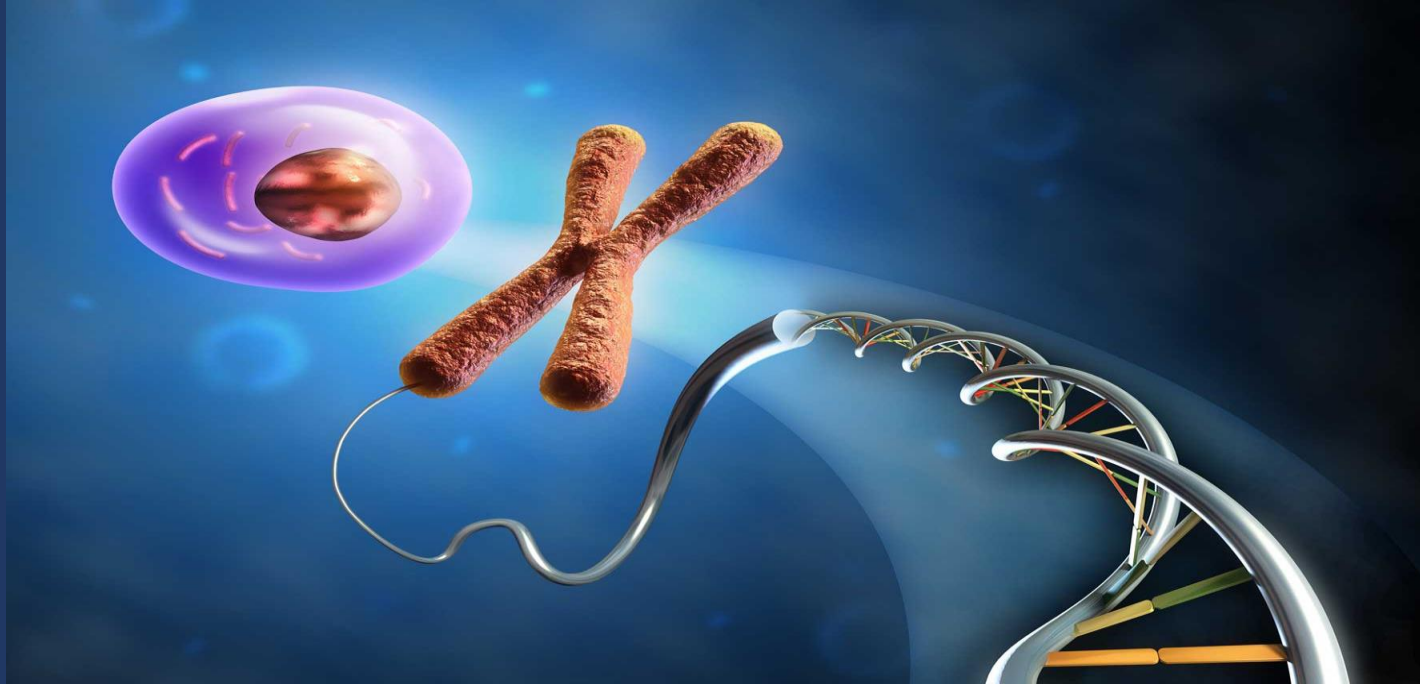


CHAPTER – 6

MOLECULAR BASIS OF INHERITANCE

At the time of Mendel the nature of those factors regulating the pattern of inheritance was not clear, over the next 100 years the nature of the putative genetic material was investigated culminating in the realisation that DNA is the genetic material at least for the majority of organisms.

DNA and RNA are the two types of nucleic acids found in living systems, DNA acts as the genetic material in most of the organisms while RNA though acts as genetic material in some virus mostly functions as a messenger.

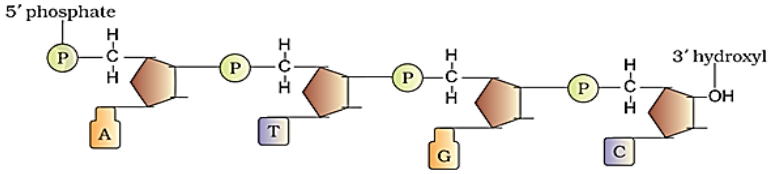
Deoxyribonucleic acid: The two kinds of nucleic acids present in living beings are DNA (Deoxyribonucleic Acid) and RNA (Ribonucleic Acid). In most species, DNA serves as genetic material. In other creatures, such as viruses, RNA also serves as genetic material and as a messenger. It serves as an adaptor, structural molecule, and in certain situations a catalytic molecule.

DNA is a lengthy polymer of deoxyribonucleotides. Base pairs are another name for a pair of nucleotides. The length of DNA is often defined as the number of nucleotides present. Human DNA has a haploid content of 3.3×10^9 bp, while *Escherichia coli* has 4.6×10^6 bp.

The polynucleotide Chain: A nucleotide is made up of three parts:

- a nitrogenous base
- a pentose sugar (ribose in the case of RNA and deoxyribose in the case of DNA), and
- a phosphate group.

Purines (Adenine and Guanine) and Pyrimidines (Cytosine, Uracil and Thymine) are the two kinds of nitrogenous bases.



A polynucleotide Chain

Cytosine is found in both DNA and RNA, whereas Thymine is found in DNA. Uracil is found in RNA in place of Thymine.

A nucleoside is formed when a nitrogenous base is connected to a pentose sugar via an N-glycosidic bond. Nucleotide is generated when a phosphate group is connected to the 5'-OH of a nucleoside via phosphodiester linkage. To make a dinucleotide, two nucleotides are connected together via a 3'-5' phosphodiester bond. More nucleotides combine to produce polynucleotide.

Salient Features of DNA: DNA contains the sugar D -2-deoxyribose. Cytosine and thymine are pyrimidine bases in DNA, while guanine and adenine are purine bases.

The structure of DNA is a double strand -helix. Because DNA molecules are so big, their molecular mass can vary greatly.

DNA has a unique replicating characteristic. The transmission of hereditary effects is controlled by RNA.

Brush Up Your Understanding

Q1. A polynucleotide is made up of.
(a) Pentose sugar
(b) Nitrogenase base
(c) Phosphate group
(d) All of the above

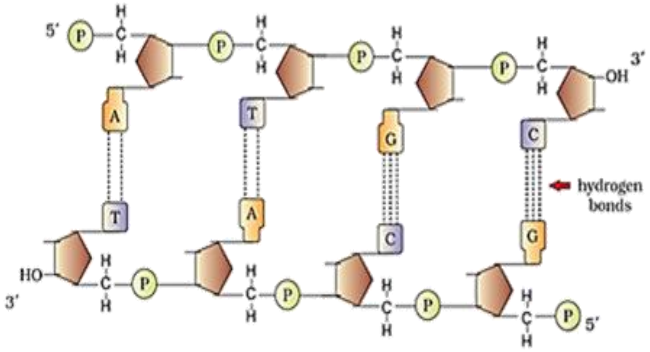
S1. (d)

Q2. Which of the following is a pyrimidine?
(a) Adenine (b) Guanine
(c) Uracil (d) All of the above

S2. (d)

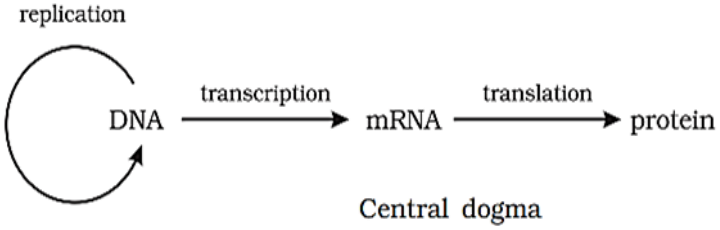
Double Helical Structure of DNA by Watson and Crick
James Watson and Francis Crick suggested the double helix concept for the structure of DNA based on X-ray diffraction evidence collected by Maurice Wilkin and Rosalind Franklin.
According to this model:

- **DNA is made of two polynucleotide chains in which backbone is made up of sugar-phosphate and bases projected inside it.**
- Two chains have antiparallel polarity. One 5' to 3' and 3'to 5'.
- The bases in two strands are linked together by H-bonds. Guanine and Cytosine form triple hydrogen bonds, whereas Adenine and Thymine form double hydrogen bonds.
- Two chains are coiled in the right hand. The pitch of the DNA helix is 3.4 nm, with each turn containing around 10 bp.
- **To provide stability, the plane of one base pair stacks over the plane of the other in a double helix. Other than this hydrogen bonding and the presence of thymine in place of uracil confers additional stability to the DNA.**



Double Standard Polynucleotide chain

The Central dogma of molecular biology, developed by Francis Crick, holds that genetic information flows from DNA —–> RNA —–> Protein.



Central dogma

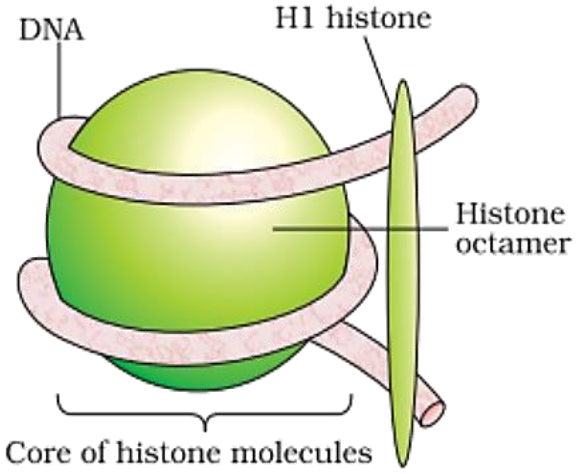
In RNA, nucleotide residues have an extra –OH group at the 2'-position in ribose, and uracil replaces Thymine.

Packing of DNA Helix
In prokaryotes, the nucleus is not clearly defined, and negatively charged DNA is mixed with positively charged proteins known as nucleoids.

In eukaryotes**, histones are positively charged proteins** that are arranged into 8 molecules termed histone octamers. To construct a nucleosome, negatively charged DNA wraps around a histone octamer. **Histones contain a high concentration of the basic amino acid residues lysines and arginines.** The side chains of both amino acid residues are positively charged.

