**Question 1:**

Group the following as nitrogenous bases and nucleosides:

Adenine, Cytidine, Thymine, Guanosine, Uracil and Cytosine.

Answer

Nitrogenous bases present in the list are adenine, thymine, uracil, and cytosine.

Nucleosides present in the list are cytidine and guanosine.

**Question 2:**

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

Answer

According to Chargaff's rule, the DNA molecule should have an equal ratio of pyrimidine (cytosine and thymine) and purine (adenine and guanine). It means that the number of adenine molecules is equal to thymine molecules and the number of guanine molecules is equal to cytosine molecules.

% A = % T and % G = % C

If dsDNA has 20% of cytosine, then according to the law, it would have 20% of guanine.

Thus, percentage of G + C content = 40%

The remaining 60% represents both A + T molecule. Since adenine and guanine are always present in equal numbers, the percentage of adenine molecule is 30%.

**Question 3:**

If the sequence of one strand of DNA is written as follows:

5′-ATGCATGCATGCATGCATGCATGCATGC-3′

Write down the sequence of complementary strand in 5′→3′ direction

Answer

The DNA strands are complementary to each other with respect to base sequence. Hence, if the sequence of one strand of DNA is

5′- ATGCATGCATGCATGCATGCATGCATGC – 3′

Then, the sequence of complementary strand in $5' \text{ to } 3'$ direction will be

3′- TACGTACGTACGTACGTACGTACGTACG – 5′

Therefore, the sequence of nucleotides on DNA polypeptide in $5' \text{ to } 3'$ direction is

5′- GCATGCATGCATGCATGCATGCATGCAT– 3′

**Question 4:**

If the sequence of the coding strand in a transcription unit is written as follows:

5′-ATGCATGCATGCATGCATGCATGCATGC-3′

Write down the sequence of mRNA.

Answer

If the coding strand in a transcription unit is

5′– ATGCATGCATGCATGCATGCATGCATGC-3′

Then, the template strand in 3′ to 5′ direction would be

3′ – TACGTACGTACGTACGTACGTACGTACG-5′

It is known that the sequence of mRNA is same as the coding strand of DNA.

However, in RNA, thymine is replaced by uracil.

Hence, the sequence of mRNA will be

5′ – AUGCAUGCAUGCAUGCAUGCAUGCAUGC-3′

**Question 5:**

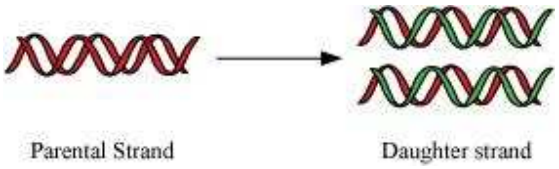
Which property of DNA double helix led Watson and Crick to hypothesise semi-conservative mode of DNA replication? Explain.

Answer

Watson and Crick observed that the two strands of DNA are anti-parallel and complementary to each other with respect to their base sequences. This type of arrangement in DNA molecule led to the hypothesis that DNA replication is semi-conservative. It means that the double stranded DNA molecule separates and then, each of the separated strand acts as a template for the synthesis of a new

complementary strand. As a result, each DNA molecule would have one parental strand and a newly synthesized daughter strand.

Since only one parental strand is conserved in each daughter molecule, it is known as semi-conservative mode of replication.




**Question 6:**

Depending upon the chemical nature of the template (DNA or RNA) and the nature of nucleic acids synthesised from it (DNA or RNA), list the types of nucleic acid polymerases.

Answer

There are two different types of nucleic acid polymerases.

**(1)** DNA-dependent DNA polymerases

**(2)** DNA-dependent RNA polymerases

The DNA-dependent DNA polymerases use a DNA template for synthesizing a new strand of DNA, whereas DNA-dependent RNA polymerases use a DNA template strand for synthesizing RNA.

**Question 7:**

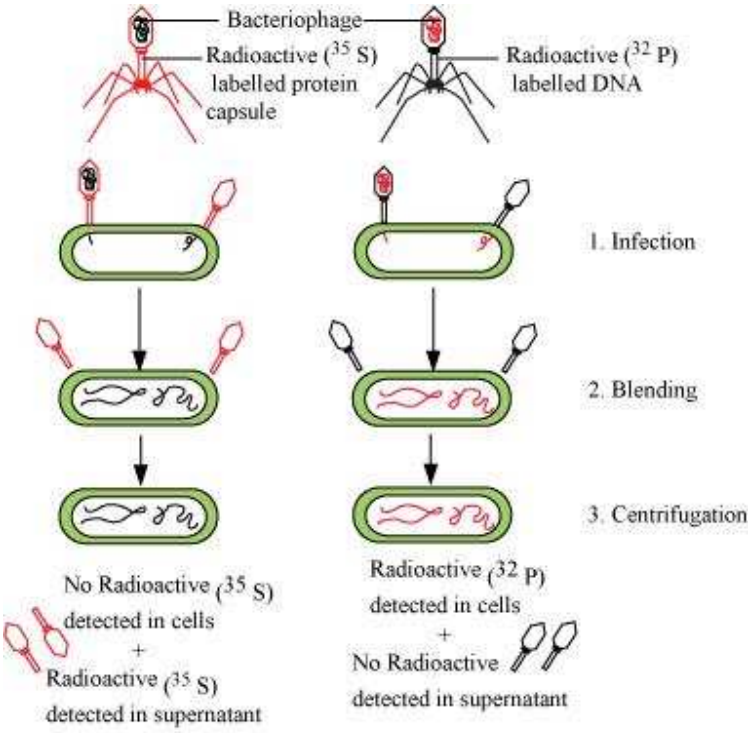
How did Hershey and Chase differentiate between DNA and protein in their experiment while proving that DNA is the genetic material?

Answer

Hershey and Chase worked with bacteriophage and *E.coli* to prove that DNA is the genetic material. They used different radioactive isotopes to label DNA and protein coat of the bacteriophage.

They grew some bacteriophages on a medium containing radioactive phosphorus ($^{32}P$) to identify DNA and some on a medium containing radioactive sulphur ($^{35}S$) to

identify protein. Then, these radioactive labelled phages were allowed to infect *E.coli* bacteria. After infecting, the protein coat of the bacteriophage was separated from the bacterial cell by blending and then subjected to the process of centrifugation. Since the protein coat was lighter, it was found in the supernatant while the infected bacteria got settled at the bottom of the centrifuge tube. Hence, it was proved that DNA is the genetic material as it was transferred from virus to bacteria.




