]**
(a) B – Denaturation at a temperature of about $98^{\circ}C$ separating the two DNA strands
(b) A – Denaturation at a temperature of about $50^{\circ}C$
(c) C – Extension in the presence of heat stable DNA polymerase
(d) A – Annealing with two sets of primers

9. What is it that forms the basis of DNA Fingerprinting **[NCERT; KCET 2006; Kerala PMT 2011; CBSE PMT (Mains) 2012]**

(a) The relative proportions of purines and pyrimidines in DNA

(b) The relative difference in the DNA occurrence in blood, skin and saliva

(c) The relative amount of DNA in the ridges and grooves of the fingerprints

(d) Satellite DNA occurring as highly repeated short DNA segments

10. The enzyme(s) responsible for the transcription of snRNAs in eukaryotes is/are **[Kerala PMT 2012]**

(a) RNA polymerase-I (b) RNA polymerase-I and II

(c) RNA polymerase-II (d) RNA polymerase-III

(e) RNases

11. Biolistics (gene-gun) is suitable for **[WB JEE 2011; CBSE PMT (Mains) 2012]**

(a) Disarming pathogen vectors

(b) Transformation of plant cells

(c) Constructing recombinant DNA by joining with vectors

(d) DNA finger printing

12. What is the first step in the Southern Blot technique **[AIIMS 2004, 08]**

(a) Denaturation of DNA on the gel for hybridization with specific probe

(b) Production of a group of genetically identical cells

(c) Digestion of DNA by restriction enzyme

(d) Isolation of DNA from a nucleated cell such as the one from the scene of crime

13. Cohen and Boyer isolated an antibiotic resistance gene, by cutting out a piece of DNA from a plasmid which was responsible for conferring antibiotic resistance, in the year **[NCERT; AMU (Med.) 2012]**

(a) 1962 (b) 1965

(c) 1972 (d) 1982

14. The pioneer contributor towards the use of human DNA fingerprinting in forensic science in India is **[BHU 2012]**

(a) Lalji (b) H. Khorana

(c) Swaminathan (d) J.C. Bose

15. Nobel prize to Kornberg and Ochoa was given for **[RPMT 2002]**

(a) Artificial synthesis of genes

(b) Chemistry of DNA and RNA

(c) 'One gene one enzyme' hypothesis

(d) Artificial synthesis of DNA

16. Which one is a true statement regarding DNA polymerase used in PCR **[NCERT; CBSE PMT (Pre.) 2012]**

(a) It is used to ligate introduced DNA in recipient cells

(b) It serves as a selectable marker

(c) It is isolated from a virus

(d) It remains active at high temperature

17. DNA finger printing technique was first developed by **[NCERT; KCET 2004; Kerala PMT 2006, 10]**

(a) Jeffreys, Wilson and Thien

(b) Boysen and Jensen

(c) Scleiden and Schwann

(d) Edward and Steptoe

18. Amplification of gene of interest by using DNA polymerase may go upto **[NCERT; AMU (Med.) 2012]**

(a) 0.1 million times (b) 1.0 million times

(c) 1.0 billion times (d) 1.0 trillion times

19. cDNA probes are copied from the messenger RNA molecules with the help of **[AIIMS 2005; CPMT 2005]**

Or

Central dogma of genetic information is modified by the discovery of **[DPMT 2007]**

(a) Restriction enzymes (b) Reverse transcriptase

(c) DNA polymerase (d) Adenosine diaminase

20. Gene synthesis is related to **[J & K CET 2005]**

(a) V. Baer (b) H.G. Khorana

(c) L. Pasteur (d) C. Linnaeus

21. Which one of the following techniques is employed in human genetic counselling **[Kerala CET 2005]**

(a) Serological technique (b) Polyploidy

(c) Genetic engineering (d) Amniocentesis

(e) Pedigree analysis

22. Choose the wrong statement **[Kerala PMT 2012]**

(a) VNTR belong to a class of mini- satellite DNA

(b) DNA sequencers work on the principle developed by Frederick Sanger

(c) HGP was coordinated by US Department of energy and the National institute of Health

(d) DNA finger printing involves identifying similarities in repetitive DNA

(e) Satellite DNA normally do not code for proteins

23. There is a restriction endonuclease called EcoRI. What does "co" part in it stand for **[NCERT; CBSE PMT (Pre.) 2011]**

(a) Coli (b) Colon

(c) Coelom (d) Coenzyme

24. GAATTC is the recognization site for which of the following restriction endonuclease **[Odicha JEE 2010]**

(a) Hind III (b) EcoR I

(c) Bam I (d) Hae III

25. *DNA* fingerprinting method is very useful for **[MP PMT 1998; Kerala PMT 2008; AFMC 2012]**

(a) *DNA* tests for identity and relationships

(b) Forensic studies

(c) Polymorphism

(d) All of the above

26. Which of the following discoveries resulted in a Nobel Prize **[CBSE PMT 2003]**
(a) Genetic engineering
(b) X-rays induce sex-linked recessive lethal mutations
(c) Cytoplasmic inheritance
(d) Recombination of linked genes

27. The enzyme needed in biological system for joining two molecules is called **[CPMT 2010]**
(a) Lyases (b) Diastases
(c) Polymerase (d) Hydrolase

28. Which one of the following pairs of terms/names mean one and the same thing **[BHU 2003; AIIMS 2013]**
(a) Gene pool- Genome
(b) Codon - Gene
(c) Cistron –Triplet
(d) DNA fingerprinting-DNA profiling

29. Genetic drift operates only in **[CBSE PMT 1998; NEET (Phase-II) 2016]**
(a) Island populations (b) Smaller populations
(c) Larger populations (d) Mendelian populations

30. Probes used in DNA finger-printing initially **[DPMT 2006]**
(a) Single stranded RNA
(b) Mini satellite
(c) 19 base long oligonucleotide
(d) All of the above

31. A distinct mechanism that usually involves a short segment of DNA with remarkable capacity to move from one location in a chromosome to another, this is called **[BHU 1999]**
(a) DNA replication (b) DNA transposition
(c) DNA hybridization (d) DNA recombination

32. Restriction endonucleases **[NCERT; MP PMT 1997, 99, 2000, 12; CBSE PMT 1998, 2004; WB JEE 2012]**
(a) Are used for *in vitro* DNA synthesis
(b) Are synthesized by bacteria as part of defense mechanism
(c) Are present in mammalian cells for degradation of DNA when the cells dies
(d) Are used in genetic engineering

33. Polymerase chain reaction is most useful in **[NCERT; BHU 2005; CPMT 2009; Odisha JEE 2011; Kerala PMT 2011]**
(a) DNA synthesis (b) DNA amplification
(c) Protein synthesis (d) Amino acid synthesis

34. The frequency of an allele in an isolated population may change due to **[CBSE PMT 1992, 2001]**
(a) Gene flow (b) Mutation
(c) Genetic drift (d) Natural selection

35. DNA fingerprinting refers to **[CBSE PMT 2004]**
(a) Techniques used for molecular analysis of different specimens of DNA
(b) Techniques used for identification of fingerprints of individuals
(c) Molecular analysis of profiles of DNA samples
(d) Analysis of DNA samples using imprinting devices

36. In genetic fingerprinting, the 'probe' refers to .... **[KCET 2010]**
(a) A radioactively labelled single stranded DNA molecule
(b) A radioactively labelled single stranded RNA molecule
(c) A radioactively labelled double stranded RNA molecule
(d) A radioactively labelled double stranded DNA molecule

37. The best HLA (human leucocyte antigen) match for transplant in order of preference is **[Kerala CET 2005]**
(a) Parent > sibling > twin > unrelated donor
(b) Sibling > twin > parent > unrelated donor
(c) Twin > sibling > parent > unrelated donor
(d) Twin > unrelated donor > parent > sibling
(e) Sibling > parent > twin > unrelated donor

38. Production of a human protein in bacteria by genetic engineering is possible because **[CBSE PMT 2003, 05]**
(a) Bacterial cell can carry out the RNA splicing reactions
(b) The human chromosome can replicate bacterial cell
(c) The mechanism of gene regulation is identical in humans and bacteria
(d) The genetic code is universal

39. To confirm ELISA for AIDS we used **[Kerala PMT 2004; MP PMT 2007]**

Or

Protein-protein hybridization results in **[BHU 2008]**
(a) Western blotting (b) Northern blotting
(c) Southern blotting (d) Eastern blotting

40. The transfer of protein from electrophoretic gel to nitrocellulose membrane is known as **[MP PMT 2003]**
(a) Transferase (b) Northern blotting
(c) Western blotting (d) Southern blotting

41. Which of the following is **not** required for any of the techniques of DNA fingerprinting available at present **[NEET (Phase-I) 2016]**
(a) Polymerase chain reaction
(b) Zinc finger analysis
(c) Restriction enzymes
(d) DNA-DNA hybridization

42. Select the correct combination of statements for DNA fingerprinting
i. It is an ELISA based technique
ii. It is a PCR based technique
iii. It is used by forensic scientists
iv. It is based on the fingerprint of an individual
v. It is a test for paternity **[WB-JEE 2016]**
(a) i, ii, iii (b) ii, iii, v
(c) i, iv, v (d) i, iii, iv