A single nucleosome includes around 200 base pairs.
Chromatin is the nucleosome's repeating unit.

Some regions of chromatin in the nucleus are loosely packed (and stain light) and are referred to as **euchromatin. Heterochromatin** is chromatin that is more densely packed and stains dark. Euchromatin is active transcriptionally, whereas heterochromatin is inactive.



Structure of nucleosome

Brush Up Your Understanding

Q1. Histones are rich in.
(a) Arginine (b) Valine
(c) Lysine (d) Both (a) and (c)

S1. (d)

Q2. The pitch of the DNA helix is.
(d) .34 nm (b) 3.4 nm
(c) .034 nm (d) .0034 nm

S1. (b)

Search for Genetic Material:

The Transforming Principle: Frederick Griffith conducted an experiment on the microorganisms ***Streptococcus pneumoniae*** in 1928. (bacterium responsible for pneumonia). This bacterium has two strains:

- those that generate smooth shining colonies (S) and
- those that form rough colonies (R) (R).

Mice infected with the S strain (virulent) develop pneumonia, but mice infected with the R strain do not.
In brief his experiment was as follows:
Inject **S** strain into mice, it dies (i)
R strain injected into mice, it survives (ii)
Inject **S** strain (heat-killed) into mice, it survives (iii)
Inject **S** strain (heat-killed) plus **R** strain (living) into mice, it dies (iv)

Griffith came to the conclusion that **R** strain bacteria had been transformed by heat-killing **S** strain bacteria. Some transforming factors were transmitted from the **S** strain to the **R** strain, allowing the **R** strain to produce a smooth polysaccharide coat and become virulent. This must be the result of genetic material transfer.

Biochemical Characterisation of Transforming Principle

Oswald Avery, Colin MacLeod, and Maclyn McCarty worked together to determine the biochemical basis of Griffith's transformative principle.

They extracted biochemicals (proteins, DNA, RNA, and so on) from heat-killed S cells to determine which ones may turn living **R** cells into **S** cells. They determined that DNA from **S** bacteria alone enabled **R** bacteria to convert. As a result, they came to the conclusion that DNA is the genetic material.

Experimental Proof that DNA is the genetic material

In one formulation, the protein component was rendered radioactive, whereas the nucleic acid (DNA) component was not.

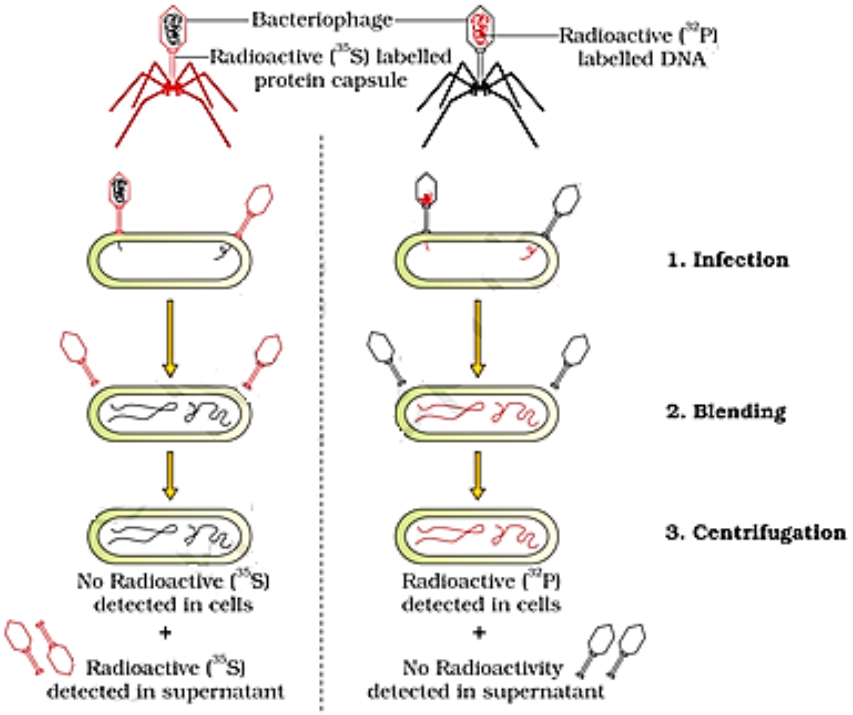
These two phage preparations were allowed to infect an *E.coli* culture. Before cell lysis, the *E.coli* cells were gently agitated in a blender to release the clinging phage particles, and the culture was centrifuged.

The heavier infected bacterial cells settled to the bottom, while the lighter virus particles remained in the supernatant.

When a bacteriophage with radioactive DNA was utilized to infect *E.coli,* the pellet contained radioactivity.

When a bacteriophage with a radioactive protein coat infected *E.coli*, the supernatant held the majority of the radioactivity.

His work demonstrates that protein does not penetrate the bacterial cell and that the only genetic substance is DNA.



An experiment conducted by Hershey and Chase

Brush Up Your Understanding

Q1. Proof that DNA is the genetic material was given by.
(a) Martha Chase (b) Alfred Hershey
(c) Both (a) and (b) (d) None of the above

S1. (c)

Q2. RNA is the genetic material in.
(a) Tobacco Mosaic Virus (b) QB bacteriophage
(c) Both (a) and (b) (d) None of the above

S2. (c)

Properties of A Genetic Material

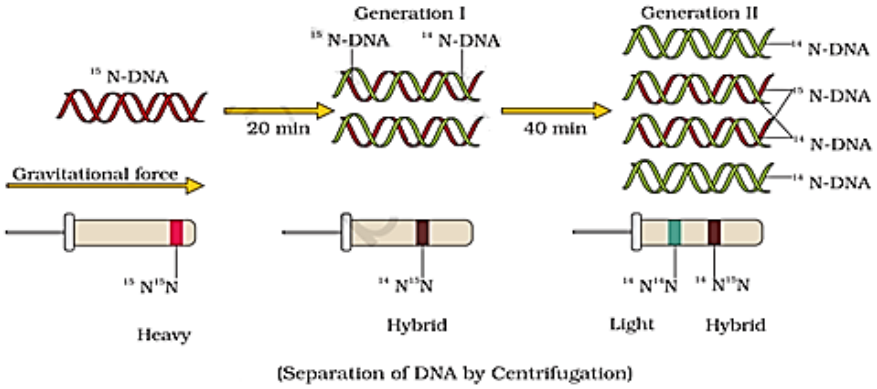
- It should be able to replicate itself (replication)
- It needs to be chemically and structurally stable.
- It should allow for the gradual changes (mutation) essential for evolution.
- It should be able to express itself using 'Mendelian Characters.'

When compared to RNA, DNA is chemically less reactive but structurally more stable. As a result, DNA is superior genetic material.

RNA is employed as a genetic material as well as a catalyst, and because it is more reactive, it is less stable. As a result, DNA has evolved from RNA.

Replication: Watson and Crick proposed that two strands of DNA split and serve as a template for the creation of new complementary strands. After replication, each DNA molecule would contain one parental and one freshly synthesised strand; this is known as **semiconservative replication.**

- Messelson and Stahl demonstrate semiconservative replication experimentally by growing *E.coli* on nutritional media containing nitrogen salts ($^{15}NH_4Cl$) tagged with radioactive ^{15}N.
- Alfred Hershey and Martha Chases (1952) studied bacteriophages, which are viruses that infect bacteria.
- ^{15}N was integrated into both strands of DNA, resulting in DNA that was heavier than DNA obtained from *E.coli* cultured on ^{14}N-containing media. The *E.coli* cells were then moved to a ^{14}N-containing media.
- They extracted the DNA and measured its density after one generation when one bacterial cell multiplied into two. Its density was halfway between that of heavier ^{15}N-DNA and lighter ^{14}N-DNA.
- Because a new DNA molecule with one ^{15}N-old strand and a corresponding ^{14}N-new strand was generated during replication (semi-conservative replication), its density is intermediate between the two.

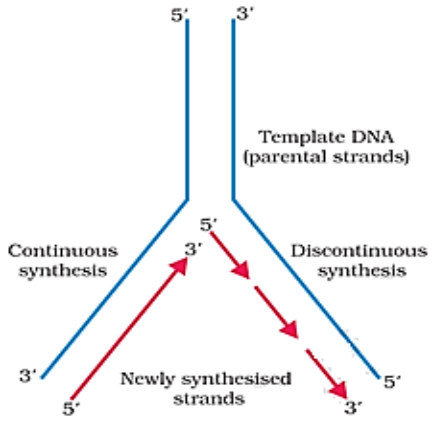


Meselson and Stahl's Experiment

Replication of DNA

Enzyme DNA polymerase is required for DNA replication, which catalyses polymerisation on one strand 5' to 3' after unwinding with the help of **Helicase** enzyme.