**Hershey and Chase experiment**

**Question 8:**

Differentiate between the followings:

**(a)** Repetitive DNA and Satellite DNA

**(b)** mRNA and tRNA

**(c)** Template strand and Coding strand

Answer

**(a)** Repetitive DNA and satellite DNA

| | **Repetitive DNA** | **Satellite DNA** |
|---|---|---|
| **1.** | Repetitive DNA are DNA sequences that contain small segments, which are repeated many times. | Satellite DNA are DNA sequences that contain highly repetitive DNA. |

**(b)** mRNA and tRNA

| | **mRNA** | **tRNA** |
|---|---|---|
| **1.** | mRNA or messenger RNA acts as a template for the process of transcription. | tRNA or transfer RNA acts as an adaptor molecule that carries a specific amino acid to mRNA for the synthesis of polypeptide. |
| 2. | It is a linear molecule. | It has clover leaf shape. |

**(c)** Template strand and coding strand

| | **Template strand** | **Coding strand** |
|---|---|---|
| **1.** | Template strand of DNA acts as a template for the synthesis of mRNA during transcription. | Coding strand is a sequence of DNA that has the same base sequence as that of mRNA (except thymine that is replaced by uracil in DNA). |
| 2. | It runs from 3' to 5'. | It runs from 5'to 3'. |

**Question 9:**

List two essential roles of ribosome during translation.

Answer

The important functions of ribosome during translation are as follows.

**(a)** Ribosome acts as the site where protein synthesis takes place from individual amino acids. It is made up of two subunits.

The smaller subunit comes in contact with mRNA and forms a protein synthesizing complex whereas the larger subunit acts as an amino acid binding site.

**(b)** Ribosome acts as a catalyst for forming peptide bond. For example, 23s *r*-RNA in bacteria acts as a ribozyme.

**Question 10:**

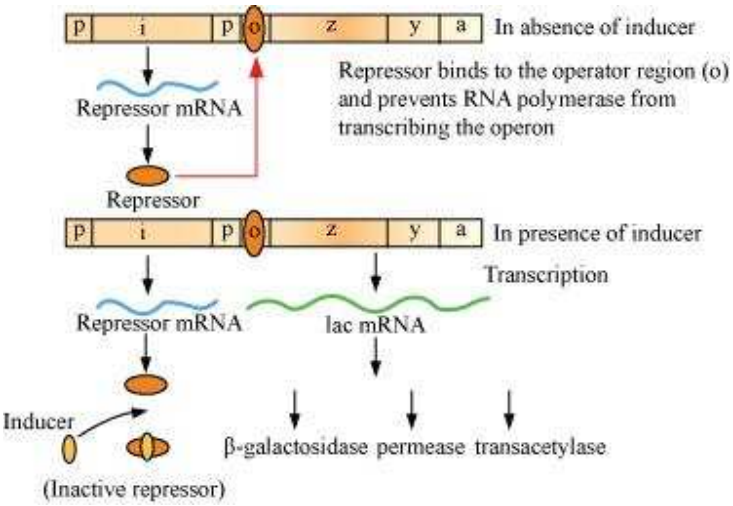
In the medium where *E. coli* was growing, lactose was added, which induced the *lac* operon. Then, why does lac operon shut down some time after addition of lactose in the medium?

Answer

*Lac* operon is a segment of DNA that is made up of three adjacent structural genes, namely, an operator gene, a promoter gene, and a regulator gene. It works in a coordinated manner to metabolize lactose into glucose and galactose.

In *lac* operon, lactose acts as an inducer. It binds to the repressor and inactivates it. Once the lactose binds to the repressor, RNA polymerase binds to the promoter region. Hence, three structural genes express their product and respective enzymes are produced. These enzymes act on lactose so that lactose is metabolized into glucose and galactose.

After sometime, when the level of inducer decreases as it is completely metabolized by enzymes, it causes synthesis of the repressor from regulator gene. The repressor binds to the operator gene and prevents RNA polymerase from transcribing the operon. Hence, the transcription is stopped. This type of regulation is known as negative regulation.




**Question 11:**

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

**(a)** Promoter

**(b)** tRNA

**(c)** Exons

Answer

**(a)** Promoter

Promoter is a region of DNA that helps in initiating the process of transcription. It serves as the binding site for RNA polymerase.

**(b)** tRNA

tRNA or transfer RNA is a small RNA that reads the genetic code present on mRNA. It carries specific amino acid to mRNA on ribosome during translation of proteins.

**(c)** Exons

Exons are coding sequences of DNA in eukaryotes that transcribe for proteins.

**Question 12:**

Why is the Human Genome project called a mega project?

Answer

Human genome project was considered to be a mega project because it had a specific goal to sequence every base pair present in the human genome. It took around 13 years for its completion and got accomplished in year 2006. It was a large scale project, which aimed at developing new technology and generating new information in the field of genomic studies. As a result of it, several new areas and avenues have opened up in the field of genetics, biotechnology, and medical sciences. It provided clues regarding the understanding of human biology.

**Question 13:**

What is DNA fingerprinting? Mention its application.

Answer

DNA fingerprinting is a technique used to identify and analyze the variations in various individuals at the level of DNA. It is based on variability and polymorphism in DNA sequences.

Application

**(1)** It is used in forensic science to identify potential crime suspects.

**(2)** It is used to establish paternity and family relationships.

**(3)** It is used to identify and protect the commercial varieties of crops and livestock.

**(4)** It is used to find out the evolutionary history of an organism and trace out the linkages between groups of various organisms.

**Question 14:**

Briefly describe the following:

(a) Transcription

(b) Polymorphism

(c) Translation

(d) Bioinformatics

Answer

**(a)** Transcription

Transcription is the process of synthesis of RNA from DNA template. A segment of DNA gets copied into mRNA during the process. The process of transcription starts at the promoter region of the template DNA and terminates at the terminator region. The segment of DNA between these two regions is known as transcription unit. The transcription requires RNA polymerase enzyme, a DNA template, four types of ribonucleotides, and certain cofactors such as $Mg^{2+}$.

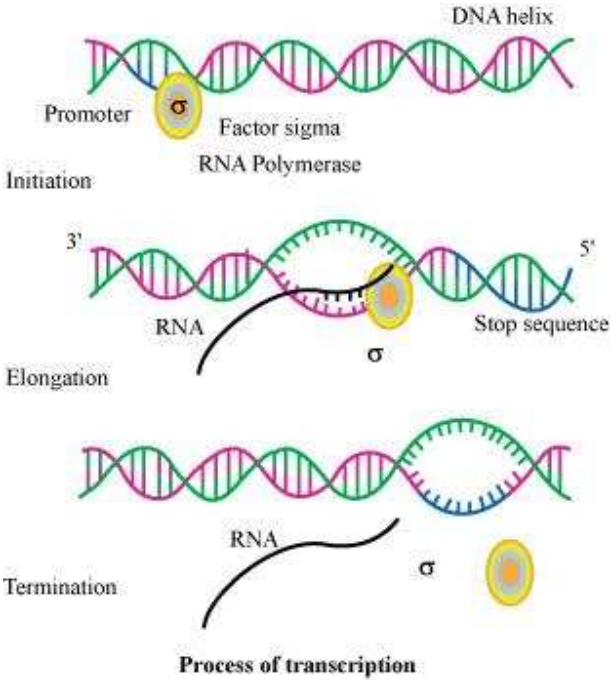
The three important events that occur during the process of transcription are as follows.