NCERT Exemplar Questions

1. In a DNA strand the nucleotides are linked together by **[NCERT]**
(a) Glycosidic bonds (b) Phosphodiester bonds
(c) Peptide bonds (d) Hydrogen bonds

2. A nucleoside differs from a nucleotide. It lacks the **[NCERT]**
(a) Base (b) Sugar
(c) Phosphate group (d) Hydroxyl group

3. Both deoxyribose and ribose belong to a class of sugars called **[NCERT]**
(a) Trioses (b) Hexoses
(c) Pentoses (d) Polysaccharides

4. The fact that a purine base always pairs through hydrogen bonds with a pyrimidine base in the DNA double helix leads to **[NCERT]**
(a) The antiparallel nature
(b) The semiconservative nature
(c) Uniform width throughout DNA
(d) Uniform length in all DNA

5. The net electric charge on DNA and histones is **[NCERT; NEET 2017]**
(a) Both positive
(b) Both negative
(c) Negative and positive respectively
(d) Zero

6. The promoter site and the terminator site for transcription are located at **[NCERT]**
(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

7. Which of the following statements is the most appropriate for sickle cell anaemia **[NCERT]**
(a) It cannot be treated with iron supplements
(b) It is a molecular disease
(c) It confers resistance to acquiring malaria
(d) All of the above

8. Which of the following is true with respect of AUG **[NCERT]**
(a) It codes for methionine only
(b) It is an initiation codon
(c) It codes for methionine in both prokaryotes and eukaryotes
(d) All of the above

9. The first genetic material could be **[NCERT]**
(a) Protein (b) Carbohydrates
(c) DNA (d) RNA

10. With regard to mature mRNA in eukaryotes **[NCERT]**
(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

11. The human chromosome with the highest and least number of genes in them are respectively **[NCERT]**
(a) Chromosome 21 and Y (b) Chromosome 1 and X
(c) Chromosome 1 and Y (d) Chromosome X and Y

12. Who amongst the following scientists had no contribution in the development of the double helix model for the structure of DNA **[NCERT]**
(a) Rosalind Franklin (b) Maurice Wilkins
(c) Erwin Chargaff (d) Meselson and Stahl

13. DNA is a polymer of nucleotides which are linked to each other by 3'-5' phosphodiester bond. To prevent polymerization of nucleotides, which of the following modifications would you choose **[NCERT]**
(a) Replace purine with pyrimidines
(b) Remove/replace 3' OH group in deoxyribose
(c) Remove/replace 2' OH group with some other group in deoxyribose
(d) Both 'b' and 'c'

14. Discontinuous synthesis of DNA occurs in one strand, because **[NCERT]**
(a) DNA molecule being synthesised is very long
(b) DNA dependent DNA polymerase catalyses polymerization only in one direction (5'→3')
(c) It is a more efficient process
(d) DNA ligase joins the short stretches of DNA

15. Which of the following steps in transcription is catalysed by RNA polymerase **[NCERT]**
(a) Initiation (b) Elongation
(c) Termination (d) All of the above

16. Control of gene expression in prokaryotes take place at the level of **[NCERT]**
(a) DNA-replication (b) Transcription
(c) Translation (d) None of the above

17. Which of the following statements is correct about the role of regulatory proteins in transcription in prokaryotes **[NCERT]**
(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

18. Which was the last human chromosome to be completely sequenced **[NCERT]**
(a) Chromosome 1 (b) Chromosome 11
(c) Chromosome 21 (d) Chromosome X

19. Which of the following are the functions of RNA **[NCERT]**
(a) It is a carrier of genetic information from DNA to ribosomes synthesizing polypetides
(b) It carries amino acids to ribosome
(c) It is a constituent component of ribosomes
(d) All of the above

20. While analyzing the DNA of an organism a total number of 5386 nucleotides were found out of which the proportion of different bases were: Adenine = 29%, Guanine = 17%, Cytosine = 32%, Thymine = 17%. Considering the Chargaff's rule it can be concluded that **[NCERT]**
(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

21. In some viruses, DNA is synthesised by using RNA as template. Such a DNA is called **[NCERT]**

(a) A-DNA

(b) B-DNA

(c) cDNA

(d) rDNA

22. If Meselson and Stahl's experiment is continued for four generations in bacteria, the ratio of $N^{15}/N^{15} : N^{15}/N^{14} : N^{14}/N^{14}$ containing DNA in the fourth generation would be **[NCERT]**

(a) 1:1:0 (b) 1:4:0

(c) 0:1:3 (d) 0:1:7

23. If the sequence of nitrogen bases of the coding strand of DNA in a transcription unit is **[NCERT]**

5' – A T G A A T G – 3',

the sequence of bases in its RNA transcript would be

(a) 5' – A U G A A U G – 3'

(b) 5' – U A C U U A C – 3'

(c) 5' – C A U U C A U – 3'

(d) 5' – G U A A G U A – 3'

24. The RNA polymerase holoenzyme transcribes **[NCERT]**

(a) The promoter, structural gene and the terminator region

(b) The promoter and the terminator region

(c) The structural gene and the terminator region

(d) The structural gene only

25. If the base sequence of a codon in mRNA is 5'-AUG-3', the sequence of tRNA pairing with it must be **[NCERT]**

(a) 5' – UAC – 3' (b) 5' – CAU – 3'

(c) 5' – AUG – 3' (d) 5' – GUA – 3'

26. The amino acid attaches to the tRNA at its **[NCERT]**

(a) 5' – end (b) 3' – end

(c) Anti codon site (d) DHU loop

27. To initiate translation, the mRNA first binds to **[NCERT]**

(a) The smaller ribosomal sub-unit

(b) The larger ribosomal sub-unit

(c) The whole ribosome

(d) No such specificity exists

28. In E.coli, the lac operon gets switched on when **[NCERT]**

(a) Lactose is present and it binds to the repressor

(b) Repressor binds to operator

(c) RNA polymerase binds to the operator

(d) Lactose is present and it binds to RNA polymerase

CT Critical Thinking

Objective Questions

1. Match the following

A.	VNTR	P.	Largest gene
B.	Introns and Exons	Q.	DNA fingerprinting
C.	Dystrophin	R.	Bulk DNA
D.	Satellite DNA	S.	Splicing

[KCET 2015]

(a) A-R, B-S, C-P, D-Q

(b) A-Q, B-S, C-P, D-R

(c) A-Q, B-P, C-S, D-R

(d) A-S, B-P, C-Q, D-R

2. Gel electyrophoresis is used for **[NCERT; CBSE PMT 2008; Kerala PMT 2012; NEET 2013]**

(a) Construction of recombinant DNA by joining with cloning vectors

(b) Isolation of DNA molecule

(c) Cutting of DNA into fragments

(d) Separation of DNA fragments according to their size

3. Palaeontologistsa unearthed a human skull during excavation. A small fragment of the scalp tissue was still attached to it. Only little DNA could be extracted from it. It the genes of the ancient man need to be analysed, the best way of getting sufficient amount DNA from this extract is **[KCET 2009]**

(a) Hybridising the DNA with a DNA probe

(b) Subjecting the DNA to polymerase chain reaction

(c) Subjecting the DNA to gel electrophoresis

(d) Treating the DNA with restriction endonucleases

4. A sequential expression of a set of human genes occurs when a steroid molecule binds to the **[CBSE PMT 2007]**

(a) Transfer RNA

(b) Messenger RNA

(c) DNA sequence

(d) Ribosome

5. In the nomenclature of enzyme restriction endonuclease the Roman numeral indicates **[MHCET 2015]**

(a) Number of times it is used

(b) The order of discovery from source

(c) Number of cuts on DNA

(d) Number of recombinants formed

6. Bacteria were grown in a medium contaning heavy isotope of nitrogen (N^{15}) for many generations and all their DNA contained many heavy nitrogen only. A bacterium of this type was transferred to normal medium and allowed to duplicate. After two divisions of heavy DNA is likely to be that **[CBSE PMT 1993]**

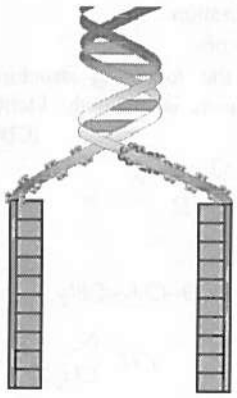
(a) Only one daughter cell will have heavy DNA

(b) Two daughter cells have normal DNA and other two have both normal and heavy DNA

(c) All daughter cells have heavy DNA

(d) Half daughter cells have heavy DNA and other hald have normal DNA

7. What is "A" and "B" in given diagram **[GUJCET 2015]**



(a) A = RNA Primer
B = RNA Helicase

(b) A = RNA Primer
B = DNA Helicase

(c) A = Single strand Binding Protein
B = DNA Helicase

(d) A = lagging strand
B = Movement of Helicase

8. Which RNA is having least age **[MP PMT 2002]**

(a) *m* RNA

(b) *t* RNA

(c) *r* RNA

(d) None of the above

9. Which of the following RNAs should be most abundant in animal cell **[Odisha PMT 2002; MP PMT 2006; NEET 2017]**

(a) *m* RNA (b) *t* RNA

(c) *r* RNA (d) catalytic RNA

10. Which of the character is not applicable to *t*-RNA **[Kerala CET 2003]**

(a) It is the smallest of the RNAs

(b) It acts as an adapter for amino acids

(c) It has a clover leaf like structure

(d) It is the largest of the RNAs

11. Satellite DNA is important because it **[AIPMT 2015]**

(a) Shows high degree of polymorphism in population and also the same degree of polymorphism in an individual, which is heritable from parents to children