As a result, replication in one strand is continuous while replication in the other strand is discontinuous in order to synthesise Okazaki fragments that are linked together by the enzyme **DNA ligase.**



The replicating fork

Brush Up Your Understanding

Q1. What is the function of DNA ligase during replication?
(a) Joins the continuously synthesizing strands of DNA
(b) Joins the discontinuously synthesizing strands of DNA
(c) Both (a) and (b)
(d) None of the above

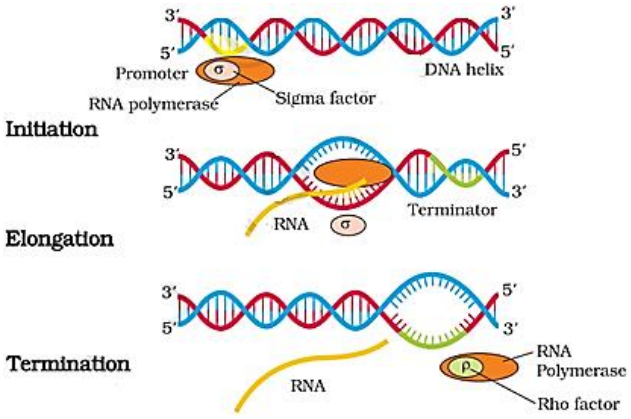
S1. (b)

Q2. The replication of DNA takes place during which of the following phase?
(a) Interphase (b) S-phase
(c) G_1 phase (d) G_2 phase

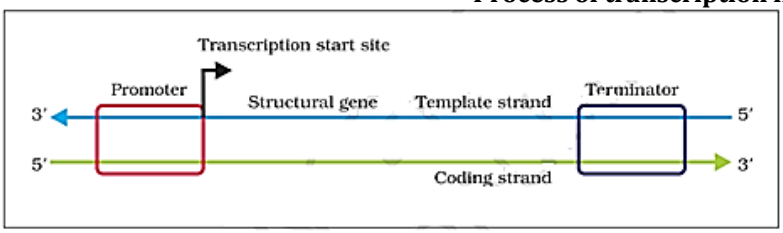
S2. (b)

Transcription: It is the process of copying genetic information from one strand of DNA into RNA. In transcription only one segment of DNA is copied in RNA. The Adenosine forms base pair with Uracil instead of Thymine.

- A promoter, a structural gene, and a terminator are all involved in DNA transcription.
- The strands with polarity 3' to 5' operate as templates and are referred to as template strands, whereas the other strand is referred to as coding strands.



Process of transcription in bacteria



Structure of a transcription unit

- The promoter is positioned at the 5' end and binds the RNA polymerase enzyme to initiate transcription.
- The sigma factor also aids in the initiation of transcription.
- The terminator is normally positioned at the 3'end of the coding strand and defines the end of transcription where the **rho** factor will attach to halt transcription.
- Exons are sequences found in mature and processed RNA. Exons are broken up by introns. In mature and processed RNA, introns do not exist.
- In eukaryotes, three RNA polymerase enzymes, I, II, and III, catalyse the production of all kinds of RNA.

RNA polymerase I : rRNAs
RNA polymerase II : messenger RNA
RNA Polymerase III: tRNA

- The mRNA serves as a template, the t-RNA transports amino acids and reads the genetic information, and the rRNA performs structural and catalytic functions during translation.
- The primary transcript is non-functional and contains both exons and introns. It goes through the splicing process, in which introns are deleted and exons are connected in a certain order.
- Capping and tailing are processes that hnRNA (heterogeneous nuclear RNA) goes through. Capping the 5' end of hnRNA with an uncommon nucleotide (methylguanosine triphosphate). Tailing polyadenylate is the addition of a tail at the 3'end of a template in an autonomous way.

Brush Up Your Understanding

Q1. A cistron is a.
(a) Segment of RNA coding for a polypeptide
(b) Segment of DNA coding for a polypeptide
(c) Segment of protein coding for a polypeptide
(d) None of the above

S1. (b)

Q2. An exon.
(a) Appear in a immature RNA
(b) Appear in a mature DNA
(c) Appear in an immature DNA
(d) Appear in mature RNA

S2. (d)

Genetic Code: The link between amino acid sequences in polypeptides and nucleotide/base sequences in mRNA is known as the genetic code. It governs the sequencing of amino acids during protein synthesis.

- George Gamow proposed that the genetic code be a combination of three nucleotides that code for 20 amino acids.
- H.G. Khorana developed chemical method for synthesising RNA molecules with defined combination of bases.
- Marshall Nirenberg's cell free system for protein synthesis finally helped the code to be deciphered.

Features of the Genetic Code

- The code is triplet. There are 61 codons that code for amino acids and three stop codons that do not code for any amino acids (UAG, UGA and UAA).
- Codon is clear and specific; it codes for a single amino acid.
- The code is degenerate. Some amino acids are coded by multiple codons.
- The codon is read in mRNA in a continuous, punctuated form.
- The codon is almost ubiquitous. AUG has two purposes. It encodes methionine and serves as an initiator codon.

Mutations and Genetic Code

The shift of amino acid residue glutamate to valine leads in a single base pair alteration (**point mutation**) in the 6th position of the Beta globin chain of Haemoglobin. This develops in a disorder known as **sickle cell anaemia.**

Insertion and removal of three or more bases, Insert or delete one or more codons, resulting in one or more amino acids and the reading frame remaining unchanged**. Frame-shift insertion or deletion mutations** are examples of such mutations.

Brush Up Your Understanding

Q1. The function of AUG IS.
(a) It codes for methionine
(b) It acts as an initiator codon
(c) It acts as a terminator codon
(d) Both (a) and (b)

S1. (d)

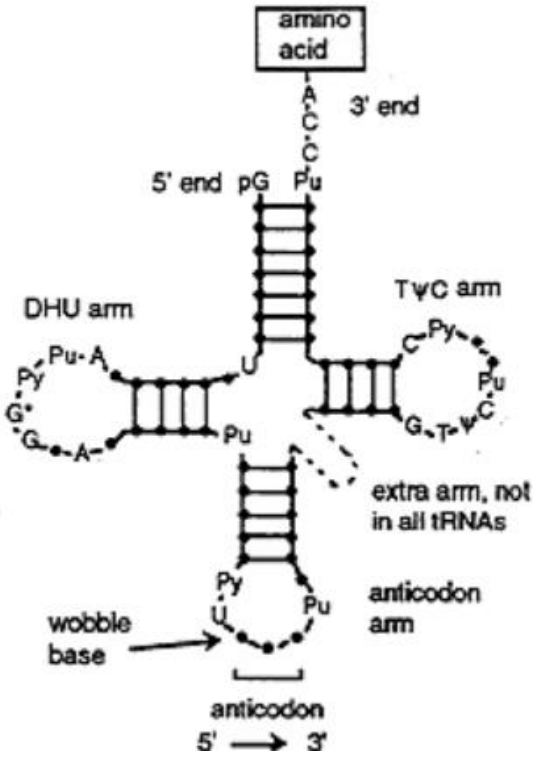
Q2. Sickle cell anaemia is an example of.
(a) Frame shift mutation (b) Point mutation
(c) Both (a) and (b) (d) None of the above

S2. (b)

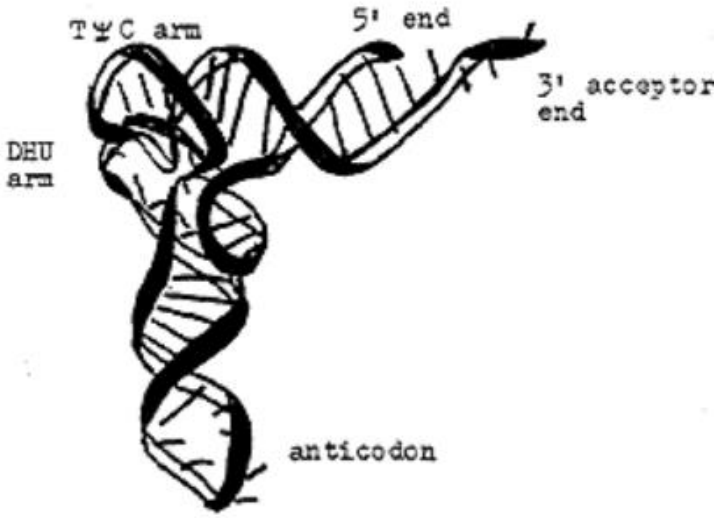
The Adapter molecule-tRNA

The t-RNA molecules are known as adaptor molecules. It has an anticodon loop with bases corresponding to the coding found on mRNA, as well as an amino acid acceptor to which amino acid attaches. Each amino acid has its own t-RNA.

The clover-leaf secondary structure of t-RNA is illustrated. The t-RNA molecule is a compact molecule that looks like an inverted L.



tRNA-the adapter molecule



The clover leaf structure (inverted L-shaped)

Translation: The process of polymerisation amino acids to generate a polypeptide is known as translation. The sequence of nucleotides in the mRNA determines the order and sequence of amino acids. Peptide bonds joins the amino acids. The following steps are involved:

- Charging of tRNA
- Peptide bond formation between two charged tRNA.
- AUG is the start codon. Untranslated regions are extra sequences in an mRNA that are not translated (UTR).
- The ribosome attaches to mRNA at the start codon to initiate translation. Ribosomes migrate from codon to codon along mRNA in order to extend the protein chain.
- At the end of the process, release factors bind to the stop codon, halting translation and releasing polypeptides from the ribosome.

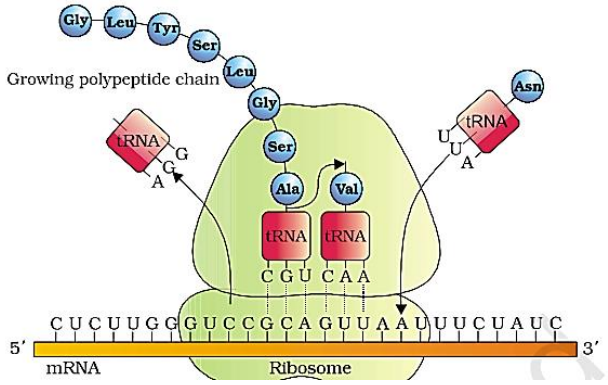


Diagram showing Translation

Brush Up Your Understanding

Q1. Aminoacylation of t-RNA takes place during which of the following process?
(a) Replication (b) Transcription
(c) Translation (d) All of the above

S1. (c)

Q2. tRNA is also called as.
(a) Mediator RNA (b) Initiator RNA
(c) Both (a) and (b) (d) None of the above

S2. **(b)**

Regulation of Gene Expression

All of the genes are not always required. The genes that are only needed sometimes are known as regulatory genes, and they are designed to function only when needed while remaining inactive at other times. Such controlled genes must thus be turned 'on' or 'off' when a certain function begins or ends. Here are some examples:

The *lac* operon: One regulatory gene (i) and three structural genes comprise the Lac operon (y,z and a). Gene i encodes the lac operon repressor. The z gene encodes beta-galactosidase, which hydrolyzes disaccharide, lactose into monomeric units, galactose, and glucose. Gene y codes for permease, which enhances cell permeability. Transacetylase is encoded by gene a.