(i) Initiation

(ii) Elongation

(iii) Termination

The DNA-dependent RNA polymerase and certain initiation factors (σ) bind at the double stranded DNA at the promoter region of the template strand and initiate the process of transcription. RNA polymerase moves along the DNA and leads to the unwinding of DNA duplex into two separate strands. Then, one of the strands, called sense strand, acts as template for mRNA synthesis. The enzyme, RNA polymerase, utilizes nucleoside triphosphates (dNTPs) as raw material and polymerizes them to form mRNA according to the complementary bases present on the template DNA. This process of opening of helix and elongation of polynucleotide chain continues until the enzyme reaches the terminator region. As RNA polymerase reaches the terminator region, the newly synthesized mRNA transcripted along with enzyme is released. Another factor called terminator factor (ρ) is required for the termination of the transcription.




**Process of transcription**

**(b)** Polymorphism

Polymorphism is a form of genetic variation in which distinct nucleotide sequence can exist at a particular site in a DNA molecule. This heritable mutation is observed at a high frequency in a population. It arises due to mutation either in somatic cell or in the germ cells. The germ cell mutation can be transmitted from parents to their offsprings. This results in accumulation of various mutations in a population, leading to variation and polymorphism in the population. This plays a very important role in the process of evolution and speciation.

**(c)** Translation

Translation is the process of polymerizing amino acid to form a polypeptide chain. The triplet sequence of base pairs in mRNA defines the order and sequence of amino acids in a polypeptide chain.

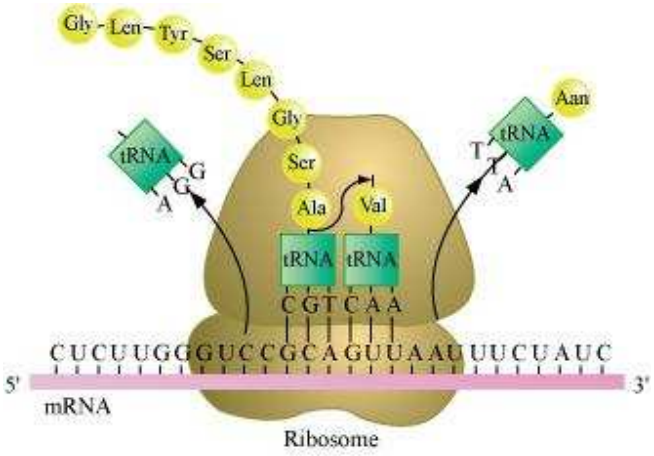
The process of translation involves three steps.

(i) Initiation

(ii) Elongation

(iii) Termination

During the initiation of the translation, tRNA gets charged when the amino acid binds to it using ATP. The start (initiation) codon (AUG) present on mRNA is recognized only by the charged tRNA. The ribosome acts as an actual site for the process of translation and contains two separate sites in a large subunit for the attachment of subsequent amino acids. The small subunit of ribosome binds to mRNA at the initiation codon (AUG) followed by the large subunit. Then, it initiates the process of translation. During the elongation process, the ribosome moves one codon downstream along with mRNA so as to leave the space for binding of another charged tRNA. The amino acid brought by tRNA gets linked with the previous amino acid through a peptide bond and this process continues resulting in the formation of a polypeptide chain. When the ribosome reaches one or more STOP codon (VAA, UAG, and UGA), the process of translation gets terminated. The polypeptide chain is released and the ribosomes get detached from mRNA.




Translation of proteins

**(d)** Bioinformatics

Bioinformatics is the application of computational and statistical techniques to the field of molecular biology. It solves the practical problems arising from the management and analysis of biological data. The field of bioinformatics developed after the completion of human genome project (HGP). This is because enormous

amount of data has been generated during the process of HGP that has to be managed and stored for easy access and interpretation for future use by various scientists. Hence, bioinformatics involves the creation of biological databases that store the vast information of biology.

It develops certain tools for easy and efficient access to the information and its utilization. Bioinformatics has developed new algorithms and statistical methods to find out the relationship between the data, to predict protein structure and their functions, and to cluster the protein sequences into their related families.

# CHAPTER 6

# MOLECULAR BASIS OF INHERITANCE

## POINTS TO REMEMBER

**Anticodon :** A sequence of three nitrogenous bases on tRNA which is complementary to the codon on mRNA.

**Transformation :** The phenomenon by which the DNA isolated from one type of a cell, when introduced into another type, is able to express some of the properties of the former into the latter.

**Nucleosome :** The structure formed when negatively charged DNA is wrapped around positively charged histone octamer.

**DNA Polymorphism :** The variations at genetic level, where an inheritable mutation is observed.

**Satellite DNA :** The repetitive DNA sequences which form a large portion of genome and have high degree of polymorphism but do not code for any proteins.

**Operon :** A group of genes which control a metabolic pathway.

**Exons :** The regions of a gene which become part of mRNA and code for different regions of proteins.

**Introns :** The regions of a gene which are removed during the processing of mRNA.

**Euchromatin :** The region of chromatin which is loosely packed and transcriptionally active.

**Heterochromatin :** The chromatin that is more densely packed, stains dark and is transcriptionally inactive.

**Splicing :** The process in eukaryotic genes in which introns are removed and the exons are joined together to form mRNA.

13. Explain the cause of Klinefelter.s syndrome. Give any four symptoms shown by sufferer of this syndrome.

14. In Mendel.s breeding experiment on garden pea, the offspring of F2 generation are obtained in the ratio of 25% pure yellow pod, 50% hybrid green pods and 25% green pods State (i) which pod colour is dominant

(ii) The Phenotypes of the individuals of F1 generation.
(iii) Workout the cross.

**LA (5 MARKS)**

15. A dihybrid heterozygous round, yellow seeded garden pea (Pisum sativum) was crossed with a double recessive plant.

(i) What type of cross is this?

(ii) Work out the genotype and phenotype of the progeny.

(iii) What principle of Mendel is illustrated through the result of this cross?

