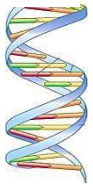
CHAPTER 5



MOLECULAR BASIS OF INHERITANCE

(A) NCERT QUESTIONS & SOLUTIONS

1. Group the following as nitrogenous bases and nucleosides :
Adenine, Cytidine, Thymine, Guanosine, Uracil and Cytosine.

Ans. Nitrogenous bases-Adenine, Thymine, Uracil and Cytosine
Nucleosides-Cytidine and Guanosine.

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

Ans. Cytosine 20%, therefore Guanine = 20%
According to Chargaff's rule,
A+T =100 - (G + C)
A+T =100-40. Since both adenine and thymine are in equal amounts

$$\text{Thymine} = \text{Adenine} = \frac{60}{2} = 30\ \%$$

3. If the sequence of one strand of DNA is written as follows: [IMP.]
5'-ATGCATGCATGCATGCATGCATGCATGC-3'
Write down the sequence of complementary strand in 5'→3' direction.

Ans. In 3' → 5' direction, 3-TACGTACGTACGTACGTACGTACGTACG-5'
In 5' → 3' direction, 5'-GCATGCATGGATGCATGGATGCATGCAT-3

4. If the sequence of the coding strand in a transcription unit is written as follows: [IMP.]
5'**-ATGCATGCATGCATGCATGCATGCATG-**3'
Write down the sequence of mRNA.

Ans. 5'-AUGCAUGCAUGCAUGCAUGCAUGCAUG-C-3'

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

Ans. Watson and crick observed that the two DNA strands are antiparallel, and have opposite polarity. This means that 5' phosphate of one strand faces that 3' hydroxyl group of other strand and that the 5' phosphate group of two strands are present in opposite position. The antiparallel arrangement of two helices allows hydrogen bonding between amino and carbonyl group of complementary base pairs. 'This led them to the hypothesis of the semi-conservative mode of DNA replication where in two strands of DNA first separate from each other followed by copying of each template strands to form DNA molecules each carrying one parental strand and newly synthesized strands.

6. Depending upon the chemical nature of the template (DNA or RNA) a f nucleic acids synthesized from it (DNA or RNA), list the types of nucleic acid polymerases.

Ans. **DNA template**

(i) DNA polymerase for DNA replication.

(ii) RNA polymerase for RNA synthesis or transcription.

RNA template

(i) RNA-dependent RNA polymerase for synthesis of RNA in some RNA viruses.

(ii) Reverse transcriptase to synthesise cDNA (complementary DNA) over RNA template.

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

Ans. Hershey and Chase (1952) conducted experiments in bacteriophage to prove that DNA is the genetic material.

Procedure:

Some bacteriophage virus were grown on a medium that contained radioactive phosphorus (^{32}P) and some in another medium with radioactive sulphur (^{35}S).

(a) Viruses grown in the presence of radioactive phosphorus (^{32}P) contained radioactive DNA.

(b) Similar viruses grown in presence of radioactive sulphur (^{35}S) contained radioactive problem.

(c) Both the radioactive virus types were allowed to infect *E.coli* separately.

(d) Soon after infection, the bacterial cells were gently agitated in blender to remove viral coats from the bacteria.

(e) The culture was also centrifuged to separate the viral particle from the bacteria cell.

Observation and Conclusions:-

(a) Only radioactive (^{32}P) was found to be associated with bacterial cell, whereas radioactive (^{35}S) was only found in surrounding medium and not in the bacterial cell.

(b) This indicates that only DNA and not the protein coat entered the bacterial cell.

(c) This proves that DNA is the genetic material which is passed from virus to bacteria and not protein.