Lactose is the substrate for the enzyme beta-galactosidase, and it governs the operon's switching on and off, thus the name inducer.

Negative regulation refers to the control of the *lac* operon by a repressor. Positive regulation also governs the operation of the *lac* operon.

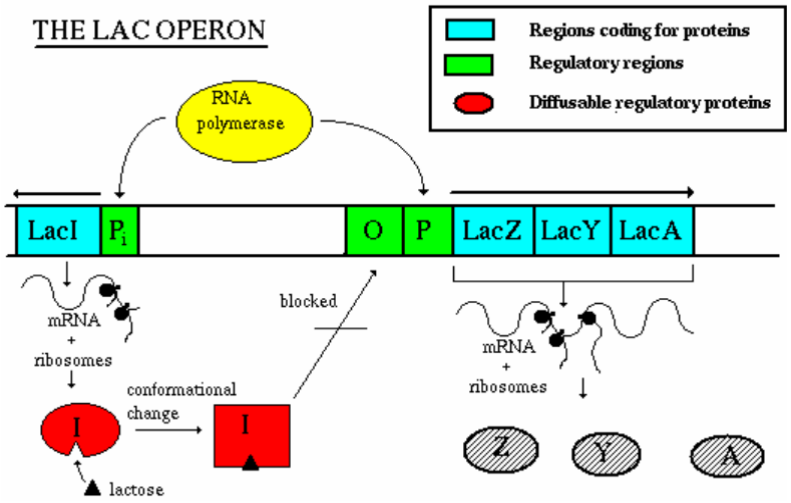
Brush Up Your Understanding

Q1. Which of the following gene, synthesises the repressor of the Lac operon all the time-continuously?
(a) Gene y (b) Gene a
(c) Gene i (d) Gene z

S1. **(c)**

Q2. The gene in the lac operon that codes for beta-galactosidase is.
(a) Gene i (b) Gene a
(c) Gene z (d) Gene y

S2. **(c)**



The *lac* operon

The Human Genome Project: The Human Genome Project was launched in 1990 with the goal of discovering the whole DNA sequence of the human genome through the use of genetic engineering techniques and bioinformatics to extract and clone the DNA segment for determining DNA sequence.

Goals of Human Genome Project:

- Identify all the genes (20,000 to 25,000) in human DNA.
- Determine the sequence of the 3 billion chemical base pairs that make up human DNA.
- Store this information in database.
- Improve tools for data analysis.
- Transfer related information to other sectors.
- To address the legal, ethical and social issues that may arise due to project.

The US Department of Energy and the National Institute of Health oversaw the experiment.

The strategy included two key approaches:

(i) the first involves identifying all of the genes that express as RNA, known as Express sequence tags (EST).
(ii) The second step is to sequence all of the genome's coding and non-coding sequences, which is known as sequence annotation.

Features of Human Genome Project:

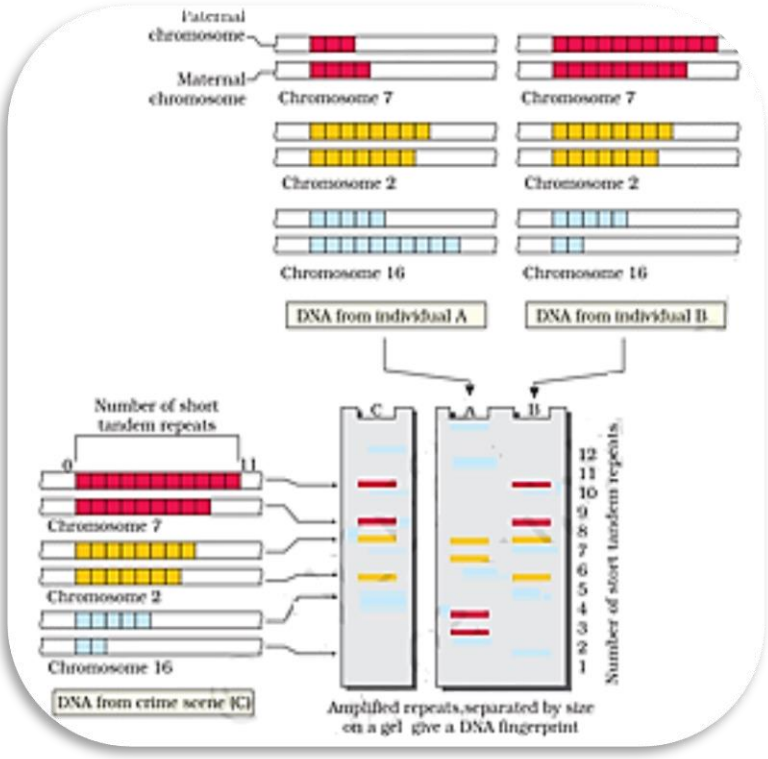
- There are 3164.7 million nucleotide bases in the human genome.
- A typical gene has 3000 bases, although sizes vary widely, with dystrophin being the biggest known human gene of 2.4 million bases.
- Proteins are coded in less than 2% of the genome.
- Repeated sequences account for a sizable component of the human genome.
- Repetitive sequences are DNA sequence lengths that are repeated numerous times, often hundreds to thousands of times.
- Chromosome 1 has the most genes (2,968), whereas chromosome Y has the fewest (231).
- Researchers have found around 1.4 million places in humans where single base DNA variations (SNPs - single nucleotide polymorphism) occur.

DNA fingerprinting is a simple approach to compare the DNA sequences of two people. It entails finding changes in a specific section of a DNA sequence known as repetitive DNA because a tiny length of DNA is repeated multiple times in this region.

Satellite DNA is divided into numerous groups based on its base makeup, segment length, and quantity of repeating units.

Polymorphism in DNA sequence provides the foundation for both genetic mapping of the human genome and fingerprinting.

Alec Jeffrey was the first to create fingerprinting technology. He employed a satellite DNA probe to detect such high polymorphism as Variable Number of Tendon Repeats (VNTR).



DNA Fingerprinting

SUMMARY

Nucleic acids are unique in their ability to direct their own replication. The resemblance of offspring to their parents depends on the precise replication of DNA and its transmission from one generation to the next. It is this DNA program that directs the development of your biochemical, anatomical, physiological, and (to some extent) behavioral traits. Once T. H. Morgan's group showed that genes are located on chromosomes, the two constituents of chromosomes—proteins and DNA—were the candidates for the genetic material.

Watson and Crick discovered the double helix by building models to conform to X-ray data. Maurice Wilkins and Rosalind Franklin used X-ray crystallography to study the structure of DNA. James Watson learned from their research that DNA was helical in shape, and he deduced the width of the helix and the spacing of nitrogenous bases. Watson and his colleague Francis Crick began to work on a model of DNA with two strands, the double helix. Watson and Crick's model, semiconservative replication, predicts that when a double helix replicates, each of the daughter molecules will have one old strand and one newly made strand. Positively charged basic proteins that surround the DNA is known as histones. The DNA wraps around the positively charged histone octamer and forms a structure called nucleosome that contains 200 base pairs of DNA helix.

The discovery of the genetic role of DNA began with research by Frederick Griffith in 1928. In 1952, Alfred Hershey and Martha Chase showed that DNA was the genetic material of the phage T2.

DNA replication is a process of producing two identical copies of DNA from a single DNA molecule. It is a process of biological inheritance.

Transcription is the process of formation of RNA such as messenger RNA from DNA before gene expression or protein synthesis occurs and translation is the process of gene expression or protein synthesis that occurs in cytosol. Ribosomes are the cell organelles that are involved in protein synthesis. The set of rules by which information encoded in genetic material is translated into proteins in the living cells is called genetic code. All the genes in the living cells is not active all the time. They become active when needed. Expression is controlled by genes are known as regulatory genes. Regulation in eukaryotes can occur at the transcriptional level, processing level, transport of mRNA from nucleus to the cytoplasm and translational level.

Lac operon consists of structural genes, operator genes, promoter genes, regulator genes, and repressor. Lac operon consist of lac Z, lac Y and lac A genes.

A mega project of sequencing human genome was launched in the year 1990 called the Human Genome Project. HGP was closely associated with the rapid development of a new area in biology called Bioinformatics. The Human Genome Project was a 13-year project coordinated by the U.S. Department of Energy and the National Institute of Health. The project was completed in the year 2003.

DNA fingerprinting involves identifying differences in some specific regions in DNA sequence called as repetitive DNA, because in these sequences, a small stretch of DNA is repeated many times.

IMPORTANT POINTERS

A bacteriophage known as φ ×174 has 5386 nucleotides.

The pitch of the DNA helix is 3.4 nm. Stacking of base pairs one over the other and hydrogen bonding provides stability to the DNA.

Francis Crick proposed the central Dogma of molecular biology.

Histones are positively charged basic proteins, their positive charge is due to amino acids lysine and arginine.

A typical nucleosome contains 200 bp of DNA helix.

Euchromatin is said to be transcriptionally active chromatin, whereas heterochromatin is inactive.

DNA as the genetic material was unequivocally resolved from Hershey-Chase experiment.

RNA is unstable and mutates at a faster rate.

The main enzyme of DNA replication is DNA polymerase, the discontinuously synthesised fragments during replication are later joined by the enzyme DNA ligase.

A cistron as a segment of DNA coding for a polypeptide, monocistronic genes are found in eukaryotes and polycistronic in prokaryotes and most bacteria.

In bacteria, the mRNA provides the template, tRNA brings aminoacids and reads the genetic code, and rRNAs play structural and catalytic role during translation.

In eukaryotes, RNA polymerase I transcribes rRNAs, 28S, 18S, and 5.8S), whereas the RNA polymerase III is responsible for transcription of tRNA, 5srRNA, and snRNAs (small nuclear RNAs). The RNA polymerase II transcribes precursor of mRNA, the heterogeneous nuclear RNA (hnRNA).

Regulation of lac operon by repressor is referred to as negative regulation.