(b) Does not code for proteins and is same in all members of the population

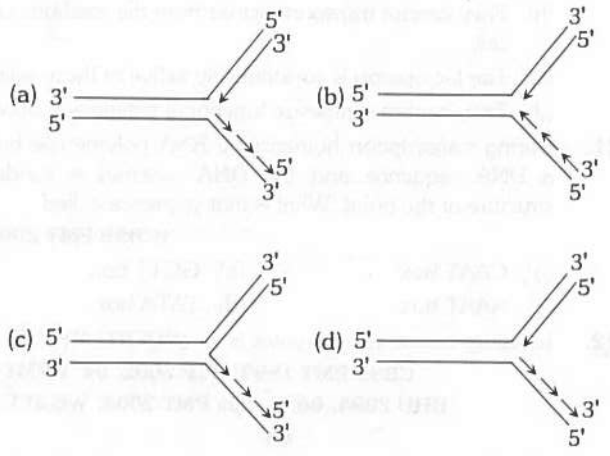
(c) Codes for enzymes needed for DNA replication

(d) Codes for proteins needed in cell cycle

12. Which one of the following pairs is correctly matched **[MP PMT 1993]**

(a) Ribosomal RNA	Carries amino acids to the site of protein synthesis
(b) Transcription	Process by which protein is synthesized
(c) Translation	Process by which m-RNA carries the information from the nucleus to ribosomes
(d) Anticodon	Site of a t-RNA molecule hydrogen bond that binds to the m-RNA molecule

13. Which one of the following correctly represents the manner of replication of DNA **[AIIMS 2003]**



14. Centre of DNA Fingerprinting and Diagnostics (CDFD) is located at **[AIIMS 2010]**

(a) Delhi (b) Chennai

(c) Kolkata (d) Hyderabad

15. Which of the following is a sulphur containing amino acid **[CMC Vellore 1994; WB JEE 2008]**

(a) Alanine (b) Glycine

(c) Methionine (d) Valine

16. The source of Taq polymerase used in PCR is a **[DUMET 2010]**

(a) Thermophilic fungus (b) Mesophilic fungus
(c) Thermophilic bacterium (d) Halophilic bacterium

17. The deflection of pitch angle between two successive steps (rungs) of DNA is **[MHCET 2015]**

(a) 72° (b) 54°
(c) 36° (d) 18°

18. Match the following in column I with column II and choose the correct combination

Column I		Column II	
A.	Termination	1.	Aminoacyl tRNA synthetase
B.	Translation	2.	Okazaki fragments
C.	Transcription	3.	GTP dependent release factor
D.	DNA replication	4.	RNA polymerase

[NCERT; Kerala PMT 2006; J & K CET 2012]

(a) A–2, B–3, C–1, D–4 (b) A–1, B–4, C–2, D–3
(c) A–3, B–1, C–4, D–2 (d) A–4, B–2, C–1, D–3
(e) A–2, B–4, C–1, D–3

19. Triplet for inhibiting process of translation is **[CBSE PMT 1996]**

(a) *UAG* (b) *UAA*
(c) *UAC* (d) *UGG*

20. *E.coli* cells with a mutated *z* gene of the lac operon cannot grow in medium containing only lactose as the source energy because **[CBSE PMT 2005]**

(a) In the presence of glucose, *E.coli* cells do not utilize lactose
(b) They cannot transport lactose from the medium into the cell
(c) The lac operon is constitutively active in these cells
(d) They cannot synthesize functional betagalactosidase

21. During transcription holoenzyme RNA polymerase binds to a DNA sequence and the DNA assumes a saddle like structure at the point. What is that sequence called **[CBSE PMT 2005, 07]**

(a) CAAT box (b) GGTT box
(c) AAAT box (d) TATA box

22. Initiating codon in eukaryotes is **[NCERT; MP PMT 1997; CBSE PMT 1999; BVP 2002, 04; DPMT 2003; BHU 2004, 06; Kerala PMT 2004; WB JEE 2012]**

Or

Identify the sense codon from the following **[KCET 2012]**

(a) AUG (b) GUG
(c) UGA (d) UAG

23. The taq polymerase enzyme is obtained from **[NEET (Phase-I) 2016]**

(a) *Thermus aquaticus* (b) *Thiobacillus ferroxidans*
(c) *Bacillus subtilis* (d) *Pseudomonas putida*

24. The PCR technique was invented by **[MP PMT 2010]**

(a) Karry Mullis (b) Cohen
(c) Boyer (d) Sanger

25. Match the enzyme in column I with its function in column II and select the correct option

Column I		Column II	
A.	β-galactosidase	1.	Joining of DNA fragments
B.	Permease	2.	Peptide bond formation
C.	Ligase	3.	Hydrolysis of lactose
D.	Ribozyme	4.	Increase permeability to β-galactosidase

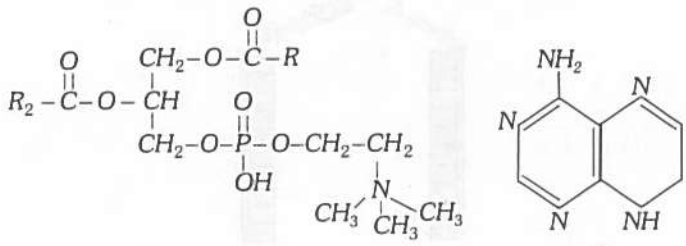
[Kerala PMT 2011]

(a) A–2, B–1, C–4, D–3 (b) A–3, B–4, C–1, D–2
(c) A–2, B–4, C–1, D–3 (d) A–1, B–2, C–4, D–3
(e) A–3, B–1, C–4, D–2

26. Satellite DNA is useful tool in **[CBSE PMT (Pre.) 2010]**

(a) Genetic engineering
(b) Organ transplantation
(c) Sex determination
(d) Forensic science

27. Which one of the following structural formulae of two organic compounds is correctly identified along with its related function **[CBSE PMT (Pre.) 2011]**



A **B**

(a) A : Lecithin – a component of cell membrane
(b) B : Adenine – a nucleotide that makes up nucleic acids
(c) A : Triglyceride – major source of energy
(d) B : Uracil – a component of DNA

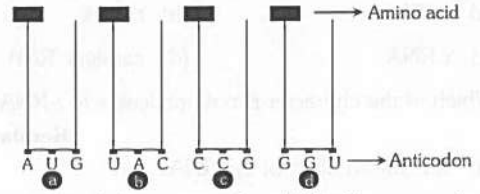
28. Which one of the following does not follow the central dogma of molecular biology **[CBSE PMT (Pre.) 2010]**

(a) HIV (b) Pea
(c) Mucor (d) Chlamydomonas

29. Genes of interest can be selected from a genomic library by using **[NEET (Karnataka) 2013]**

(a) Cloning vectors (b) DNA probes
(c) Gene targets (d) Restriction enzymes

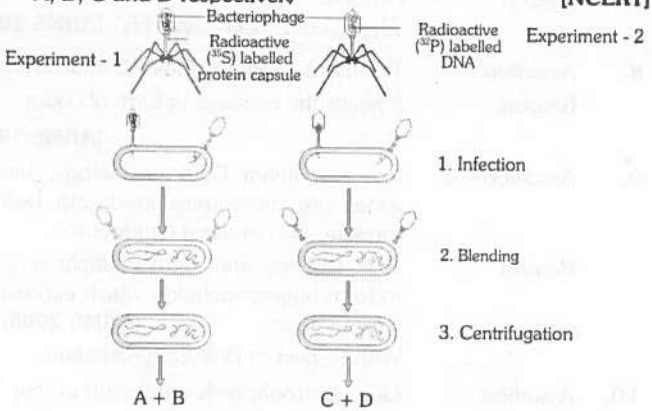
30. Find the sequence of binding of the following amino acyl-tRNA complexes during translation to a mRNA transcribed by a DNA segment having the base sequence 3' TACATGGGTCCG5' **[NCERT]**



Choose the right answer in which the correct order of alphabets is showing

(a) b, a, d, c (b) a, b, d, c
(c) b, a, c, d (d) a, b, c, d

31. Alfred Hershey and Martha Chase made a big contribution in proving DNA role as the hereditary molecule. The experiment is shown in the figure. A and C are the presence or absence of radioactivity detected in cells . B and D are the presence or absence of radioactivity detected in supernatants cells. Identify A, B, C and D respectively **[NCERT]**



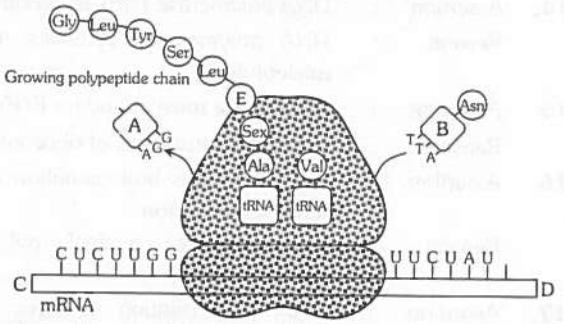
(a) A - No Radioactivity (^{35}S) detected in cells; B - Radioactivity (^{35}S) detected in supernatant; C - No Radioactivity (^{32}P) detected in cells; D - Radioactivity (^{32}P) detected in supernatant

(b) A - No Radioactivity (^{35}S) detected in cells; B - Radioactivity (^{35}S) detected in supernatant; C - Radioactivity (^{32}P) detected in cells; D - No Radioactivity (^{32}P) detected in supernatant

(c) A - Radioactivity (^{35}S) detected in cells; B - No Radioactivity (^{35}S) detected in supernatant; C - Radioactivity (^{32}P) detected in cells; D - No Radioactivity (^{32}P) detected in supernatant

(d) A - No Radioactivity (^{35}S) detected in cells; B - Radioactivity (^{32}P) detected in supernatant; C - Radioactivity (^{35}S) detected in cells; D - No Radioactivity (^{32}P) detected in supernatant

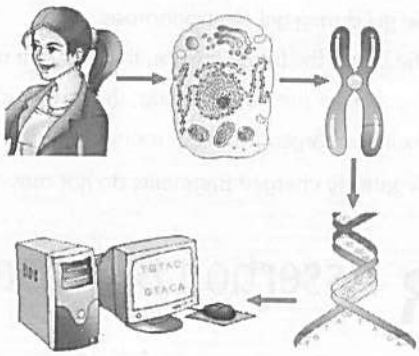
32.