**ANSWERS**

**VSA (1 MARK)**

1. (i) Many varieties with contrasting forms of characters

(ii) Can easily be cross pollinated as well as self pollinated.

2. Dog flower (Snapdragon or Antirrhinum sp.)

3. GAG changes as GUG, Glutamic acid is substituted by valine.

4. (i) Klinefelter.s Syndrome (ii) Down.s syndrome

5. Their daughter can never be haemophilic. (0%).

6. Test cross 1 : 1.

**SA-II (2 MARKS)**

7. (i) Female; (ii) Male; (iii) Female (iv) Male

8. **Turner.s Syndrome :** The individual is female and it has 45 chromosomes i.e., one X chromosome is less.

**Klinefelter.s Syndome :** The individual is male and has 47 chromosomes i.e., one extra X chromosome.

**Central Dogma :**

Replication


**Replication fork :** The Y shaped structure formed when double stranded DNA is unwound upto a point during its replication.

**VNTR :** Variable Number Tandem Repeats

**YAC :** Yeast Artificial Chromosome

**BAC :** Bacterial Artificial Chromosome

**SNPs :** Single Nucleotide polymorphism

**HGP :** Human Genome Project

**hnRNA :** Heterogenous nuclear RNA. It is precursor of mRNA.

Chemical Structure of Polynucleotide Chain (DNA/RNA) : A nucleotide has three components.

1. **Nitrogen base**
   - (i) Purines : Adenine and Guanine
   - (ii) Pyrimidines : Cytosine, Thymine and Uracil

   Thymine in DNA and Uracil in RNA.
2. **Pentose Sugar :** Ribose (in RNA) or Deoxyribose (in DNA).
3. **Phosphate Group**

- ❑ Nitrogen base is linked to pentose sugar through N-glycosidic linkage.
- ❑ Nitrogen base + Sugar = Nucleoside
- ❑ Phosphate group is linked to 5´.OH of a nucleoside throughNM phosphoester linkage.
- ❑ Nucleoside + Phosphate group = Nucleotide.
- ❒ Two nucleotides are linked through 3´.5´ phosphodiester linkage to form a dinucleotide
- ❒ A polynucleotide chain has free phosphate group at 5´.end of ribose sugar and 3´.OH group at other end.

RNA is highly reactive than DNA : In RNA nucleotide has an addition .OH group at 2´.position in the ribose; RNA is also catalytic.

**Double-helix Structure of DNA :** Proposed by Watson and Crick in 1953.

(i) DNA is made up of two polynucleotide chains.

(ii) The backbone is made up of sugar and phosphate and the bases project inside.

(iii) Both polynucleotide chains are antiparallel i.e. one chain has polarity 5´-3´ and other chain has 3´.5´.

(iv) These two strands of chains are held together by hydrogen bonds i.e. A=T, C ≡ G.

(v) Both chains are coiled in right handed fashion. The pitch of helix is 3.4 nm with 10 bp in each turn.

**Hershey and Chase Experiement :** In 1952, Hershey and Chase performed an experiment on bacteriophages (Viruses that infect bacteria) and proved that

DNA is the genetic material.

| Bacteriophage | Bacteriophage |
|---|---|
| Radioactive ($35^S$) labelled protein coat | Radioactive ($32^P$) labelled DNA |
| ↓ | ↓ |
| **Infection :** E.coli | E.coli |

↓

**Blending :** Viral coats removed from the bacteria.

↓

**Centrifugation :** Viral particles separated from the bacterial cell.

| ↓ | ↓ |
|---|---|
| No radioactive ($35^S$) detected in bacterial cells but detected in supernatant supernatant | Radioactive ($35^P$) detected in baterial cells but not in |

**Conclusion :** DNA is the genetic material.

**Meselson and Stahl.s Experiment :**

- Meselson and Stahl performed the experiment in 1958 on *E.coli* to prove that DNA replication is semiconservative.
- E.coli was grown in $^{15}NH_4Cl$ for many generations.
- 15N was incorporated into newly synthesised DNA.
- This heavy DNA could be differentiated from normal DNA by centrifugation in cesium chloride (CsCl) density gradient.

Then they transferred these E.coli into a medium with normal $^{14}NH_4Cl$.

- After 20 minutes, it was found that all the DNA molecules of daughter cells were hybrid.First generation.
- After 40 minutes, it was found that 50% DNA molecules were hybrid and 50% were normal-second generation.

**DNA Replication :**

(i) **Origin of replication -** it is the starting point when replication of DNA begins.

(ii) **Replication fork -** for long DNA molecules, since the two strands of DNA cannot be seperated in its entire length, the replication occur within a small opening of DNA helix, referred to as replication fork.

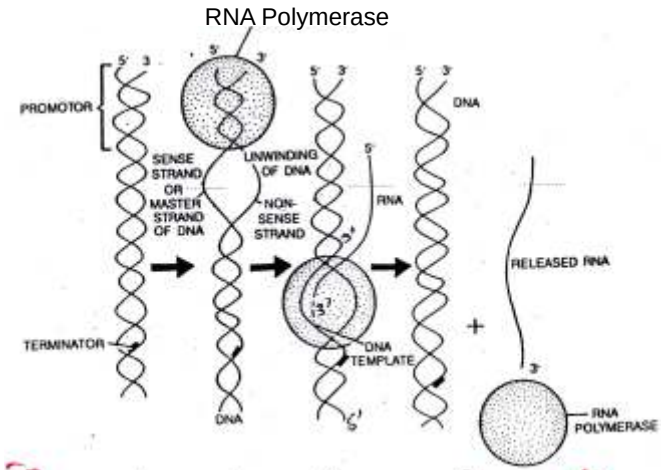
(iii) **Continuous synthesis -** DNA dependent DNA polymerase catalyses polymerisation only in 5.→3. direction, one strand (the template with polarity 3'→ 5'), the replication is continuous.

(iv) **Discontinuous synthesis -** In the template with 5'→3' the replication is disecontinuous and the fragments are joined by enzyme ligase.

**Transcription :** The proces of copying genetic informations from our strand of DNA into RNA.

**Transcription in Prokaryotes :** In prokaryotes the process of transcription is completed in three steps:

1. **Initiation :** RNA polymerase binds with initiation factor (sigma factor) and then binds to promotor site.
2. **Elongation :** RNA polymerase separates from sigma factor and adds nucleoside triphosphate as substrate. RNA is formed during the process following the rule of coplementarity and remains bound to enzyme RNA polymerase.
3. **Termination :** On reaching terminator region RNA polymerase binds with rho factor (terminator factor). As a result nascent RNA separates.