Polymorphism in DNA sequence is the basis of genetic mapping of human genome as well as of DNA fingerprinting.

The technique of DNA Fingerprinting was initially developed by Alec Jeffreys.

MULTIPLE CHOICE QUESTIONS

Q1. Which of the following are nucleic acids found in living systems?
(a) DNA (b) RNA
(c) Protein (d) Both (a) and (b)

Q2. What is genomics?
(a) it is the study of all of a person's genes and their interactions with each other and with the environment
(b) it is the study of all of a person's protein and their interactions with each other and with the environment
(c) it is the study of all of a person's blood count and their interactions with each other and with the environment
(d) it is the study of all of a person's behaviour and their interactions with each other and with the environment

Q3. How can we define the length of a DNA?
(a) by defining the number of nucleosides present in it
(b) by defining the number of nucleotides present in it
(c) by defining the number of amino acids present in it
(d) by defining the number of acid groups present in it

Q4. What is the haploid content of human DNA?
(a) 3.3×10^8 bp (b) 3.3×10^9 bp
(c) 3.3×10^{10}bp (d) 3.3×10^{11} bp

Q5. Which of the following are the components of a nucleotide?
(a) A nitrogenous base (b) A pentose sugar
(c) A phosphate group (d) All of the above

Q6. Which of the following base is common for both DNA and RNA?
(a) Adenine (b) Guanine
(c) Cytosine (d) Thymine

Q7. Which of the following linkage is present between two nucleotides?
(a) N-glyosidic linkage
(b) 3'-5' phosphodiester linkage
(c) 5'-3' phosphodiester linkage
(d) None of the above

Q8. Which of the following forms the backbone of a polynucleotide chain?
(a) Sugar and protein (b) Protein and fat
(c) Fat and protein (d) Sugar and phosphate

Q9. Who of the following first identified DNA?
(a) Francis Crick (b) Friedrich Meischer
(c) James Watson (d) All of the above

Q10. According to Chargaff's law.
(a) The ratio between AT and GC is constant and unequal
(b) The ratio between AT and GC is not constant but equal
(c) The ratio between AT and GC is not constant and is also unequal
(d) The ratio between AT and GC is constant and equal

Q11. Which of the following is correct about DNA double helix?
(a) It is made up of two polynucleotide chains
(b) The two chains have anti-parallel polarity
(c) The bases in the two strands are paired through H-bonds
(d) All of the above

Q12. The number of hydrogen bonds between Adenine and Thymine and Guanine and Cytosine in the bases of the two strands of DNA are.
(a) 2, 6 (b) 6, 2
(c) 2, 3 (d) 3, 2

Q13. The Central Dogma in molecular biology is.
(a) DNA RNA Protein (b) RNA DNA Protein
(c) Protein RNA Protein (d) None of the above

Q14. What is the charge on DNA?
(a) Neutral (b) Negative
(c) Positive (d) None of the above

Q15. Histones are.
(a) Acidic proteins (b) Basic proteins
(c) Neutral (d) None of the above

Q16. Which of the following amino acids make histones basic in nature?
(a) Aspartic acid (b) Lysine
(c) Arginine (d) Both (b) and (c)

Q17. A typical nucleosome contains.
(a) 100 bp of DNA helix
(b) 200 bp of DNA helix
(c) 300 bp of DNA helix
(d) 400 bp of DNA helix

Q18. Which of the following constitutes the repeating unit of chromatin?
(a) Histone (b) Histone octamer
(c) Nucleosome (d) All of the above

Q19. Which of the following is transcriptionally active chromatin?
(a) NHC (b) Heterochromatin
(c) Euchromatin (d) None of the above

Q20. Who of the following performed experiments on *Streptococcus pneumonia*?
(a) Mendel (b) T.H. Morgan
(c) Frederick Griffith (d) All of the above

Q21. What was the observation of Frederick Griffith after he perform experiments on *Streptococcus* regarding the 'R' strain of bacteria. The bacteria howed.
(a) Binary fission (b) Budding
(c) Transformation (d) Fragmentation

Q22. Who of the following proved that DNA is the genetic material?
(a) Griffith
(b) Oswald Avery
(c) Alfred Hershey and Martha Chase
(d) All of the above

Q23. In which of the following RNA acts as a genetic material?
(a) Tobacco Mosaic Virus
(b) QB bacteriophage
(c) Both (a) and (b)
(d) All of the above

Q24. Why is DNA better genetic material than RNA?
(a) It is less reactive
(b) It is structurally stable
(c) It does not degrade easily
(d) All of the above

Q25. The protein synthesising machinery revolves around.
(a) DNA (b) RNA
(c) Amino acids (d) All of the above

Q26. DNA replicated.
(a) Conservatively
(b) Separately
(c) Semi-conservatively
(d) Uniformly

Q27. What was the composition of hybrid DNA and light DNA in the culture that was extracted by Meselson and Stahl from *E.coli* culture after 40 minutes of growth?
(a) Intermediate density
(b) Equal density of hybrid DNA and light DNA
(c) More hybrid DNA and less light DNA
(d) Less hybrid DNA and more light DNA

Q28. Which of the following is the main enzyme of DNA replication?
(a) DNA dependent RNA polymerase
(b) DNA dependent DNA polymerase
(c) DNA ligase
(d) All of the above

Q29. DNA replication occurs in which of the following direction?
(a) 5' 3' (b) 3' 5'
(c) Both (a) and (b) (d) None of the above

Q30. Which of the following enzymes joins the discontinuously synthesized DNA fragments?
(a) DNA polymerase (b) Taq polymerase
(c) DNA ligase (d) RNA polymerase

Q31. Which of the following provides the 'origin of replication' for DNA replication to start?
(a) DNA polymerase (b) Template strand
(c) A vector (d) All of the above

Q32. In which phase of the cell cycle the replication of DNA takes place?
(a) M-phase (b) G_1-phase
(c) Interphase (d) S-phase

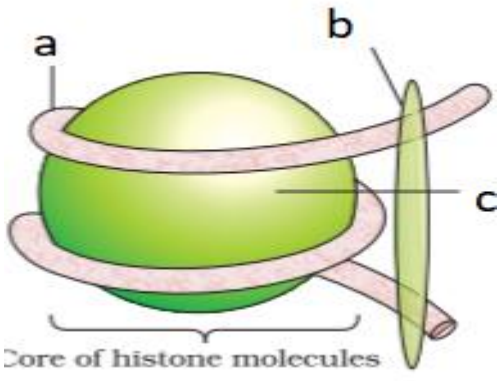
Q33. What is transcription?
(a) copying of genetic information from one strand of the DNA into DNA
(b) copying of genetic information from one strand of the DNA into RNA
(c) copying of genetic information from one strand of the DNA into protein
(d) copying of genetic information from one strand of the DNA into amino acids

Q34. Which of the following is correct about transcription?
(a) The DNA of an organism gets duplicated
(b) Only a segment of DNA and one strand is copied into RNA
(c) Both (a) and (b)
(d) None of the above

Q35. Why both the strands of DNA are not copied during transcription?
(a) Both stands may code for RNA molecule with different sequences.
(b) If two RNA molecules are formed, then they can form dsRNA
(c) If dsRNA would be formed, how would translation occur
(d) All of the above

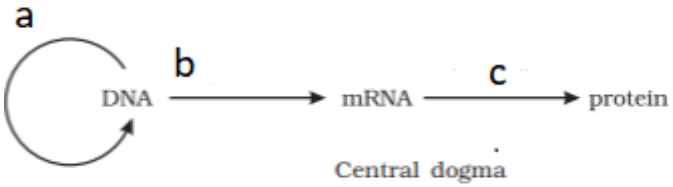
Q36. Which of the following flank the structural gene in a transcription unit?
(a) A promoter (b) A terminator
(c) Both (a) and (b) (d) None of the above

Q37. Look at the picture and name a, b and c.



(a) H1 histone, DNA, Histone octamer
(b) Histone octamer, H1 histone, DNA
(c) DNA, Histone octamer, H1 histone
(d) DNA, H1 histone, histone octamer

Q38. Look at the picture and main a, b and c



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

Q39. Which of the following is a DNA sequence that provides binding site for RNA polymerase during transcription?
(a) Structural gene (b) Promoter
(c) Terminator (d) All of the above

Q40. Which of the following is the functional unit of inheritance?
(a) Chromosome (b) Gene
(c) Protein (d) None of the above

Q41. Which of the following is a segment of DNA that quotes for a polypeptide?
(a) Intron (b) Exon
(c) Cistron (d) None of the above

Q42. Which of the following is correct about exons?
(a) They appear in a processed RNA
(b) They are the expressed sequences
(c) They are interrupted by introns
(d) All of the above

Q43. Which of the following types of RNA are present in bacteria?
(a) mRNA (b) tRNA
(c) rRNA (d) All of the above

Q44. Which of the following RNA play structural and catalytic role during translation?
(a) mRNA (b) tRNA
(c) rRNA (d) All of the above

Q45. Which of the following acts as substrate in transcription?
(a) ATP
(b) ADP
(c) Nucleoside triphosphate
(d) All of the above

Q46. Which of the following factor acts as initiation factor in transcription?
(a) Rho factor (b) Sigma factor
(c) Both (a) and (b) (d) None of the above

Q47. Which of the following RNA transcribes rRNA?
(a) RNA polymerase III (b) RNA Polymerase II
(c) RNA polymerase I (d) All of the above

Q48. RNA polymerase II transcribes which of the following type of RNA?
(a) Precursor mRNA (b) hnRNA
(c) Both (a) and (b) (d) None of the above

Q49. What is splicing?
(a) Removal of exons and joining of introns
(b) Removal of introns and joining of RNA
(c) Removal of introns and joining of amino acids
(d) Removal of introns and joining of exons

Q50. In which of the following process methyl guanosine triphosphate is added to 5' end of hnRNA?
(a) Tailing (b) Capping
(c) Extension (d) Termination

Q51. How many adenylate residues are added at the 3'end in a template independent manner in the tailing process of hnRNA?
(a) 300-400 (b) 200-300
(c) 100-200 (d) 50-100