The above figure refers to translation. In which of the four options A, B, C, D and E are correctly identified **[NCERT]**

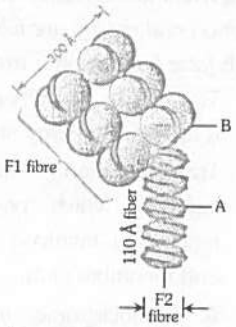
	A	B	C	D	E
(a)	Uncharged tRNA	Charged/ Aminoacylated tRNA	5' end	3' end	Lysine
(b)	Uncharged tRNA	Charged/ Aminoacylated tRNA	3' end	5' end	Glycine
(c)	Uncharged tRNA	Charged/ Aminoacylated tRNA	5' end	3' end	Glycine
(d)	Charged/ Aminoacylated tRNA	Uncharged tRNA	5' end	3' end	Glycine

33. The given diagram illustrates **[NCERT]**



(a) Chromosome walking
(b) Humoral Analysis
(c) Human Genome Project
(d) Method of DNA fingerprinting

34. The adjacent figure represents the structure of basic 30 nm fibre of chromosome of eukaryotes. Choose the correct option in which F1, F2, A and B are correctly identified **[NCERT]**



	F1	F2	A	B
(a)	Nucleosome	Solenoid	DNA	Histone octamer
(b)	Solenoid	Nucleosome	DNA	Nonhistone octamer
(c)	Solenoid	Nucleosome	RNA	Histone octamer
(d)	Solenoid	Nucleosome	DNA	Histone octamer

35. Commonly used vectors for human genome sequencing are **[CBSE PMT 2014]**

(a) Expression Vectors (b) T/A Cloning Vectors
(c) T-DNA (d) BAC and YAC

36. Match the items in Column-I with those in Column-II and choose the correct answer

Column-I		Column-II	
P.	PCR	i.	Insertion of a vector into target cell
Q.	Transformation	ii.	Post-transcriptional modification of protein
R.	DNA ligation	iii.	Replication of DNA
S.	Ribozyme action	iv.	Creation of recombinant DNA

[WB-JEE 2016]

(a) P-ii, Q-iv, R-i, S-iii (b) P-iii, Q-i, R-iv, S-ii
(c) P-iii, Q-i, R-ii, S-iv (d) P-iv, Q-iii, R-i, S-ii

37. What is the criterion for DNA fragments movement on agarose gel during gel electrophoresis **[NEET 2017]**

(a) The larger the fragment size, the farther it moves

(b) The smaller the fragment size, the farther it moves

(c) Positive charged fragment moves to farther end

(d) Negatively charged fragments do not move

A R Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion

(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion

(c) If the assertion is true but the reason is false

(d) If both the assertion and reason are false

(e) If the assertion is false but reason is true

1. Assertion : The uptake of DNA during transformation is an active, energy requiring process.
Reason : Transformation occurs in only those bacteria, which possess the enzymatic machinery involved in the active uptake and recombination.

2. Assertion : A monocistronic *m*RNA can produce several types of polypeptide chains.
Reason : The terminator codon is present on the *m*RNA. **[KCET 2009]**

3. Assertion : Regulator and operator genes are not associated with constitutive genes.
Reason : Constitutive genes need not be repressed.

4. Assertion : Initiation step of protein synthesis in prokaryotes and eukaryotes has several differences.
Reason : They both form *m*RNA – *t*RNA complex with smaller subunit of ribosome.

5. Assertion : *Agrobacterium tumefaciens* is popular in genetic engineering because this bacterium is associated with the roots of all cereal and pulse crops.
Reason : A gene incorporated in the bacterial chromosomal genome gets automatically transferred to the crop with which the bacterium is associated. **[AIIMS 2005]**

6. Assertion : mRNA attaches to ribosome through its 3' end.
Reason : The mRNA has F-capsular nucleotide and bases of lagging sequence. **[AIIMS 2002]**

7. Assertion : Histones are basic proteins of major importance in packaging of eukaryotic DNA, DNA and histones comprise chromatin forming the bulk of eukaryotic chromosome.
Reason : Histones are five major types H_1, H_2A, H_2B, H_3 and H_4 **[AIIMS 2000]**

8. Assertion : The tRNA molecules possess anticodons.
Reason : It needs the message in form of codon. **[AIIMS 1995]**

9. Assertion : In recombinant DNA technology, human genes are often transferred into bacteria (prokaryotes) or yeast (eukaryote).
Reason : Both bacteria and yeast multiply very fast to form huge population which express the desired gene. **[AIIMS 2005, 08]**

With respect to DNA fragmentation

10. Assertion : Gel electrophoresis and elution are two important processes.
Reason : After staining with ethidium bromide it has to be exposed to U.V. light. **[KCET 2015]**

11. Assertion : The nitrogen bases of the two chains of DNA are held together by hydrogen bonds.
Reason : Both chains of DNA are antiparallel.

12. Assertion : One of the two strands of DNA is called sense strand and other is called antisense strand.
Reason : Sense strand of DNA forms complementary RNA.

13. Assertion : Plasmids are extrachromosomal DNA.
Reason : Plasmids are found in bacteria and are useful in genetic engineering. **[AIIMS 2001]**

14. Assertion : DNA polymerase-I acts as proofreader.
Reason : DNA polymerase-I removes mismatched nucleotides.

15. Assertion : rRNA is the most abundant RNA.
Reason : rRNA is a constituent of ribosomes.

16. Assertion : An mRNA has both initiation codon and termination codon.
Reason : It specifies only a single polypeptide or number of them.

17. Assertion : DNA fingerprinting involves identifying differences in some specific regions in DNA sequence.
Reason : In repetitive DNA sequences, a small stretch of DNA is repeated many times. **[AIIMS 2009]**

18. Assertion : Ribosomes protect *m*RNA from ribonuclease.
Reason : mRNA is located in the gap between the two ribosomal subunits.

19. Assertion : In prokaryotes, there are three initiation factors used for protein synthesis.
Reason : All the initiation factors have their own functions.

20. Assertion : The bacteria and other prokaryotes show high adaptability to the changing environment.
Reason : Member of kingdom Monera are efficient in regulating gene expression.

21. Assertion : Replication and transcription occur in the nucleus but translating occurs in the cytoplasm.
Reason : *m*RNA is transferred from the nucleus into the cytoplasm where ribosomes and amino acids are available for protein synthesis. **[AIIMS 2005, 08]**

22. Assertion : DNA found in mitochondria and chloroplast are called prochromosome.
Reason : They are similar to prokaryotic chromosome.

23. Assertion : Killer strain of *Paramecium aurelia* can kill sensitive strain.
Reason : If sensitive strain is provided kappa particle, it becomes killer.