**Transcription in Eukaryotes :**

- ❑ In eukaryotes three types of RNA polymerases found in the nucleus (apart from RNa polymerases are found in the organelles) are involved in transcription.

  **RNA Polymerase I :** Transcribes rRNAs.

  **RNA Polymerase II :** Transcribes hnRNA (which is precursor of mRNA).

  **RNA Polymerase III :** Transcribes tRNA, 5 srRNA and snRNA.

- ❑ The primary transcript has both exon and intron regions.
- ❑ Introns which are non-coding regions removed by a process called splicing.
- ❑ hnRNA undergoes two additional processes :
  - (a) **Capping :** An unusual nucleotide (methylguanosine triphosphate) is added to 5'_.end of hnRNA.
  - (b) **Tailing :** Adenylate residues (200-300) are added at 3'-end. It is fully processed hnRNA, now called mRNA is transported out of the nucleus

**Lac Operon**

- The concept of operon was proposed by Jacob Monod. Operon is a unit of prokaryotic gene expression.
- The lac operon consists of one regulatory gene (the i-gene) and three structural genes (z, y and a).
- The i-gene codes for repressor of lac operon.
- Lactore is an inducer.

❑ Gene z - Codes for b-galactosidase
Gene y - Codes for permease
Gene a - Codes for transacetylase.

**In the absence of Inducer (lactose)**

Repressor (i-gene) binds with operator (o)

↓

Operator turns off

↓

RNA polymerase stops the transcription

↓

Structural genes (z, y and a) do not produce lac mRNA and enzymes

**In the presence of Inducer (lactose)**

Repressor binds to inducer (lactose)

↓

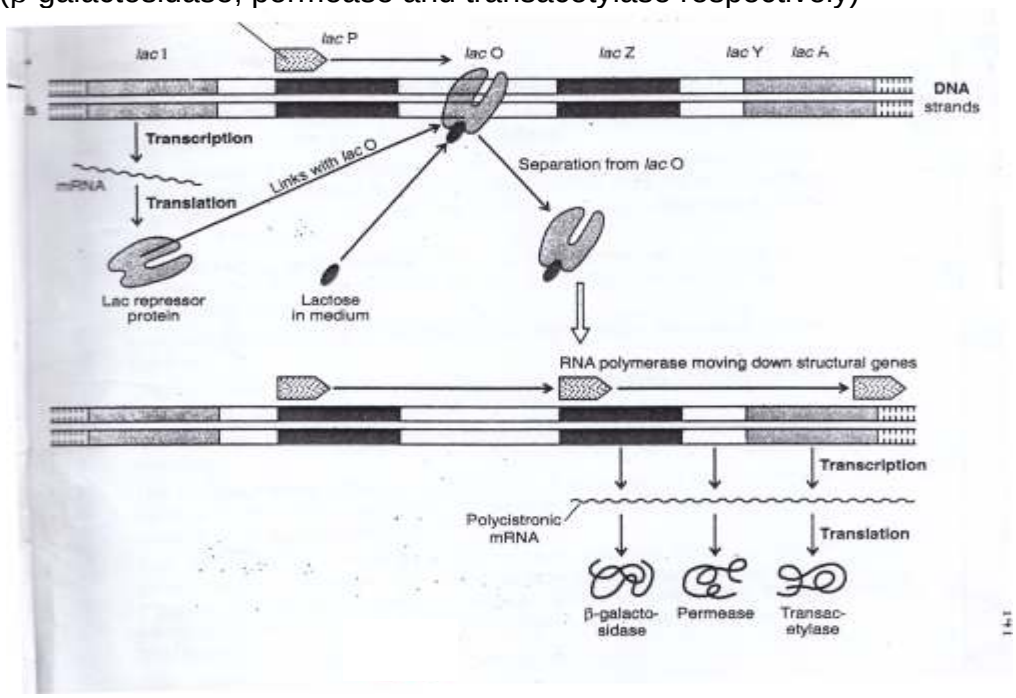
Operator (o) turns ON

↓

RNA polymerase starts the transcription

↓

Structural genes (z, y and a) produce mRNA and enzymes (β-galactosidase, permease and transacetylase respectively)



## Packaging of DNA Helix

- The average distance between the two adjacent base pairs is 0.34 nm (0.34x10.9m or 3.4°A)
- The number of base pairs in *E.coli* is $4.6x10^6$.
- **DNA Packaging in Prokaryates -** DNA is not scattered throghout the cell. DNA (negatively charged) is held by some proteins (has positive charges) in a region termed as .nucleoid.. The DNA in nucleoid is organised in large loops held by proteins.
- **DNA packaging in Eukayotes -** There is a set of positively charged basic proteins called histones. Histones are rich in the basic amines and residues lysines and arginines.
- Histones are organised to form a unit of eight molecules called histone octamer.
- The negatively charged DNA is wrapped around positively charged histone octamer to form a structure called nucleosome
- Nucleosomes constitute the repeating unit of a structure in nucleus called chromatin
- The beads-on-string structure in chromatin is packaged to form chromatin fibres that are futher coiled and condensed at metaphase stage of cell division to form chromosomes
- The packaging of chromatin at higher level requires additional set of protein that collectively are referred to as Non-histone chromosomal (NHC) proteins. At places chromatin is density packed to form darkly staining heterochromatin. At other places chromatin is loosely packed to form euchromatin

## Genetic Code

(i) The codon is triplet 61 codons code for amino acids and 3 codons function as stop codons (UAG, UGA, UAA)

(ii) One codon codes for only one amino acid, hence the codon is unambiguous and specific.

(iii) Some amino acids are coded by more than one cadon . degenerate

(iv) The codon is read in mRNA in a contiguous fashion. There are no punctuations