Q52. Which among the following are the salient features of a genetic code?
(a) The code is degenerate
(b) The code is universal
(c) The codon is triplet
(d) All of the above

Q53. What is the speciality of AUG codon?
(a) It codes for methionine (met)
(b) It acts as a stop codon
(c) It acts as initiator codon
(d) Both (a) and (c)

Q54. Which of the following mutation causes sickle cell anaemia?
(a) Frame shift mutation (b) Point mutation
(c) Both (a) and (b) (d) All of the above

Q55. Which of the following RNA are specific for each amino acid?
(a) mRNA (b) rRNA
(c) tRNA (d) All of the above

Q56. Which of the following part of the tRNA binds to the amino acids?
(a) Anticodon loop (b) Acceptor end
(c) Both (a) and (b) (d) None of the above

Q57. The secondary structure of tRNA is.
(a) Inverted-S (b) Inverted-V
(c) Clover leaf shaped (d) Inverted-L

Q58. What is translation?
(a) it is the process of polymerisation of protein to form a polypeptide
(b) it is the process of polymerisation of NTP to form a polypeptide
(c) it is the process of polymerisation of RNA to form a polypeptide
(d) it is the process of polymerisation of amino acid to form a polypeptide

Q59. Which of the following is correct about aninoacylation of tRNA?
(a) Amino acids are activated in the presence of ATP
(b) Amino acids get's linked to their cognate tRNA
(c) The process is also called as charging of tRNA
(d) All of the above

Q60. Which of the following is the cellular factory for the synthesis of proteins inside a cell?
(a) Mitochondria
(b) Endoplasmic reticulum
(c) Ribosome
(d) Nucleus

Q61. The process of translation begins when.
(a) The small subunit encounters an mRNA
(b) The small subunit encounters an tRNA
(c) The small subunit encounters an rRNA
(d) All of the above

Q62. Which of the following RNA in bacteria acts as a catalyst?
(a) 18sRNA (b) 5.8sRNA
(c) 28S rna (d) 23s rRNA

Q63. In eukaryotes, regulation of gene expression can be exerted at the.
(a) Transcriptional level
(b) Processing level (splicing level)
(c) Transport of mRNA from nucleus
(d) All of the above

Q64. Which of the following gene in *lac* operon codes for repressor?
(a) Gene *z* (b) Gene *y*
(c) Gene *i* (d) Gene *a*

Q65. Which of the following gene codes for permease in the *lac* operon that increases the permeability of the cell to beta galactosidase?
(a) Gene *i* (b) Gene *y*
(c) Gene *a* (d) All of the above

Q66. Which of the following is the substrate for enzyme beta galactosidase and regulates the switching on and off of the *lac* operon?
(a) Glucose (b) Galactose
(c) Lactose (d) All of the above

Q67. Regulation of lac operon is referred to as.
(a) Positive regulation
(b) Negative regulation
(c) Neutral
(d) None of the above

Q68. BAC stands for.
(a) Bacterial artificial case
(b) Bacterial artificial chromosome
(c) Bonus artificial chromosome
(d) Bright artificial case

Q69. Who of the following developed the technique of DNA fingerprinting?
(a) Alec Jefferys (b) Har Gobind Khorana
(c) Maruice Wilkins (d) All of the above

Q70. SNPs stand for.
(a) Stand nucleotide polymorphism
(b) Single nucleoside polymorphism
(c) Single nucleotide polymorphism
(d) None of the above

ASSERTION AND REASON

Direction: in the following questions, a statement of assertion (A) is followed by a statement of reason (R). Choose the correct option among a, b, c and d.

Q1. Assertion (A): the replication occur within a small opening of the DNA helix, referred to as replication fork.
Reason (R): The discontinuously synthesised fragments during DNA replication are later joined by the enzyme helicase.
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A)
(c) Assertion (A) is true but reason(R) is false
(d) Assertion (A) is false but reason(R) is true

Q2. **Assertion (A):** DNA is the predominant genetic material in most of the organisms.
Reason (R): A molecule that can act as a genetic material should be stable chemically and structurally.
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A)
(c) Assertion (A) is true but reason(R) is false
(d) Assertion (A) is false but reason(R) is true

Q3. **Assertion (A):** The unequivocal proof that DNA is the genetic material came from the experiments of Alfred Hershey and Martha Chase.
Reason (R): They worked on *Streptococcus pneumonia.*
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A)
(c) Assertion (A) is true but reason(R) is false
(d) Assertion (A) is false but reason(R) is true

Q4. **Assertion (A):** a set of positively charged, basic proteins is called histones.

Reason (R): Histones are rich in the basic amino acid residues lysine and arginine

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

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

(c) Assertion (A) is true but reason(R) is false

(d) Assertion (A) is false but reason(R) is true

TRUE AND FALSE

Q1. The unequivocal proof that DNA is the genetic material came from the experiments of Alfred Hershey and Martha Chase. They grew some viruses on a medium that contained radioactive magnesium and some others on medium that contained radioactive nitrogen.

Q2. Nucleoid is a region in DNA where it is held with some proteins.

Q3. Mono-cistronic genes are mostly found in prokaryotes and bacteria.

Q4. The mRNAs play structural and catalytic role during translation.

PRACTICE QUESTIONS

Q1. Assuming that 50 heavy (i.e. containing N^{15}) DNA molecules replicated twice in a medium containing N^{14}, we expect.

(a) 100 half heavy and half light and 150 light DNA molecules

(b) 100 half heavy and half light and 100 light DNA molecules

(c) 50 heavy and 150 light DNA molecules

(d) 50 heavy and 100 light DNA molecules

Q2. The enzyme which shows polymerising activity in 5'→ 3' direction is.

(a) DNA polymerase III

(b) DNA polymerase II

(c) DNA polymerase I

(d) All of these

Q3. DNA polymerase I is involved in.

(a) Removal of RNA primer

(b) Filling of gap

(c) Joining of okazaki fragments

(d) Both (a) and (b)

Q4. DNA replication in lagging strand of most of the eukaryotic organisms is.

(a) continous (b) discontinous

(c) Both (a) and (b) (d) None of the above

Q5. Unidirectional flow of information called central dogma was given by

(a) F.H.C. Crick (b) Temin

(c) Baltimore (d) Dulbecco

Q6. In eukaryotes, RNA III catalyses the synthesis of.

(a) All rRNA and tRNA

(b) mRNA, HnRNA and SnRNA

(c) 5S rRNA, tRNA and SnRNA

(d) 28S, 18S and 5S rRNA

Q7. The core enzyme requires a factor for termination of RNA synthesis at some sites. This is known as.

(a) Sigma factor (b) Rho factor

(c) Gamma factor (d) Alpha particle

Q8. If one strand of DNA has the base sequence ATCCACGACTAG and the second strand undergoes transcription what would be the base sequence on mRNA?

(a) TACGTGCTGATC (b) ATCCACGACTAG

(c) AUCCACGACUAG (d) AUGCACGACTAG

Q9. During protein synthesis, amino acid gets attached to tRNA with the help of.

(a) mRNA (b) Aminoacyl synthetase

(c) Ribosome (d) rRNA

Q10. The first amino acid in any polypeptide chain of prokaryote is always.

(a) Formylated methionine

(b) Formylated arginine

(c) Lysine

(d) Methionine

Q11. Which site of a tRNA molecule forms hydrogen bonds with mRNA molecule?

(a) Codon

(b) Anticodon

(c) 5' end of the t-RNA molecule

(d) 3' end of the t-RNA molecule

Q12. To code the 50 amino acids in a polypeptide chain, what will be the minimum number of nucleotides in its cistron?

(a) 50 (b) 153

(c) 306 (d) 309

Q13. The genetic code is called a degenerate code because.
(a) One codon has many meanings
(b) More than one codon has the same meaning
(c) One codon has one meaning
(d) There are 64 codons present

Q14. In nucleoside which of the following bond exists between sugar and nitrogenous base?
(a) Phosphodiester bond
(b) Hydrogen bond
(c) Phosphoester bond
(d) N-glycosidic bond

Q15. By which of the following bond phosphoric acid remain linked with 5' carbon of sugar in one nucleotide?
(a) Phosphodiester bond
(b) N-Glycosidic bond
(c) Hydrogen bond
(d) None of the above

Q16. In RNA, every nucleotide residue has an additional –OH group at which of the following position.
(a) 2' position of deoxyribose
(b) 1' position of ribose sugar
(c) 3' position of ribose sugar
(d) 2' position of ribose sugar

Q17. DNA as an acidic substance present in nucleus was first identified by.
(a) Wilkins and Franklin
(b) Watson and Crick
(c) Friedich meischer
(d) Altmann

Q18. Double helix model of DNA proposed by Watson and Crick was based on.
(a) X-ray diffraction data of Meischer
(b) X-ray crystallography data of Wilkins and Franklin
(c) X-ray diffraction data of Watson and Crick
(d) X-ray diffraction data of Chargaff

Q19. Regarding the features of double helix structure of DNA which of the following is wrong?
(a) Two polynucleotide chains have antiparallel polarity
(b) The bases in two strands are paired through phosphodiester bonds
(c) Adenine form two hydrogen bonds with thymine
(d) The pitch of the helix is 3.4 nm

Q20. In addition to hydrogen bonding which of the following feature confers stability to helical structure?
(a) Phosphodiester bond
(b) Pairing between one purine and one pyrimidine
(c) Glycosidic linkage between sugar and nitrogenous base
(d) The plane of one base pair stacks over the other

Q21. Which of the following is responsible for constant distance between two polynucleotide chains in DNA?
(a) Antiparallel polarity of two polynucleotide strands
(b) Hydrogen bonding
(c) Pairing between one purine and one pyrimidine
(d) All the above

Q22. Positive charge and basic nature of histone is due to abundance of.
(a) Lysines and tryptophan
(b) Arginine & threonines
(c) Lysines and arginines
(d) Tryptophan and threonines