24. Assertion : Scaffold proteins are nonhistone chromosomal proteins.
Reason : They are rich in lysine and arginine.

25. Assertion : RNA produced during transcription in eukaryotic cells cannot be straight away used in photosynthesis.
Reason : RNA splicing phenomena helps in the removal of exons. **[KCET 2010]**

26. Assertion : Recognition site should be preferably single and responsive to commonly used restriction enzyme.
Reason : In *pBR* 322 alien DNA is ligated generally in the area of *Bam-HI* site of tetracycline resistance gene. **[AIIMS 2009]**

Answers

Nucleic acid (DNA/RNA)

1	a	2	b	3	b	4	b	5	b
6	d	7	d	8	a	9	b	10	a
11	b	12	a	13	d	14	d	15	b
16	b	17	b	18	a	19	b	20	b
21	b	22	c	23	a	24	b	25	d
26	c	27	c	28	b	29	b	30	a
31	c	32	b	33	d	34	e	35	a
36	a	37	c	38	d	39	a	40	c
41	a	42	c	43	a	44	a	45	c
46	a	47	c	48	c	49	c	50	c
51	d	52	b	53	c	54	d	55	c
56	b	57	a	58	c	59	c	60	d
61	c	62	c	63	b	64	d	65	a
66	a	67	a	68	b	69	c	70	a
71	b	72	b	73	b	74	d	75	b
76	a	77	b	78	d	79	d	80	c
81	b	82	a	83	c	84	b	85	d
86	a	87	a	88	d	89	d	90	b
91	a	92	a	93	c	94	b	95	d
96	a	97	a	98	b	99	a	100	a
101	d	102	b	103	b	104	c	105	d
106	d	107	b	108	c	109	b	110	b
111	c	112	c	113	c	114	c	115	d
116	c	117	d	118	b	119	d	120	b
121	a	122	b	123	d	124	b	125	a
126	d	127	d	128	b	129	d	130	b
131	d	132	d	133	b	134	e	135	c
136	b	137	b	138	b	139	b	140	b
141	c	142	d	143	d	144	a	145	c
146	a	147	c	148	c	149	b	150	b
151	a	152	a	153	a	154	e	155	d
156	c	157	b	158	b	159	c	160	d
161	c	162	d	163	a	164	d	165	d
166	c	167	d	168	b	169	a	170	c
171	e	172	a	173	b	174	c	175	c
176	d	177	b	178	c				

Gene regulation and Genetic code

1	d	2	c	3	d	4	d	5	a
6	d	7	c	8	a	9	a	10	a
11	b	12	d	13	a	14	b	15	b
16	c	17	c	18	d	19	b	20	a
21	a	22	a	23	a	24	a	25	b
26	e	27	a	28	b	29	d	30	d
31	d	32	d	33	a	34	b	35	d
36	a	37	b	38	c	39	c	40	a
41	b	42	a	43	c	44	a	45	b

46	a	47	b	48	d	49	b	50	d
51	a	52	d	53	a	54	b	55	d
56	c	57	c	58	c	59	b	60	e
61	a	62	b	63	a	64	b	65	a
66	c	67	d	68	c	69	d	70	a
71	a	72	a	73	d	74	b	75	a
76	d	77	d	78	a	79	b	80	b
81	a	82	c	83	b	84	c	85	a
86	d	87	c						

Protein Synthesis

1	b	2	d	3	c	4	d	5	e
6	a	7	a	8	a	9	c	10	a
11	d	12	b	13	a	14	b	15	a
16	a	17	c	18	d	19	c	20	d
21	a	22	b	23	b	24	d	25	a
26	b	27	a	28	b	29	c	30	c
31	c	32	d	33	b	34	b	35	b
36	d	37	d	38	d	39	c	40	b
41	a	42	b	43	e	44	b	45	a
46	d	47	d	48	b	49	c	50	b
51	c								

DNA Finger Printing

1	e	2	b	3	a	4	a	5	b
6	b	7	d	8	c	9	d	10	d
11	c	12	d	13	c	14	a	15	d
16	d	17	a	18	c	19	b	20	b
21	e	22	d	23	a	24	b	25	d
26	b	27	c	28	d	29	b	30	b
31	b	32	bd	33	b	34	c	35	c
36	a	37	c	38	d	39	a	40	c
41	b	42	b						

NCERT Exemplar Questions

1	b	2	c	3	c	4	c	5	c
6	b	7	d	8	d	9	d	10	b
11	c	12	d	13	b	14	b	15	b
16	b	17	d	18	a	19	d	20	b
21	c	22	d	23	a	24	c	25	b
26	b	27	a	28	a				

Critical Thinking Questions

1	b	2	d	3	b	4	c	5	b
6	b	7	b	8	a	9	c	10	d
11	a	12	d	13	d	14	d	15	c
16	c	17	c	18	c	19	b	20	d
21	d	22	a	23	a	24	a	25	b
26	d	27	a	28	a	29	b	30	a
31	b	32	c	33	c	34	d	35	d
36	b	37	b						

Assertion and Reason

1	a	2	e	3	a	4	b	5	d
6	d	7	b	8	b	9	a	10	b
11	b	12	b	13	a	14	a	15	b
16	b	17	a	18	a	19	a	20	a
21	a	22	a	23	b	24	c	25	c
26	b								

AS Answers and Solutions

Nucleic acid (DNA/RNA)

5. (b) Prokaryotic nucleoid consists of DNA only; no histones associated with it.

7. (d) The phenomenon of separating of two strand of DNA molecule by breaking of hydrogen bond at the temp 90°C.

9. (b) Anticodon arm is responsible for recognizing and binding codons in the m-RNA.

12. (a) Nobel prize for artificial synthesis of RNA was given to S. Ochoa (1959).

14. (d) Uracil base is found in RNA, in this way, uridine monophosphate is the nucleotide of RNA.

18. (a) Spliceosomes cut introns from hn–RNA and exons are joined by RNA ligase. It is called splicing.

22. (c) The DNA ligase joins the new and old segments of the strand under repair. This makes the damaged DNA strand normal.

25. (d) The eukaryotic cell, transcribes a precursor RNA much longer than mRNA. This is called heterogenous nuclear RNA.

26. (c) mRNA carries genetic information in cytoplasm for the synthesis of proteins. For this reason only, it was named messenger RNA by Jacob and Monad. It constitutes 5% of total RNA.

31. (c) The enzyme helicase unwind the helix (by disrupting *H* bonds) while topo-isomerase break and release tension of strands of *DNA*. Topo-isomerase also take part in recombination.

43. (a) In 1928, **Frederick Griffith** performed transformation experiment by using *Streptococcus pneumoniae*.

48. (c) Replication of DNA is in unidirectional and Bidirectional.

57. (a) In a nucleotide, purine or pyrimidine nitrogenous base is joined by deoxyribose pentose sugar (D), which is further linked with phosphate (P) group to form nucleotides.

58. (c) According to Watson-Crick model, the DNA molecule consists of two long, parallel chains which are spirally coiled around a common axis in a regular manner to form a double helix.

62. (c)
$$\begin{array}{cccccccc} A & G & C & T & T & C & G & A \\ | & | & | & | & | & | & | & | \\ T & C & G & A & A & G & C & T \end{array}$$

66. (a) Okazaki segments are formed during semidiscontinuous replication. The okazaki fragments are later joined together, forming a continuous lagging strand.

67. (a) Fibrillar region of nucleolus is called NOR. and this region contains genes coding for 18 s and 28 s ribosomal RNA.

68. (b) Reverse transcriptase or RNA dependent DNA polymerase enzyme catalyze the transcription of DNA by some viral RNA. This process is also known as teminism.

70. (a) Enzyme involved in transcription is RNA polymerase –II which consist five polypeptide $\alpha, \beta, \beta, \omega$ and σ.

73. (b) The strands of double helix run in opposite direction [one strand-leading $(5' \rightarrow 3')$ and other one is lagging] lagging strand is synthesized in opposite direction $(3' \rightarrow 5')$ and must be copied discontinuously resulting in okazaki fragments (discovered by Reiji okazaki in 1968).

75. (b) Non-genetic RNA is of 3 types mRNA, tRNA, rRNA and they are related with synthesis of proteins.

79. (d) Restriction endonucleases are enzymes that are specialised to cut DNA at specific sites in the regions having palindromic sequences.

80. (c) Endonucleases enzymes cut DNA at specific desired place so it is called chemical knives of DNA.

82. (a) The tRNA has many varieties. Each variety carries a specific amino acid from the amino acid pool to the mRNA on the ribosomes to form a polypeptide hence its name. A tRNA molecule as proposed by R.W. Holley in 1965, has the resemblance of a clover leaf that results from self-folding and base pairing, creating paired stems and unpaired loops.

84. (b) Because it carries and transfers the genetic information from one generation to another.

86. (a) Enzyme helicase unwinds the DNA helix and unzips the two strands of DNA.

87. (a) Exon is the active part of *m*-RNA and intron is the inactive part of *m*-RNA. Which codes the formation of specific protein.

89. (d) Transposons are genetic elements which were originally discovered in maize plant by B. McClintock. It is responsible for turning the expression of gene on or off.

90. (b) With the help of restriction enzymes to cut a DNA sequence. A restriction enzyme *Eco R*1 will cut DNA only if sequence $\begin{array}{ccccc} G & A & T & T & C \\ C & T & A & A & G \end{array}$ is present.

91. (a) DNA polymerase was discovered by kornberg and his colleagues in 1955.

92. (a) Amino acid binds with 3′ end of *m*-RNA

94. (b) According to chargaff (1950) rules $A + T \neq G + C$.

95. (d) DNA ligase adjoins the nucleotides in DNA strand.

96. (a) In transition, a purine (A or G) or a pyrimidine (C or T or U) in triplet code of DNA or mRNA is replaced by its type. *i.e.*, a purine replaces purine and pyrimidine replaces pyrimidine.

97. (a) Bases sequence in DNA will decide the base sequence in RNA. Uracil (U) will work as substitute for thymine (T) in mRNA. Complementary base pairing for mRNA will be $\begin{array}{ccccc} A & T & A & C & G \\ U & A & U & G & C \end{array}$.

98. (b) The two template strands of a replicating DNA molecule are antiparallel $(5' \rightarrow 3'$ and $3' \rightarrow 5')$ at the unwinding replication fork (y-shaped). In bacteria and many DNA phages this extending is bi-directional.

99. (a) Replication of DNA occurs at $5' \rightarrow 3'$ direction on template DNA.

100. (a) *RNA* polymerase-III forms $t - RNA$ in Eukaryotes

101. (d) DNA polymerase I is a repairing enzyme which introduce and join the defected segment of DNA.