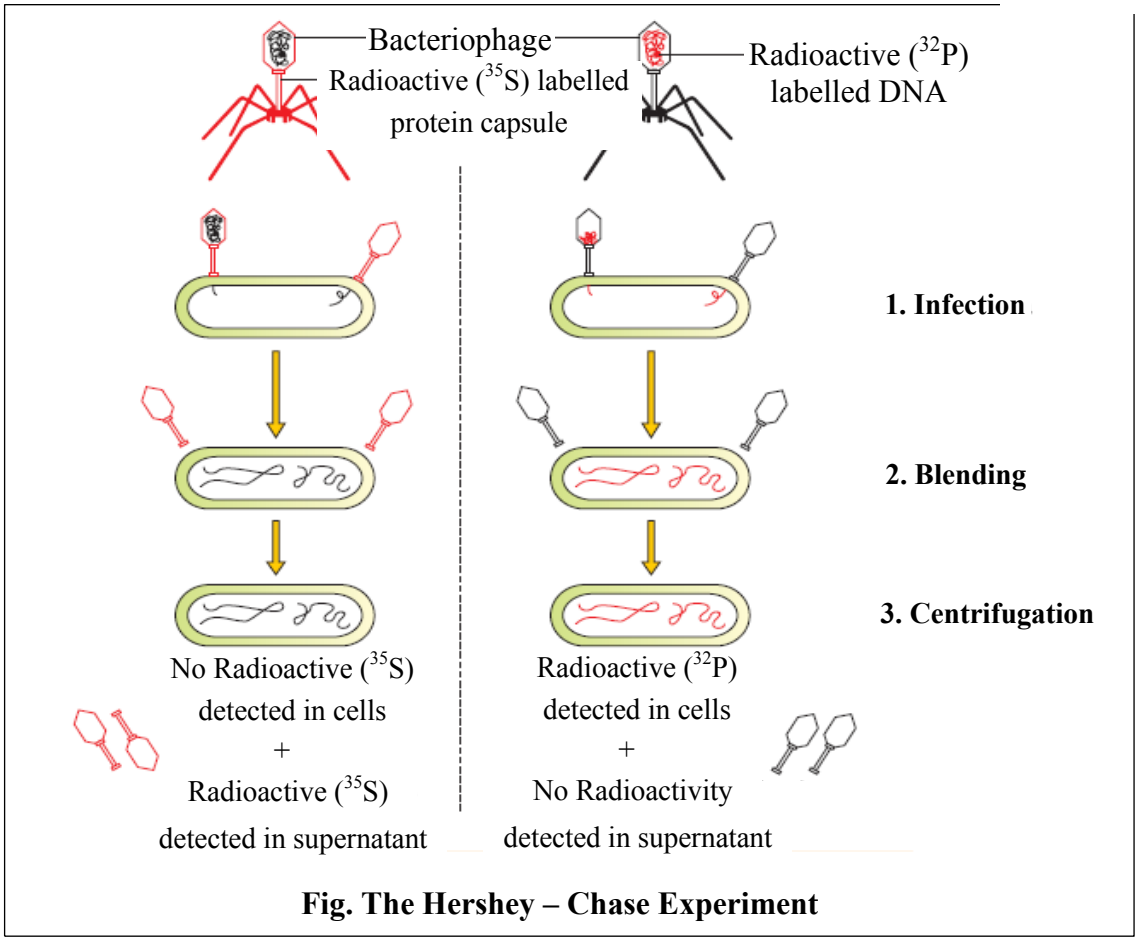


Fig. The Hershey – Chase Experiment

8. Differentiate between the following : **[IMP.]**

(a) Repetitive DNA and satellite DNA

(b) mRNA and tRNA

(c) Template strand and coding strand

Ans. (a) Repetitive DNA and satellite DNA :-

S.No.	Repetitive DNA	satellite DNA
1	DNA in which certain base sequence are repeated many times are called repetitive DNA.	DNA in which portion of the gene is tandemly repeated is called satellite DNA.
2	Repetitive DNA sequence are transcribed	Satellite DNA sequences are not transcribed

(b) mRNA and tRNA:-

S.No.	mRNA	tRNA
1	It is linear.	It is clover –leaf shaped.
2	It carries coded information.	It carries information for association with an amino acid and an anticodon for its incorporation in a polypeptide.
3	mRNA undergoes additional processing, capping and tailing splicing .	It does not required any processing.
4	Nitrogen bases are unmodified	Nitrogen bases may be modified.-

(c) Template strand and coding strand :-

S.No.	Template strand	Coding strand
1	It is the strand of DNA which taken part in transcription.	It is the strand that dose not take part in transcription.
2	The polarity is 3'→ 5'	The polarity is 5' → 3'.
3	Nucleotide sequence is complementary.	The nucleotide sequence is same as the one present in mRNA except for presence of thymine instead of uracil.

9. List two essential roles of ribosome during translation.

Ans. Two essential roles of ribosome during translation are:

(i) One of the rRNA (23S in prokaryotes) acts as a peptidyl transferase ribozymne for formation of peptide bonds

(ii) Ribosome provides sites for attachment of mRNA and charged (RNAs for polypeptide synthesis).