Q23. Negative charge of DNA is due to which of the following constituent.
(a) Sugar
(b) Nitrogenous base
(c) Phosphoric acid
(d) Hydroxyl group (–OH) present on sugar

Q24. Which of the following is actual sequence of packaging of DNA in eukaryotic cells from left to right below?
(a) DNA , Chromatin, Nucleosome, Chromosome
(b) DNA, Nucleosome, Chromosome, Chromatin
(c) DNA, Nucleosome, Chromatin, Chromosome
(d) DNA, Chromosome, Chromatin, Nucleosome

Q25. The packaging of chromatin at higher level requires additional set of proteins that is known as.
(a) Histone proteins
(b) NHC proteins
(c) Homeotic proteins
(d) Domain proteins

Q26. Regarding to Meselson and Stahl experiment for semi conservative nature of DNA replication select the wrong statement?
(a) 15N of 15NH4Cl was incorporated in DNA and other compounds
(b) 15N & 14N can be differentiate on the basis of radioactive activity
(c) Heavy and normal DNA molecules could be distinguished by CsCl density gradient centrifugation
(d) 15N used in 15NH4Cl was not a radioactive isotope

Q27. If normal *E.Coli* is allow to grow for 80 minutes in $_{15}$NH4Cl medium then what would be the proportion of hybrid and heavy density DNA molecules?
(a) 1 : 7 (b) 7 : 1
(c) 14 : 2 (d) 1 : 4

Q28. Which of the following is not a criterion for determination of genetic material?
(a) Ability of replication
(b) Chemically and structurally stable
(c) It should be non mutable
(d) Ability to express itself in from of Mendelian characters

Q29. At which of the following levels, regulation of gene expression in eukaryotes does not occur?
(a) Transcription level
(b) Processing level
(c) Transport of ribosomal subunits from nucleus to cytoplasm level
(d) Translation level

Q30. Regarding to role of RNA in protein synthesis find out the odd one out.
(a) m-RNA - provides the template
(b) t-RNA - brings amino acids
(c) r-RNA - read genetic code
(d) sn-RNA splicing

ASSERTION AND REASONING

Direction: in the following questions, a statement of assertion (A) is followed by a statement of reason (R). Choose the correct option among a, b, c and d.

Q1. **Assertion (A):** Central dogma is the flow of information from DNA to mRNA and then decoding the information present in mRNA in the form of protein.
Reason (R): In retroviruses, reverse of central dogma occurs.
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A)
(c) Assertion (A) is true but reason(R) is false
(d) Assertion (A) is false but reason(R) is true

Q2. **Assertion (A):** DNA is made of two polynucleotide chains, where the backbone is constituted by sugar-phosphate.
Reason (R): The two chains have parallel polarity.
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A)
(c) Assertion (A) is true but reason(R) is false
(d) Assertion (A) is false but reason(R) is true

Q3. **Assertion (A):** The DNA-dependent DNA polymerases catalyse polymerisation only in one direction, that is 5′ → 3′ direction.
Reason (R): The discontinuously synthesised fragments during replication are later joined by the enzyme DNA helicase.
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A)
(c) Assertion (A) is true but reason(R) is false
(d) Assertion (A) is false but reason(R) is true

Q4. **Assertion (A):** There are three RNA polymerases in the nucleus of eukaryotes.
Reason (R): Amon the three RNA polymerases, RNA polymerase III is responsible for transcription of tRNA, 5srRNA, and snRNAs.
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A)
(c) Assertion (A) is true but reason(R) is false
(d) Assertion (A) is false but reason(R) is true

SOLUTIONS MULTIPLE CHOICE

S1. **(d)** DNA and RNA are two types of nucleic acids found in living systems, DNA acts as the genetic material in most of the organisms while RNA acts as genetic material in some of the virus.

S2. **(a)** the determination of the complete nucleotide sequence of the Human Genome during the last decade has set in a new era of genomics.

S3. **(b)** the length of the DNA can be defined as a number of nucleotide (base pairs) present in it.

S4. **(b)** Each organism has different content of DNA base pair content.

S5. **(d)** the structure of a polynucleotide is complex. The chain is composed of various nucleotides that are further made of a nitrogenous base, pentose sugar and a phosphate group.

S6. **(c)** cytosine is common for both DNA and RN.

S7. **(b)** two nucleotides are linked by 3'-5'phosphodiester linkage to form a dinucleotides.

S8. **(d)** the backbone of a polynucleotide chain is formed due to sugar and phosphate, the nitrogenous bases linked to sugar moiety project from the backbone of a DNA.

S9. **(b)** DNA was first identified by Fredrich Meischer in the year 1869.

S10. **(d)** Chargaff summarised that for a double-stranded DNA the ratios between adenine and thymine and guanine and cytosine are constant and equals one.

S11 (d) it was in 1953 that James Watson and Francis Crick based on the X-ray diffraction data produced by Maurice Wilkins and Rosalind Franklin proposed a very simple but famous double helix model for the structure of DNA.

S12. (c) the bases in two strands are paired through hydrogen bonds forming base pairs. Adenine forms two hydrogen bonds with thymine from the opposite stand and vice versa while guanine is paired with cytosine with three hydrogen bonds.

S13. (a) The central dogma is same in all organisms leaving some virus in which the flow of information is in the reverse direction.

S14. (b) The charge on DNA is negative so it runs towards the positive pole when run on agarose gel electrophoresis.

S15. (c) the DNA in the nucleoid is organised in last loops that are held together by a basic protein called histones.

S16. (d) protein acquire charge depending upon the abundance of amino acids structure with charged side chains, histones are rich in the basic amino acid residue, lysine and arginine.

S17. (b) the negatively charged DNA is wrapped around the positively charged histone octamer to form a structure called nucleosome that contains 200 base pairs of DNA helix.

S18. (c) nucleosomes constitutes the repeating unit of chromatin thread like stained bodies seen in nucleus.

S19. (c) in a nucleus, some region of chromatin is loosely packed and stains light and is referred to as euchromatin, the chromatin that is more densely packed and stains dark is called heterochromatin. Euchromatin is said to be transcriptionally more active.

S20. (c) in 1928, Friedrich Griggith in a series of experiments with *Streptococcus* witness the miraculous transformation the bacteria.

S21. (c) after his experiments Frederick Grifitth concluded that the 'R' strain of bacteria that somehow been transformed by the heat killed 'S' bacteria. Some transforming principle transferred from the heat killed 'S' strain had enabled the 'R' strain to synthesise a smooth polysaccharide coat and become virulent.

S22. (c) Alfred Hershey and Martha Chase in 1952 worked with viruses that infect bacteria called bacteriophages , they grew some virus on a medium that contained radioactive phosphorus and some others on medium that contained radioactive sulphur, with subsequent experiments they found that DNA is the genetic material.

S23. (c) In most, DNA is the predominant material, RNA acts as the genetic material only in some of them.

S24. (d) the genetic material should be stable enough not to change with stages of life cycle, age or with change in physiology of the organism, all these properties are there in DNA therefore it makes it a better genetic material than RNA.

S25. (b) both DNA and RNA are able to mutate, RNA can directly code for synthesis of protein and can easily express characteristics therefore the protein synthesizing machinery has evolved around RNA.

S26. (c) the two strands of DNA act as a template for the synthesis of new complementary strands, after the completition of replication each DNA has one parental and one newly synthesized strand, this is semiconservative DNA replication.

S27. (b) the experiments were performed by Matthew Meselson and Franklin Stah by growing *E.coli* in a medium containing a heavy isotope of Nitrogen.

S28. (b) DNA polymerase is the main enzyme of DNA replication and uses a DNA template to catalyse the polymerisation of the deoxynucleotides.

S29. (a) the DNA dependent DNA polymerases catalyse polymerisation only in one direction that is 5' → 3'

S30. (c) on the template strand the replication is continuous while on the other strand with the polarity of 5' → 3'prime the replication is discontinuous, the discontinuously synthesised strands are later joined by enzyme DNA ligase.

S31. (c) there is a definite region in DNA where replication originate, such regions are termed as 'origin of replication' and the vectors provide the origin of replication.

S32. (d) in eukaryotes the replication of DNA takes place at the S-phase of the cell cycle.

S33. (b) in transcription, the DNA acts as a template so that it can be copied into the RNA.

S34. (b) In replication the total DNA gets copied while in transcription, it is not so, only a segment of DNA gets transcribed.

S35. (d) Both strands of DNA are not copied because it may produce two RNA strands that may form a dsRNA, a stable molecule, and would not be able to provide a template for translation to occur.

S36. (c) in a transcriptional unit, a structural gene is flanked by the promoter and a terminator.

S37. (d) the negatively charged DNA is wrapped around the positively charged histone octamer to form a structure that is called a nucleosome.

S38. (c) Francis Crick proposed the central dogma in molecular biology which states that the genetic information flows from DNA to RNA and RNA to protein.

S39. (b) promoter and terminator flank the structural gene in a transcription unit, promoter is located upstream of the structural and is a sequence that provides binding site for RNA polymerase.

S40. (b) functional unit of inheritance is gene, that were called as 'factor; by Mendel.

S41. (c) Cistron is a segment of DNA that quotes for a polypeptide

S42. (d) Exon is a portion of a gene that codes for amino acids, it is interrupted by introns, when a RNA gets processed, the intertwining sequences are removed and they do not appear in a mature RNA.

S43. (d) all the three types of RNA present in bacteria and all of them are needed to synthesise a protein in a cell.

S44. (c) mRNA provide the template, tRNA brings amino acids and reads the genetic code and rRNA plays structural and catalytic role during translation.

S45. (c) RNA polymerase uses nucleoside triphosphates as substrates and polymerises in a template dependent fashion.

S46. (b) the Sigma factor acts as an initiation factor and associates transiently to start transcription.

S47. (c) RNA polymerase I transcribes rRNA (28S, 18S, 5.8S) RNA.

S48. (c) hnRNA is the heterogeneous RNA and precursor RNA are synthesised by RNA polymerase II.