102. (b) Avery, Mc Leod and Mc Carty (1944) proved that DNA was the transforming agent.

104. (c) *Diplococcus pneumoniae*.

105. (d) mRNA is a polymer of ribo-nucleotide as a complementary strand to DNA and carries genetic in formation in cytoplasm for the synthesis of proteins.

106. (d) The strand of DNA, the enzyme forms DNA fragments in small pieces again in $5' \rightarrow 3'$ direction initiating from RNA primer. The primer is formed with the help of primase enzyme.

107. (b) During replication two strands of DNA separate or double stranded DNA uncoils by action of enzymes helicase or unwindase enzyme (unwinding protein).

108. (c) RNA Polymers catalyse polymerization only in one direction, that is $5' \rightarrow 3'$ and the strand that has the polarity $3' \rightarrow 5'$ act as a template.

109. (b) Gyrase is a type of topoisomerase in *E.coil* helps in unwinding of DNA.

112. (c) New DNA strand is formed on 3′ to 5′ strand continuously in $5' \rightarrow 3'$ direction. This strand which is formed continuously is called leading strand.

113. (c) Restriction endonuclease enzyme cuts the internal phosphodiester bonds of DNA. Endonuclease act only on double stranded DNA.

114. (c) Nucleotides are the building blocks or monomeric units. Each nucleotides contain Nitrogen bases (Purines and pyrimidines), pentose sugar (5c) and phosphoric acid.

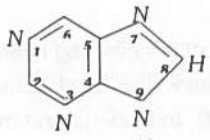
122. (b) The two strands (polynucleotide chains) of Double helix are antiparallel complementary. The sequence of nitrogenous bases in one determines the sequence of nitrogenous bases in the other.

125. (a) In each turn of the double helix structure of *DNA*, there are 10 base pairs each placed at a distance of 3.4 Å. Hence, if the length of *DNA* has 45,000 *bp*, the complete turns of *DNA* molecule is 4,500.

133. (b) B-DNA is the right handed coiled and normal type of DNA.

146. (a) In caping an unusual nucleotide (methyl guanosinetriphosphate) is added to the 5' end of *hn*RNA. In tailing, a adinilate residues (200-300) are added at 3' end in template independent manner.

159. (c) 3' –5' phosphodiester bond is formed between carbon 3 of one nucleotide and carbon 5 of the other nucleotide.

161. (c)  Purine Base

162. (d) DNA is the polymer of deoxyribonucleotides. Nucleic acid is made up of units of nucleotide. In a nucleotide, purine or pyrimidine nitrogenous base is joined by deoxyribose pentose sugar (D), which is further linked with Phosphate (P) group to form nucleotides.

166. (c) Probe – 15–30 long Radioactive/Non radioactive segment *DNA/RNA* that is used in hybridization with *DNA* segment.

169. (a) 23 S rRNA is catalytic RNA.

Gene regulation and Genetic code

1. (d) Genetic code is triplet and in each triplet code three bases are present (4^3).

2. (c) Mc Clintock discovered jumping genes (Transposons, 1940) in maize and she named them as controlling elements or mobile genetic elements in maize. For this work, she was awarded Nobel prize in (1983).

4. (d) Termination codons are also known as the non-sense codons or stop codons becuase they stop the process of protein synthesis being not coded for amino acid during translation.

6. (d) A single amino acid is specified by a sequence of three nucleotides in mRNA *i.e.*, called codon. Due to triplet nature, it consist of 64 codon.

13. (a) Regulation of lac operon by repressor is referred as negative regulation. Human genome has approximately 30000 genes.

15. (b) Amino acid is coded by a group of three bases called as codon.

18. (d) Lac operon : cluster of genes that regulates production of enzymes needed to metabolize lactose in bacterial cells (*E. coli*). It is an inducible operon.

19. (b) Marshall Nirenberg and Hargobind Khorana have determined which sequence of bases coded is for which amino acids with the help of experiments.

23. (a) Operon model was given by Jacob and Monad (1961) for regulation of protein synthesis in prokaryotes.

27. (a) Regulator gene produces a repressor that binds to operator gene and stops the working of the latter.

28. (b) Operator gene controls the activity of structural gene which synthesizes *m*-RNA (transcription).

32. (d) Structural genes are those genes which actually synthesise mRNAs.

33. (a) UGC and UGU both codons are responsible for cystein amino acid.

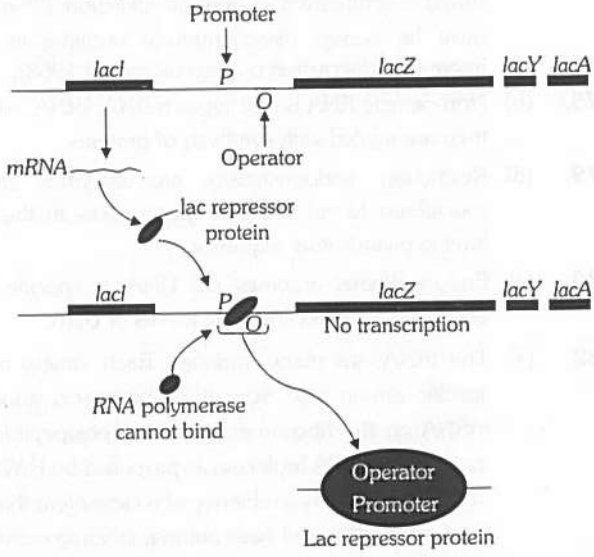
35. (d) Anticodon are also called codon recognition site. This site has three unpaired bases whose sequence is complementary with a codon in mRNA.

36. (a) Because CUC and UCC code for respectively Leucine and Serine.

37. (b) Codon AAA and AAG code for lysine amino acid.

38. (c) The genetic code is a triplet code. Three adjacent bases, termed a codon specify one amino acid. The first, second and third bases represent 5' to 3' direction.

39. (c) Operator gene is a part of *DNA* between promoter and structural gene, where repressor binds to stop activity of *RNA* polymerase.



41. (b) Both polypeptide and DNA or mRNA have a linear arrangement of their components.

43. (c) Glycine is the simplest amino acid because it has no functional group in the side chain.

$$H_2N-CH(H)-COOH$$

(Glycine)

46. (a) A short sequence of DNA where the repressor binds preventing RNA polymerase from attaching to the promoter this is called on/off switch of transcription.

48. (d) The same genetic code is said to be present in all kinds of living organisms including virus bacteria, unicellular and multicellular organisms.

51. (a) Operon model was given by Jacob and Monad (1961) for regulation of protein synthesis in prokaryotes (Bacteria).

54. (b) When more than one codon may specify the same amino acid, this is called degeneracy of codon. Except for tryptophan and methionine all other 18 amino acids have more than one codon.

59. (b) Differential expression of genes is responsible of different type of protein by which different cells of organs are formed.

64. (b) Regulatory gene – 'i', structural genes – z, y, a

65. (a) The chemical formula is $(SCH_2 - CH(NH_2)CO_2H)_2$

69. (d) Out of 64 codons, 61 codons code for amino acids and the rest three UAG, UAA and UGA are stop codons (*i.e.* do not specify any amino acids)

71. (a) 5'——GAATTC——3'
3'——CTTAAG——5'

80. (b) Operon consist of – regulator gene, promoter gene, operator gene and structural gens.

81. (a) Structural gene Y produces permease enzyme.

86. (d) Glutamate [Glutamic acid] and Aspartate [Aspartic acid] contain more-COOH groups and are considered acidic amino acids.

Protein Synthesis

1. (b) Transcription is the formation of RNA over the template of DNA. It creates single stranded RNA which has a coded information similar to the sense or coding strand of DNA with the exception that T is replaced by U.

2. (d) Formation of protein with the help of information present in m-RNA is called translation.

3. (c) Temin and Baltimore (1972) discovered Reverse transcription (Teminism) in retroviruses. For this work, Temin, Baltimore and Dulbecco were given Nobel prize (1975).

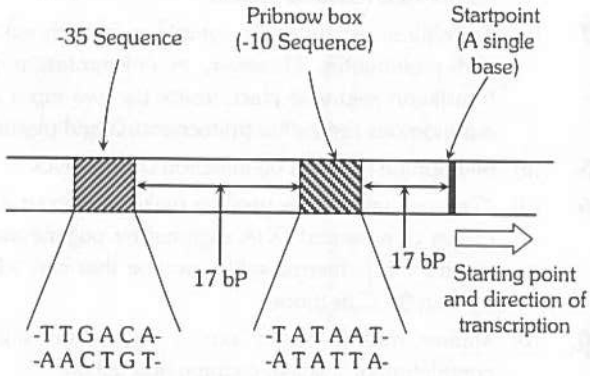
4. (d) Regulator gene controls the activity of operator gene by producing repressor molecules or it codes for repressor protein (gene regulatory protein).

11. (d) By the process of translation and transcription proteins are formed, which are responsible for growth and differentiation.

12. (b) The transcription unit is that stretch or sequence of DNA that is transcribed into a single RNA molecule. A typical transcription unit has a promoter, a start site, a coding region and a terminator sequence at the end.