(v) The code is nearly universal

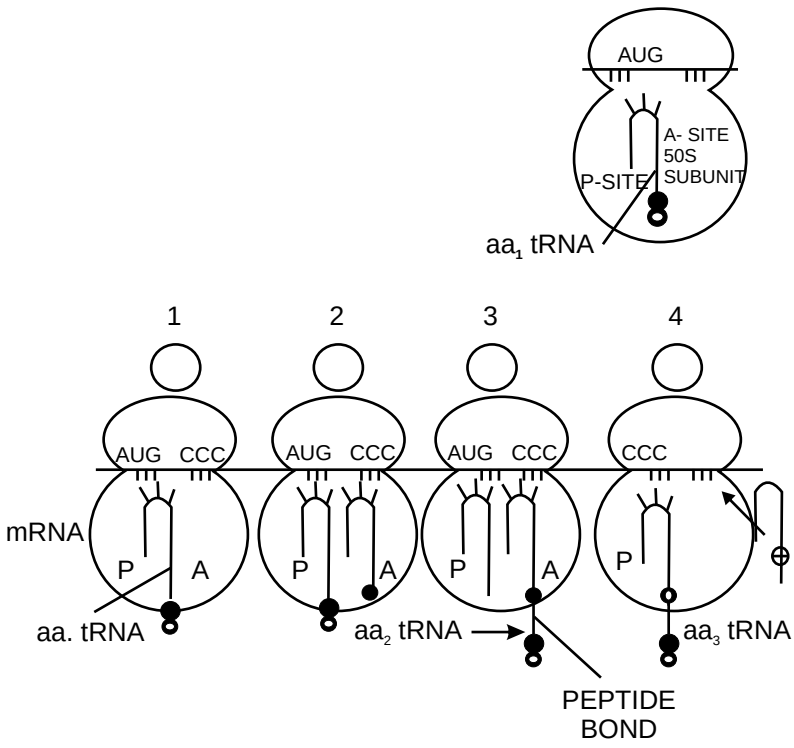
(vi) AUG has dual functions. It codes for Methionine (met) and it also acts as initiator codon.

**tRNA.the Adapter Molecule :**

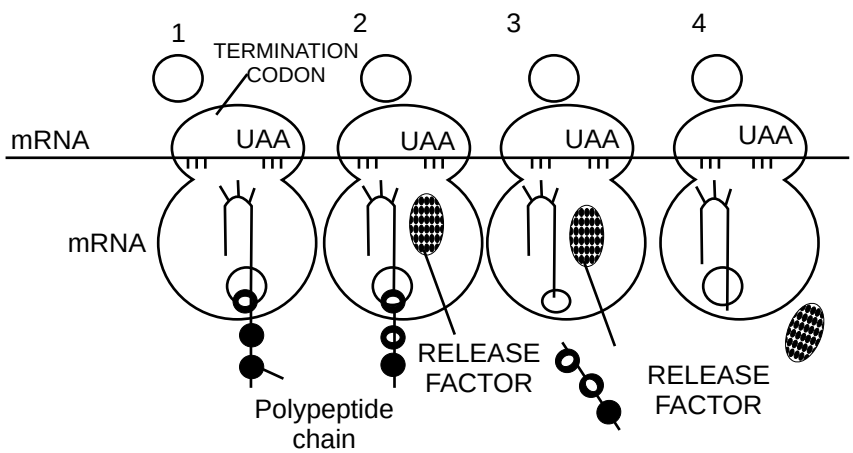
- tRNA has an anticoden loop that has bases complementary to the code and also has an amino acid accepter end through which it binds to amino acid.

**Translation :**

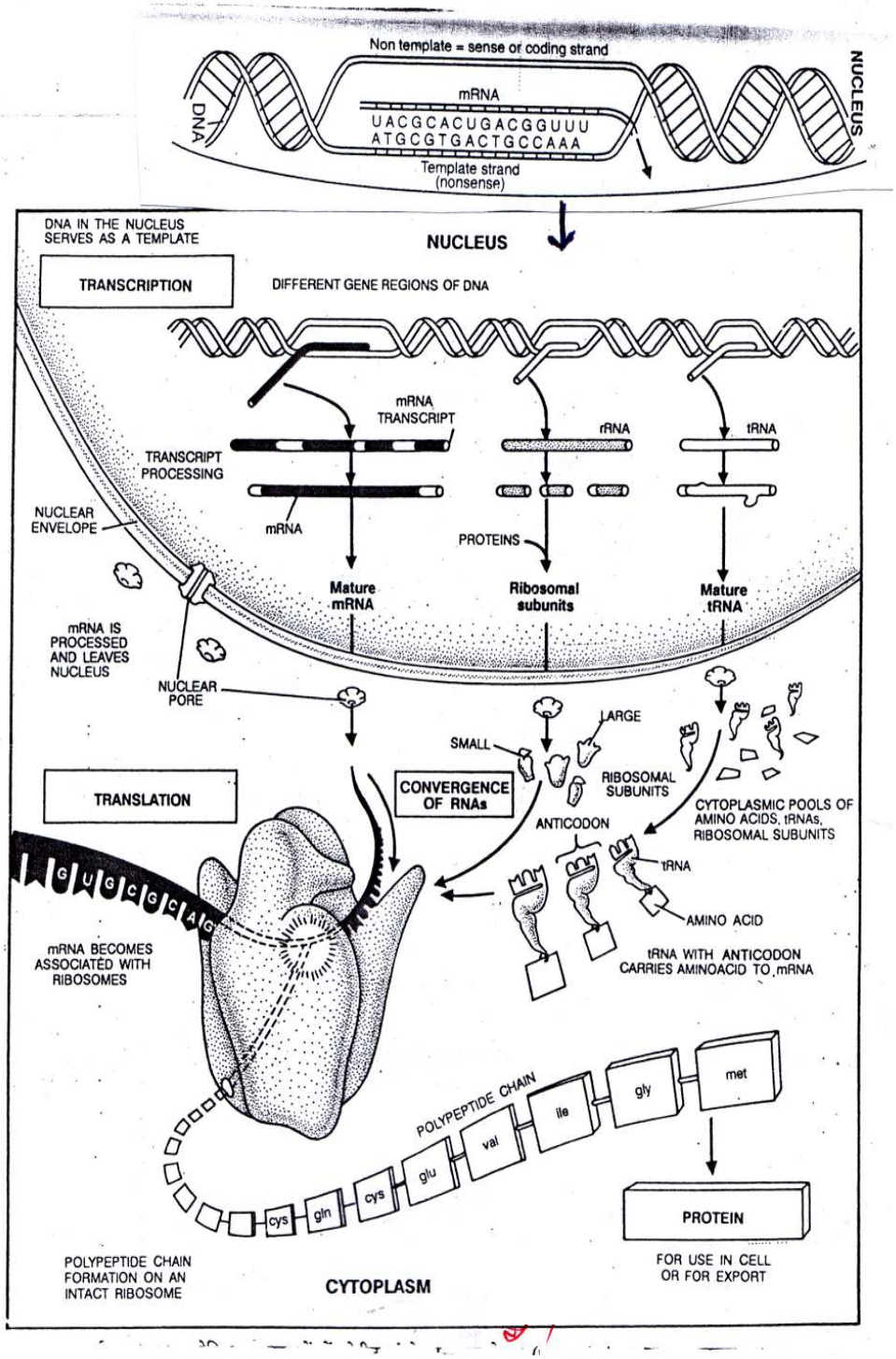
- Translation refers to the process of polymerisation of amino acids to form a polypeptide. The order and requence of amino acids are defined by the sequence of bases in the mRNA.
- First step is - charging of tRNA or aminoacylation of tRNA-here amino acids are activated in the presence of ATP and linked to specific tRNA.
- Initiation - Ribosome binds to mRNA at the start codon (AUG) that is recognised by the initiator tRNA.
- **Elongation phase -** Here complexes composed of an amino acid linked to tRNA, sequentially bind to the appropriate codon in mRNA by forming complementary base pairs with tRNA codon. The ribosomes move from codon to codon along with the mRNA. Amino acids are added one by one, translated into polypeptide sequences.
- **Termination -** Release factors binds to the stop codon, terminating translation and releasing the complete polypetide from the ribosome.