S49. (d) The primary transcripts consists of both exons and introns so it is subjected to splicing where introns are removed and exons are joined in a defined order.

S50. (b) in capping, an unusual nucleotide, methyl guanosine triphosphate is added to the 5' end of heterogeneous RNA.

S51. (b) in the tailing process adenylate residues (200 to 300) are added at the 3' and in a template independent manner, it is the fully processed hnRNA that is now called as mRNA and is transported out of the nucleus for translation.

S52. (d) George Gamow proposed that there are four bases that code for 20 amino acids. Har Gobind Khorana developed a chemical method to synthesise RNA molecules with defined combinations of bases. Marshall Nirenberg's cell free system for protein synthesis finally helped the code to be deciphered.

S53. (d) AUG has dual functions, it codes for amino acid methionine and serves the function of an initiator codon, while the stop codons are UAA, UAG, UGA.

S54. (b) in sickle cell anaemia, point mutation causes a change of single base pair in the gene for beta globin chain that results in the change of amino acid residue, glutamate to valine.

S55. (c) tRNA is also called as soluble RNA and acts as an adaptor molecule and is specific for each amino acid.

S56. (b) tRNA has an anticodon loop that has bases complementary to the code and it also has an amino acid acceptor and to which it binds to amino acids.

S57. (c) the secondary structure of tRNA is a clover leaf, in actual structure tRNA is a compact molecule which looks like inverted L.

S58. (d) translation is the process of formation of a polypeptide by the coming together of amino acids whose order and sequence are defined by the sequence of bases in the mRNA.

S59. (d) amino acylation of tRNA is the first phase of translation and energy consuming process.

S60. (c) protein synthesis takes place on the ribosome.

S61. (a) the ribosome consists of structural RNA and different proteins in its inactive state, when the small subunit encounters an mRNA the process of translation of the mRNA into protein begins.

S62. (d) the ribosome (23S rRNA in bacteria is the enzyme-ribozyme) acts as a catalyst for the formation of peptide bond.

S63. (d) regulation of gene expression is a very broad term and in eukaryotes it can be exerted at any of the above mentioned levels.

S64. (c) the *i* gene codes for the repressor of the *lac* operon, gene *z, y,* and *a* are the structural genes.

S65. (b) the gene *y* codes for permease which increases the permeability of the cell to beta galactosidase all the 3 gene products in *Lac* Operon are required for metabolism of lactose.

S66. (c) lactose is the substrate for enzyme beta galactosidase hence is it is also called as inducer for the operon.

S67. (b) The repressor of the operon is synthesised from the i-gene all the time. In the presence of inducer (lactose) the repressor is inactivated by interaction with the inducer, that allows the RNA polymerase to access the promoter and transcription proceeds.

S68. (b) BAC is bacterial artificial chromosome that is used as a vector in cloning a segment of DNA.

S69. (a) in DNA fingerprinting a satellite DNA is used as a probe that shows very high degree of polymorphism.

S70. (c) single nucleotide polymorphism in humans is an information that promises to revolutionise the process of finding chromosomal locations for disease associated sequences and tracing human history.

ASSERTION AND REASON

S1. (c) The discontinuously synthesised fragments during DNA replication are later joined by the enzyme DNA ligase.

S2. (a) For a molecule to act as a genetic material it should be able to generate its replica, it should be stable chemically and structurally and it should be able to express itself in the form of 'Mendelian Characters'. DNA possess all these features so it is the genetic material in most of the organisms.

S3. (c) Alfred Hershey and Martha Chase worked with viruses that infect bacteria called bacteriophages.

S4. (a) Histones are rich in the basic amino acid residues lysine and arginine. Both the amino acid residues carry positive charges in their side chains. Histones are organised to form a unit of eight molecules called histone octamer.

TRUE AND FALSE

S1. (False) Alfred Hershey and Martha Chase grew some viruses on a medium that contained radioactive phosphorous and some others on medium that contained radioactive sulphur.

S2. (True)

S3. (False) Mono-cistronic genes are mostly found in eukaryotes.

S4. (True)

PRACTICE SOLUTIONS

S1. (b) Semi conservative type of DNA replication, Fresh DNA molecule has one parent strand i.e. (N^{15}) which is heavy and other strand (N^{14}) N14 lighter. Therefore, 50 heavy DNA molecule in first replication makes 100 hybrid DNA molecule and other replication 100 DNA will be also hybrid (1/2 heavy and 1/2light) and 100 light DNA molecules.

S2. (c) DNA polymerase I catalyze the polymerization directed by the template of nucleotides into double-stranded DNA in a 5'-3' direction. DNA Polymerase I exhibits a 3' – 5' exonuclease function or a "proofreading", that lessens the failure rate during replication of DNA.

S3. (d) DNA polymerase I is involved in the removal of RNA primer and filling of gaps.

S4. (b) DNA replication in lagging strand of most of the eukaryotic organism is discontinuous.

S5. (a) the uni-directional flow of information was given by Crick.

S6. (c) In eukaryote cells, RNA polymerase III transcribes DNA to synthesize ribosomal 5S rRNA, tRNA and other small RNAs.

S7. (b) ρ is a transcription terminator that binds a CA-rich sequence called as a rut (rho utilization) element on mRNA and migrates in the 5' --> 3' direction until it reaches the transcription complex that is paused at a termination site.

S8. (c) it would be AUCCACGACUAG.

S9. (b) During protein synthesis, amino acid gets attached to tRNA with the help of aminoacyl-tRNA synthetase

S10. (a) The first amino acid in any polypeptide chain of a prokaryote is always formylated methionine. The first amino acid is methionine in eukaryotes. This is because AUG is a start codon that codes for formylated methionine in prokaryotes and methionine in eukaryotes.

S11. (b) The complementary bases on the codon and anticodon are held together by hydrogen bonds. Codon is present on the mRNA and anticodon is present on the tRNA. Codon on mRNA forms hydrogen bonds with anticodon site of a tRNA. The ribosome allows the binding of tRNA to the mRNA carrying a specific amino acid.

S12. (b) cistron is a segment of DNA that codes for one polypeptide. The polypeptide has 50 amino acids, then its cistron will have 51 codons (50 codons code for amino acids and 1 will code for stop codon). Since each codon is triplet, so for 50 amino acids, the minimum length of cistron will be 51 x 3 = 153 bp.

S13. (b) many codons have same meanings so genetic code is degenerate.

S14. (d) In DNA and RNA the nitrogen base is attached to the sugar molecule to form the nucleoside. The sugars deoxyribose and ribose are linked to the nitrogenous base by glycosidic linkage. It is also known as N-glycosidic bond.

S15. (a) The diester bond between phosphoric acid and two sugar molecules in the DNA and RNA backbone links two nucleotides together to form oligonucleotide polymers. The phosphodiester bond links a 3' carbon to a 5' carbon in DNA and RNA. During the reaction of two of the hydroxyl groups in phosphoric acid with a hydroxyl group in two other molecules, two ester bonds in a phosphodiester group are formed. the 3' end has a free hydroxyl group at the 3' carbon of a sugar, and the 5' end has a free hydroxyl group or phosphate group at the 5'-carbon of a sugar. The synthesis proceeds from the 5' to the 3' end.

S16. (d) the additional –OH group is present at the 2' position of the ribose sugar.

S17. (c) Friedrich Meischer was a Swiss physician and was the first to isolate nucleic acid or DNA as a distinct molecule. He named it 'nuclein' that is DNA associated with proteins and isolated it from the cell nuclei.

S18. (b) Watson and Crick's proposed model of DNA was based on the data given from various experiments and important X-ray crystallography work by Rosalind Franklin and Maurice Wilkins

S19. (b) The bases in DNA in two strands are paired through hydrogen bond (H-bonds).

S20. (d) The factors conferring stability to ds DNA are the base pair stacking i.e., the individual bases form a strong stacking interaction thereby providing stability to the double helix and hydrogen bonds between the nitrogenous bases.

S21. (d) The distance between two complementary strands always remains the same because there are hydrogen bonds between the nitrogen bases of two strands restricting movement. The bonds are formed correctly on the opposite ie the bonds are between purines and pyrimidines.

S22. (c) The histone proteins are rich in basic amino acids lysine and arginine which gives a positive charge to them. The positive charge of histone proteins helps in the winding of negatively charged DNA around them.

S23. (c) The reason why DNA is negatively charged is the phosphate group that makes up every nucleotide (pentose + nitrogenous base + phosphate).

S24. (c) At a simplest level chromatin is a double stranded helical DNA, next DNA is complexed by wrapping around histones to form nucleosomes. Each nucleosome folds up to form chromatin. The chromatin further become complex to form chromosome.

S25. (b) the packaging of chromatin at higher level requires additional set of proteins collectively referred to as non-histone chromosomal (NHC) proteins.

S26. (b) $_{15}N$ is not a radioactive isotope, and it can be separated from $_{14}N$ only based on densities

S27. (c) In every 20 mins, the E.coli replicates. After 80 mins, about 4 generations of bacteria are obtained. After 80 mins, two hybrids are obtained which has 2 heavy DNA. The light DNA obtained are 14.

S28. (c) A molecule that can act as a genetic material must fulfill the following criteria:
It should be able to generate its replica (Replication), it should be stable chemically and structurally, it should provide the scope for slow changes (mutation) that are required for evolution, it should be able to express itself in the form of 'Mendelian Characters'.

S29. (c) Regulation of gene expression can be exerted at following levels:
(i) transcriptional level during formation of primary transcript,
(ii) processing like splicing, terminal additions or modifications,
(iii) translational level.

S30. (c) During translation, messenger RNA (mRNA) provides the template to synthesize a chain of amino acids that form a protein. Transfer RNA (tRNA) reads the genetic code and brings amino acid specified by the codon. RNA polymerase binds to DNA sequence called the promoter and initiates transcription.

ASSERTION AND REASON

S1. (b)

S2. (c) The two chains of the DNA have an anti-parallel polarity.

S3. (c) The discontinuously synthesised fragments during replication are later joined by the enzyme DNA ligase.

S4. (a)