Promoter is that sequence of a transcription unit where RNA polymerase binds and initiates transcription. *E. coli* promoter have the following 4 consensus sequences:

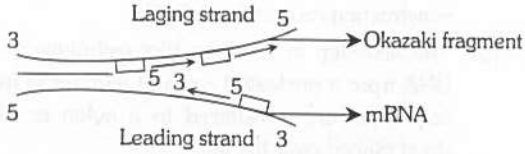
1. **Start point** is the site within a promoter from which transcription begins.
2. **– 10 sequence** is 10 bP upstream of the start point and has consensus sequence TATAAT. This is commonly known as **Pribnow box.**
3. – 35 sequence is on 35 bP upstream of the start point. It has consensus sequence TTGACA.
4. The distance between – 10 to – 35 sequences is 16-18 and seems to be critical for proper orientation of RNA polymerase during transcription initiation.



15. (a) Transcription unit consists of promoter, structural gene and terminator.

17. (c) The non-template strand has same sequence as in *m*-RNA but thymine is replaced by uracil here.

18. (d) Polymerize in the 5' - to 3' direction and explain 3' - to - 5' DNA replication



19. (c) Activities of RNA polymerase is regulated by proteinous transcriptional factors.

22. (b) During protein synthesis *m*RNA formation takes place by DNA, this process is called transcription.

23. (b) These rings contain active DNA or RNA and proteins are synthesized here.

25. (a) Translocation means the shifting of ribosomes along m-RNA. This step requires elongation factor (translocase) and simultaneously the hydrolysis of GTP takes place that provides energy for the translocation (not ATP).

27. (a) Formation of mRNA by DNA in nucleus is called transcription and formation of polypeptide chain on ribosome with the help of mRNA is called translation.

28. (b) During the protein synthesis three successive stages *i.e.*, chain initiation, chain elongation and chain termination are found.

30. (c) Histones are low molecular weight proteins with high proportion of positively charged basic amino acids arginine and lysine.

31. (c) Changed proteins are formed in mutations due to the reason that mRNA transcribed from the mutated gene and the abnormal mRNA introduce different amino acids in the polypeptide chain formed with changed message.

32. (d) DNA does not move to the site of protein synthesis to directly guide the process. Instead, it transfers its information to mRNA molecules which move to the ribosomes to direct protein synthesis.

35. (b) On ribosomes present in cytoplasm as well as in mitochondria, mitochondria and chloroplast also have their own DNA, RNA and ribosomes so can synthesis half of their required protein.

37. (d) Translation occurs in the cytoplasm in both eukaryotes and prokaryotes. However, in eukaryotes, a part of translation also take place inside the two types of semi autonomous organelles (mitochondria and plastids).

45. (a) Methionine is coded by initiation codon *AUG*.

46. (d) "Taq polymerase" is used to make numerous identical copies of a desired DNA segment by polymerase chain reaction. It is thermostable enzyme that can withstand heating 90°*C* or more.

50. (b) Mature mRNA comes out in cytoplasm only after completion of splicing, capping and tailing.

DNA Finger Printing

8. (c) Expansion proceeds at 72°*C* in the presence of Taq DNA polymerase in PCR.

9. (d) VNTR (Variable Number of Tandom Repeats - Type of satellite DNA) is basis of DNA finger printing.

11. (c) Biolistic-it is direct gene transferd method for constructing recombinant DNA.

12. (d) The first step in southern blot technique is isolation of DNA from a nucleated cell and then these isolated DNA sequences are transferred to a nylon or nitrocellulose sheet placed over the gel.

15. (d) Severo Ochoa of Spain and Arthur Kornberg of USA described *in vitro* synthesis of nucleic acids. They were awarded Nobel prize for the same in 1959.

17. (a) 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.

23. (a) In EcoRI, 'co' stands for coli (species of bacteria, from where it is obtained)

26. (b) H.J. Muller (USA) was awarded Nobel prize in 1946 for his contribution on radiation genetics (by *X*-rays).

28. (d) The dark bands on *X*-rays film represent the DNA fingerprints or the DNA profiles.

29. (b) Genetic drift is a random change in gene frequency from one generation to another in a population.

30. (b) DNA finger print of an individual is essentially a southern blot of his DNA digested with an endonuclease and probed with a radioactive DNA probe. The probes used for DNA finger printing are usually prepared from minisatellite of microsatellite DNA.

32. (b,d) Restriction endonuclease *Eco* RI is produced by bacterium *Escherichia colistrain* RY 13. It cuts DNA at very specific site and is used in genetic engineering.

33. (b) PCR is a method for amplifying a specific piece of DNA molecule without the requirement for time-consuming cloning procedures.

35. (c) DNA fingerprinting is a modern technique that compares sets of DNA by locating identical sequences of nucleotides, often for purposes of forensic identification.

39. (a) HIV antibodies can be detected by the ELISA test. A positive ELISA should be confirmed using another test called the western blot test.

40. (c) Western blotting technique is used for transfer of protein from poly-acrylamide gel electrophoresis (PAGE) onto nitrocellulose membrane. Northern blotting is used for RNA transfer and southern blotting for DNA transfer.

Critical Thinking Questions

4. (c) Ex. Oval albumin synthesis in oviduct of chick is influenced by estrogen (steroid) (Transcriptional controle)

6. (b) After two divisions, four bacterial cells are formed in which two daughter bacterial cells have normal DNA and other two have both normal and heavy DNA because DNA replicates by semiconservative method in bacteria.

9. (c) rRNA is the most abundant RNA (70-80% of total RNA in a cell) which has 3-4 types.

13. (d) The new strands of DNA are formed in the $5' \rightarrow 3'$ direction from the $3' \rightarrow 5'$ template DNA by the addition of deoxyribonucleotides to the 3' end of primer RNA.

15. (c) Methionine is the sulphur containing amino acid because it has sulphur atom in side chain.

19. (b) UAA and UGA is termination codons. This is the final step during which the process of protein synthesis is stopped.

20. (d) The enzyme like lactase or β-galactosidase which is formed in response to the presence of its called inducible enzyme.

21. (d) TATA box is present in eukaryotic promoter region. It has a resemblance with pribnow box of prokaryotes. TATA box was identified by Dr. Hogness and so it is also called as Hogness box. During the process of transcription the RNA polymerase binds to TATA box due to which DNA assumes a saddle like structure at this place.

22. (a) In Eukaryotes chain initiation codon is generally AUG, which always codes for methionine.

27. (a) *A* is the formula of Lecithin. Lecithin is a phospholipid and is the component of the cell membranes. *B* is the formula of adenine which is a nitrogenous base not a nucleotide.

35. (d) Commonly used vectors for human genome sequencing are BAC (Bacterial artificial chromosome) and YAC (Yeast artificial chromosome).

37. (b) During electrophoresis, DNA is filtered through pores, based on size. It moves toward anode

Assertion and Reason

1. (a) Transformation does not involve passive entry of DNA molecules through permeable cell walls and membranes. It does not occur 'naturally' in all species of bacteria, only in those species possessing the enzymatic machinery are involved in the active uptake and recombination processes. Even in these species, all cells in a given population are not capable of active uptake of DNA. Only competent cells, which possess a so – called competence factor are capable of serving as recipients in transformation.

2. (e) Eukaryotic *m*RNA is called monocistronic *i.e.*, formed from one gene. These have been described to contain only 1 initiation site, who gave one *m*RNA-one polypeptide chain hypothesis.

The terminator codon is present on *m*RNA molecule, which stops the formation of a polypeptide chain at that point, the three termination codons are UGA, UAA and UAG.

3. (a) Regulator gene controls the operator gene in cooperation with a chemical compound called inducer present in the cytoplasm. The regulation gene codes for and produce a protein substance called repressor. The repressor substance combines with the operator gene to repress its function. Therefore it is called regulator gene.

The constitutive genes keep on functioning all the time. They need not be repressed. Therefore, the regulator and operator genes are not associated with them.

4. (b) The differences between initiation step of protein synthesis in eukaryotes and prokaryotes are :

(i) In prokaryotes initiation factors are three – IF1, IF2 and IF3. Eukaryotes have at least ten initiation factors – eIF1, eIF2, eIF3, eIF4A, eIF4B, eIF4C, eIF4D, eIF4F, eIF5 and eIF6.

(ii) In eukaryotes, formylation of methionine does not take place. In prokaryotes *t*RNA is charged with formylated methionine.

(iii) The larger subunit of ribosome combines with 40S – *m*RNA – $tRNA^{Met}$ (in case of prokaryotes, 30S) complex to form intact ribosome. It requires initiation factor IF1 in prokaryotes and factors eIF1, eIF4 (A, B, C) in eukaryotes.

5. (d) *Agrobacterium tumefacienes* is a rod shaped free living bacteria it cause infection only in broad leave dicot plant through the wound site and transfer the tumour inducing gene to host plant and cause tumour. This spontaneous transfer of gene only by the agrobacterium.

6. (d) mRNA attaches itself to 30S unit of ribosome through its 5' end. This process is helped by G-cap nucleotide and basis of leader sequence present on mRNA where G-cap is present as in eukaryotes.

7. (b) DNA with histone octamer form a nucleosome which comprises a major part of chromatin. Histones are of 5 types.

8. (b) tRNA has anticodons which read the message expressed in the form of codons in mRNA and occupy a specific place on mRNA. tRNA also recognises the amino acids.

9. (a) Bacteria and yeast can easily grow in culture medium and multiply very fast so it is best for making many copies of recombinant DNA, and express character of desired gene.