ELONGATION




TERMIINATION


Non template = sense or coding strand
DNA
mRNA
UACGCACUGACGGUUU
ATGCGTGACTGCCAAA
Template strand
(nonsense)
NUCLEUS
DNA IN THE NUCLEUS
SERVES AS A TEMPLATE
NUCLEUS
TRANSCRIPTION
DIFFERENT GENE REGIONS OF DNA
mRNA
TRANSCRIPT
rRNA
tRNA
TRANSCRIPT
PROCESSING
NUCLEAR
ENVELOPE
mRNA
PROTEINS
Mature
mRNA
Ribosomal
subunits
Mature
tRNA
mRNA IS
PROCESSED
AND LEAVES
NUCLEUS
NUCLEAR
PORE
LARGE
SMALL
RIBOSOMAL
SUBUNITS
CYTOPLASMIC POOLS OF
AMINO ACIDS, tRNAs,
RIBOSOMAL SUBUNITS
TRANSLATION
CONVERGENCE
OF RNAs
ANTICODON
tRNA
AMINO ACID
tRNA WITH ANTICODON
CARRIES AMINOACID TO mRNA
mRNA BECOMES
ASSOCIATED WITH
RIBOSOMES
POLYPEPTIDE CHAIN
met
gly
ile
val
glu
cys
gln
cys
PROTEIN
FOR USE IN CELL
OR FOR EXPORT
POLYPEPTIDE CHAIN
FORMATION ON AN
INTACT RIBOSOME
CYTOPLASM

- **Human Genome Project** was a 13 year project coordinated by the U.S. Department of energy and National Institute of Health, It was completed in 2003.

**Important goals of HGP**

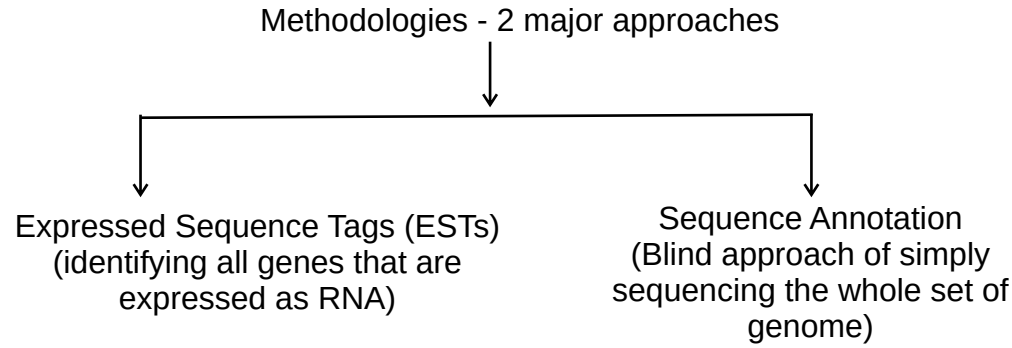
(i) Identify all the approximately 20,000-25,000 genes in human DNA.

(ii) Determine the sequences of the 3 million chemical base pairs that make up human DNA.

(iii) Store this information in database.

(iv) Transfer related technologies to other sectors, such as industries.

(v) Address the ethical, legal and social issues (ELSI) that may arise from the project.




Salient features of Human Genome - Refer Pg - 120, NCERT Class XII)

**DNA Fingerprinting -** It is a technique of determining nucleotide sequences of certain areas of DNA which are unique to each individual

**Principle of DNA Fingerprinting -** Short nucleotide repeats in the DNA are very specific in each individual and vary in number from person to person but are inherited. These are .Variable Number Tandem Repeats. (VNTRs). Each individual inherits these repeats from his/her parents which is used as genetic markers. One half of VNTR alleles of the child resembles that of the mother and other half the father.

**Steps/procedure in DNA fingerprinting .**

— Extraction of DNA - using high speed refrigerated centrifuge.

— Amplification - many copies are made using PCR

— Restriction Digestion - using restriction enzymes DNA is cut into fragments.

— Separation of DNA fragments - using electrophoresis-agarose polymer gel.

— Southern Blotting : Separated DNA sequences are transferred on to nitrocellulose or nylon membrane.

— Hybridisation : The nylon memberane exposed to radio active probes.

— Autoradiography : The dark bands develop at the probe site.

**Applications of DNA Fingerprinting**

(i) identify criminals in forensic labs.

(ii) determine paternity

(iii) verify whether a hopeful immigrant is really close relative of an already established resident.

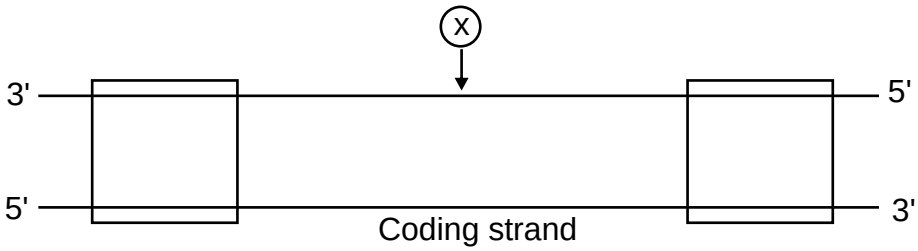
(iv) identify racial graps to rewrite biological evolution.

## QUESTIONS

### VSA (1 MARK)

1. Name the factors for RNA polymerase enzyme which recognises the start and termination signals on DNA for transcription process in Bacteria.
2. Mention the function of non-histone protein.
3. During translation what role is performed by tRNA
4. RNA viruses mutate and evolve faster than other viruses. Why?

5. Name the parts 'X' and 'Y' of the transcription unit given below.




6. Mention the dual functions of AUG.
7. Write the segment of RNA transcribed from the given DNA .

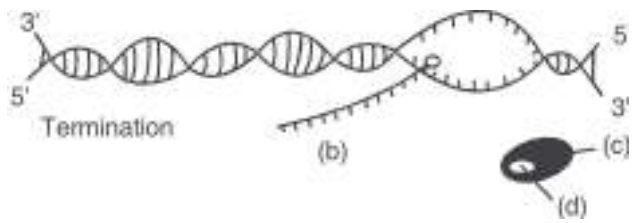
3′ → A T G C A G T A C G T C G T A . 5′ - Template Strand

5′ ← T A C G T C A T G C A G C A T . 3′ . Coding Strand.