10. (b)

11. (b) The nitrogen bases of DNA are of two types namely (i) pyrimidines and (ii) purines. The nitrogen bases of the two chains formed complementary pairs with purine of one and pyrimidine of the other held together by hydrogen bonds. The two chains are antiparallel with $5' \rightarrow 3'$ orientation of one and $3' \rightarrow 5'$ orientation of the other.

12. (b) Only one of the two strands of DNA possesses correct hereditary information. It is known as sense strand. Its complementary strand is called antisense strand. Antisense RNA that is made from the DNA strand that is complementary to the sense strand of the DNA.

13. (a) Plasmids are possessed by bacteria. These are extrachromosomal DNA. These are used in genetic engineering.

14. (a) DNA polymerase I can also remove thymine dimers produced due to UV irradiation and fill the gap due to excision. The newly formed segment is sealed by DNA ligase.

15. (b) The amount of rRNA is 70-80% of total RNA. It is a constituent of ribosomes. RNAs of eukaryotes are of four types –28 S, 18 S, 5.8 S and 5 S. Prokaryotic ribosomes have three types of RNAs –23 S, 16 S amd 5 S.

16. (b) *m*RNA is a long RNA. It gets attached to ribosome. *m*RNA has methylated region at the 5' terminus. It functions as a cap for attachment with ribosome. Cap is followed by an initiation codon (AUG) either immediately or after a small noncoding region. Then there is coding region followed by termination codon (UAA, UAG or UGA). There is then a small noncoding region and poly A area at the 3' terminus. An *m*RNA may specify only a single polypeptide or a number of them. The former is called monocistronic while the latter is known as polycistronic.

17. (a) DNA finger printing involves repetitive DNA, because in these sequences a small stretch of DNA is repeated many times.

18. (a) The *m*RNA is located in the gap between the two ribosomal subunits, as a result of which the ribosome protects a stretch of 25 nucleotides of the *m*RNA from degradation by ribonuclease.

19. (a) In prokaryotes, three initiation factors are present – IF_1, IF_2, IF_3. All three factors are essential for initiation when natural *m*RNA are used as templates. IF_3 binds to the 30 S ribosomal subunit and is required for its binding to the *m*RNA starting site. IF_3 also functions as a ribosome dissociation factors. IF_2 binds the initiator *f* Met- *t*RNA and carries it to the ribosome (together with GTP) in response to the first AUG codon. IF_1 participates in the interaction between IF_2 and the initiator *t*RNA.

20. (a) To a considerable degree, the adaptability of bacteria and other prokaryotes depends on their ability to "turn on" "turn off" the expression of specific sets of genes in response to environmental changes. Regulatory mechanisms of this type are very important in microorganisms because of the frequent exposure of these organisms to sudden changes in environment. They provide microorganisms with a great deal of "plasticity", an ability to rapidly adjust their metabolic processes in order to achieve maximum growth and reproduction under highly variable environmental conditions.

21. (a) DNA replication and transcription takes place in nucleus as the required material DNA and RNA are present in nucleus. During transcription *m*RNA take the coded information from DNA to the cytoplasm where translation takes place. Translation is the process of protein synthesis. It is separated from transcription in both space and time. It prevents the intermixing of raw materials, protect DNA from respiratory enzymes and ribosomal machinery from nuclease.

22. (a) Prokaryotic chromosome (prochromosome) consists of a naked double strand of DNA that is the DNA is not associated with histone proteins. DNA is not linear but is circular with no free ends. DNAs of mitochondria and chloroplast resembles prokaryotic chromosome and are, therefore, called organelle prochromosome.

23. (b) *Paramecium aurelia* has two strains : killer and sensitive. The killer strain is able to kill the sensitive strain protist by means of chemical paramecin, secreted by minute cytoplasmic particles called kappa particle. The sensitive strain protists do not have kappa particles. The sensitive strain can also become killer if it receive sufficient kappa particles.

24. (c) Structural nonhistone chromosomal proteins are called scaffold proteins as they constitute the core axis of the chromosome. They contain very little lysine and arginine but instead possess abundant tyrosine and tryptophan types of amino acids.

25. (c)

26. (b) Recognition site or site where alien DNA can be inserted should be single because occurrence of more than one recognition site will cause DNA fragmentation and disturb gene cloning.

Molecular Basis of Inheritance

SET Self Evaluation Test

1. During lytic life cycle of a virulent DNA phage which of the following does not occur **[Odisha JEE 2008]**
   (a) Host cell produce large number virions
   (b) The host cell lyse
   (c) New phages are released
   (d) The phage DNA integrated into the host chromosomes

2. Match the names of the scientists with their contributions and choose the correct answer

Name of the scientist	Contributions
A. Walter Sutton	1. Discovered penicillin
B. Stanley Cohen	2. Discovered double helical structure of DNA
C. Alexander Flemming	3. Discovered the chromosomal basis of heredity
D. James D. Watson	4. Discovered r–DNA
E. Thomas Hunt morgan	5. Described the phenomena of linkage and crossing over

[Kerala PMT 2006, 08]
   (a) A – 2, B – 1, C – 4, D – 3, E – 5
   (b) A – 3, B – 4, C – 1, D – 2, E – 5
   (c) A – 1, B – 3, C – 2, D – 4, E – 5
   (d) A – 4, B – 3, C – 2, D – 1, E – 5

3. Amino acid binding site of t-RNA is **[MP PMT 2013]**
   (a) 5' end (b) Anticodon loop
   (c) DHU loop (d) –CCA 3' end

4. Match List I and List II and select the answer using the code given below the lists :

List I (Scientist)	List II (Discovery)
1. Frederick Griffith	Phenomenon of transformation
2. Gamow	A sequence of 3 nucleotide codes for a single amino acid
3. Friedrich Miescher	Isolated DNA for the first time

[MP PMT 1993]
   (a) 1, 2 and 3 are correct
   (b) 1 and 2 are correct, 3 is false
   (c) 1 is correct, 2 and 3 are false
   (d) 1 and 3 are correct, 2 is false

5. Genetic code of nucleic acid depends upon **[RPMT 1995]**
   (a) Number of nucleic acid (b) Position of nucleic acid
   (c) Sequence of nucleic acid (d) All the above

6. What is the best way to test the relatedness of two species **[Odisha JEE 2009]**
   (a) RNA and proteins
   (b) DNA & proteins
   (c) Antibodies and transposons
   (d) None of these

7. Which of the following types of RNA molecule can be described as soluble, relatively small and having a folded compact shape **[CPMT 2005]**
   (a) rRNA (b) tRNA
   (c) mRNA (d) Nucleolar RNA

8. If the sequence of bases in DNA is ATTCGATG, then the sequence of bases in its transcript will be **[CBSE PMT 1995; AMU (Med.) 2010]**
   (a) GUAGCUUA (b) UAAGCUAC
   (c) CAUCGAAU (d) AUUCGAUG

9. DNA has four different types of nucleotides. These are **[KCET 1994; MP PMT 1994, 95; EAMCET 1995; CBSE PMT 1996; MHCET 2003; Kerala CET 2003; AFMC 2010]**
   (a) Adenine, Uracil, Thymine, Alanine
   (b) Adenine, Thymine, Guanine, Cytosine
   (c) Adenine, Thymine, Uracil, Cytosine
   (d) None of these

10. A unit composed of a sugar and base linked by β glycosidic bond is known as a **[BHU 1995; MP PMT 1997]**
   (a) Nucleotide (b) Nucleoside
   (c) Glycoside (d) Purine

11. 3-D structure of RNA is called **[MHCET 2001]**
   (a) Clover leaf model (b) Hair pin model
   (c) Helical model (d) Plate model

12. Gel-Electrophoresis Unit separates the DNA according to their **[MP PMT 2011]**
   (a) Charge (b) Concentration
   (c) pH (d) Size

13. In which of the following combinations, the compounds in ascending order based on their molecular weights are arranged **[AIIMS 2010]**
   (a) DNA, RNA, AMP, ADP, ATP
   (b) DNA, RNA, ATP, ADP, AMP
   (c) AMP, ADP, ATP, RNA, DNA
   (d) AMP, ATP, ADP, DNA, RNA

14. The term, genetic RNA refers to **[KCET 2011]**
   (a) Genetic material of RNA viruses
   (b) RNA that carries genetic message
   (c) RNA that helps gene regulation in *lac*-operon
   (d) RNA present in mitochondria

15. Which is correct match of phenomenon and its explanation **[AIIMS 2011]**
   (a) Central dogma → RNA → DNA → Protein → RNA
   (b) Reverse transcription–PCR–Many copies of DNA sequence
   (c) Transcription–Formation of RNA and proteins
   (d) RNA silencing–Use of dsRNA

AS Answers and Solutions

1	d	2	b	3	d	4	a	5	c
6	b	7	b	8	b	9	b	10	b
11	a	12	d	13	c	14	a	15	b

3. (d) 3' end is also called carrier end. Here a specific amino acid joins it. It, in all cases, has a base triplet CCA with-OH at the tip.

7. (b) t RNA molecules have been variously termed as soluble RNA or supernatant RNA or adapter RNA.

13. (c) The arrangement of compounds in ascending order according to their molecular weight is
AMP, ADP, ATP, RNA, DNA

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