**SA-II (2 MARKS**

8. The process of termination during transcription in a prokaryotic cell is being represented here. Name the label a, b, c and d.

(a)




9. Complete the blanks a, b, c and d on the basis of Frederick Griffith Experiment.

S Strain → inject into mice → (a)

R strain → inject into mice → (b)

S strain (heat killed) → inject into mice → (c)

S strain (heat killed) + R strain (live) → inject into mice → (d)

10. Give two reasons why both the strands of DNA are not copied during transcription.
11. Mention any two applications of DNA fingerprinting.
12. State the 4 criteria which a molecule must fulfill to act as a genetic material.

## SA-I (3 MARKS)

13. Give six points of difference between DNA and RNA in their structure/ chemistry and function.

14. Explain how does the hnRNA becomes the mRNA.

OR

Explain the process of splicing, capping and tailing which occur during transcription in Eukaryotes.

15. Name the three major types of RNAs, specifying the function of each in the synthesis of polypeptide.

16. Enlist the goals of Human genome project.

17. A tRNA is charged with the amino acid methionine.

    (i) Give the anti-codon of this tRNA.

    (ii) Write the Codon for methionine.

    (iii) Name the enzyme responsible for binding of amino acid to tRNA.

18. Illustrate schematically the process of initiation, elongation and termination during transcription of a gene in a bacterium.

## LA (5 MARKS)

19. What is meant by semi conservative replication? How did Meselson and Stahl prove it experimentally?

20. What does the lac operon consist of? How is the operator switch turned on and off in the expression of genes in this operon? Explain.

21. State salient features of genetic code.

22. Describe the process of transcription of mRNA is an eukaryotic cell.

23. Describe the various steps involved in the technique of DNA fingerprinting.

## ANSWERS

## VSA (1 MARK)

1. Sigma (s) factor and Rho(p) factor)

2. Packaging of chromatin

3. (i) Structural role

   (ii) Transfer of amino acid.

4. —OH group is present on RNA, which is a reactive group so it is unstable and mutate faster.

5. X . Template strand, Y . Terminator.

6. (i) Acts as initiation codon for protein synthesis

   (ii) It codes for methionine.

7. 5' . U A C G U C A U G C A G C A U 3' (In RNA .T. is replaced by .U.)

**SA-II (2 MARKS)**

8. (a) DNA molecule (b) mRNA transcript

   (c) RNA polymers (d) Rho factor

9. (a) Mice die (b) mice live

   (c) mice live (d) mice die

10. (a) If both the strands of DNA are copied, two different RNAs (complementary to each other) and hence two different polypeptides will produce; If a segment of DNA produces two polypeptides, the genetic information machinery becomes complicated.

    (b) The two complementary RNA molecules (produced simultaneously) would form a double stranded RNA rather than getting translated into polypeptides.

    (c) RNA polymerase carries out polymerisation in 5'—3' direction and hence the DNA strand with 3'—5' polarity acts as the template strand. (Any two)

11. (i) To identify criminals in the forensic laboratory.

    (ii) To determine the real or biological parents in case of disputes.

    (iii) To identify racial groups to rewrite the biological evolution. (Any two)

12. (i) It should be able to generate its replica.

    (ii) Should be chemically and structurally stable.

    (iii) Should be able to express itself in the form of Mendelian characters.

    (iv) Should provide the scope for slow changes (mutations) that are necessary for evolution.

## SA-I (3 MARKS)

13.

| | DNA | | RNA |
|---|---|---|---|
| (i) | Double stranded molecules | (i) | Single stranded molecules |
| (ii) | Thymine as pyrimidine base | (ii) | Uracil as pyrimidine base |
| (iii) | Pentose sugar is Deoxyribose | (iii) | Sugar is Ribose |
| (iv) | Quite stable and not very reactive | (iv) | 2´-OH makes it reactive |
| (v) | Dictates the synthesis of Polypeptides | (v) | Perform their functions in protein synthesis. |
| (vi) | Found in the nucleus. | (vi) | They are transported into the cytoplasm. |

14. hnRNA is precursor of mRNA. It undergoes

(i) **Splicing :** Introns are removed and exons are joined together.

(ii) **Capping :** an unusual nucleotide (methyl guanosine triphosphate is added to the 5´ end of hnRNA.

(iii) Adenylate residues (200-300) are added at 3´ end of hnRNA.

OR

Refer fig. 6.11, page 110, NCERT book. Biology - XII

15. (i) mRNA-(Messenger RNA) : decides the sequence of amino acids.

(ii) tRNA-(Transfer RNA) : (a) Recognises the codon on mRNA (b) transport the aminoacid to the site of protein synthesis.

(iii) rRNA (Ribosomal RNA) : Plays the structural and catalytic role during translation.

16. Refer points given on page 118, NCERT, Biology XII.

17. (a) UAC (b) AUG

(c) Amino-acyltRNA synthetase.

18. Refer figure 6.10, page 109, NCERT Biology XII.

## LA (5 MARKS)

19. Meselson and Stahl, performed an experiment using E.coli to prove that DNA replication is semi conservative.

— They grew *E.coli* in a medium containing 15 $NH_4Cl$.

— Then separated heavy DNA from normal (14N) by centrifugation in CsCl density gradient.

— The DNA extracted, after one generation of transfer from 15N medium to 14N medium, had an intermediate density.

— The DNA extracted after two generations consisted of equal amounts of light and hybrid DNA.

— They proved that DNA replicates in a semiconservative manner. (Refer figure 6.7, page 105, NCERT Biology XII).

20. Lac Operon consists of the following :

— **Structural genes :** z, y, a which transcribe a polycistronic mRNA. . gene 'z' codes for b-galactosidase

— gene 'y' codes for permease.

— gene 'a' codes for transacetylase.

— **Promotor :** The site where RNA polymerase binds for transcription.

— Operator : acts as a switch for the operon

— **Repressor :** It binds to the operator and prevents the RNA Polymerase from transcribing.

— **Inducer :** Lactose is the inducer that inactivates the repressor by binding to it.

— Allows an access for the RNA polymerase to the structural gene and transcription.

— Refer figure 6.14, page 117, NCERT, Biology XII.

21. Refer notes

22. Refer notes 35 and figure 6.11, page 110, NCERT Biology XII.

23. Refer points to remember . Steps involved in DNA fingerprinting