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?

Ans. It is because the repressor protein binds to the operator region of the operon and prevent RNA polymerase from transcribing the operon.

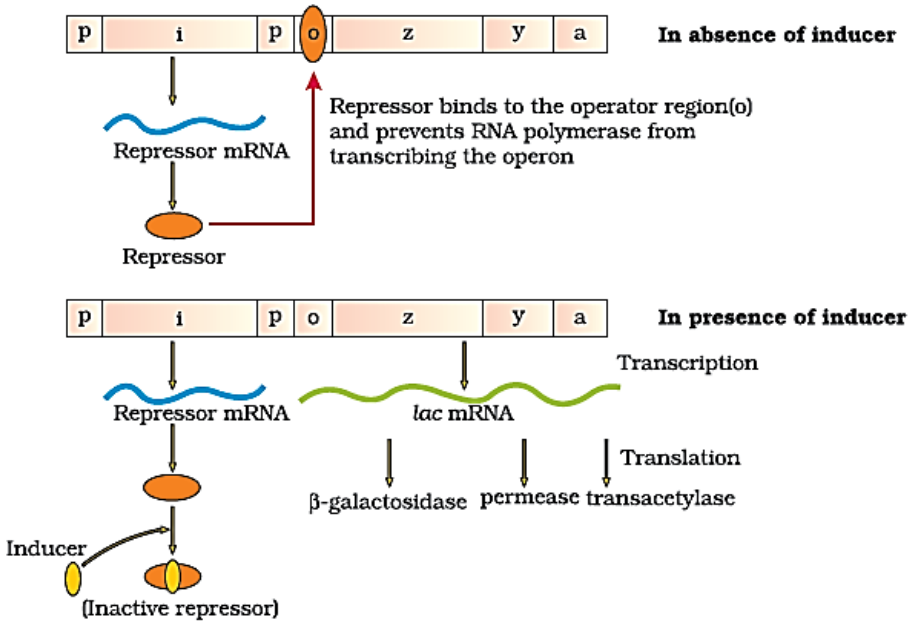


Figure - The *lac* Operon

11. Explain (in one or two lines) the function of the following :

(a) Promoter (b) tRNA (c) Exons

Ans. (a) Promoter : It is the segment of DNA which lies adjacent to the operator and functions as the binding site for RNA polymerase tocarry transcription if allowed by operator.

(b) tRNA : It acts as an adaptor molecule that picks up a particular amino acid from cellular poll and takes the same over to site A of mRNA for incorporation into polypeptide chain.

(c) Exons : These are the coding segments present in primary transcript which after splicing joined to form functional mRNA.

12. Why is the Human Genome Project called a mega project?

Ans. Human Genome Project is called a mega project because of following reasons:

- Sequencing of more than 3×10^9 bp.
- Identification of all the approximately 20,000 – 25,000 genes in human DNA.
- High expenditure of more than 9 billion US dollars.
- Identification of all the alleles of genes and their functions.
- Storage of data for sequencing would require space equal to 3300 books of 1000 pages each if each page will consist of 1000 letters.

13. What is DNA fingerprinting? Mention its application.

Ans. DNA fingerprinting is the technique to determine the relationship between by studying the similarity and dissimilarity of VNTR (variable number of tandem repeats). its applications are:

- It is used as a tool in forensic tests to identify criminals.
- To settle paternity disputes.
- To identify racial groups to study biological evolution.

14. Briefly describe the following:

(a) Transcription (b) Polymorphism (c) Translation (d) Bioinformatics

Ans. **(a) Transcription**: It is the formation of RNA over the template of DNA. It forms single-stranded RNA which has a coded information similar to the sense or coding strand of DNA with the exception that thymine is replaced by uracil.

(b) Polymorphism: Genetic polymorphism means occurrence of genetic material in more than one form. It is of two major types, i.e allelic polymorphism and SNP.

Allelic polymorphism: Allelic polymorphism occurs due to multiple alleles of a gene Allele possess different mutations which alter the structure and function of a protein formed by as a result, change phenotype may occur.

SNPs or single nucleotide polymorphism: Over 1.4 million single-base DNA differences have been observed in human beings. According to SNP every human being is unique. SNP is very useful for locating alleles, identifying disease –associated sequences and tracing human history.

(c) Translation: It is the process during which the genetic information which is stored in the sequence of nucleotides in a mRNA molecules is converted following direction of the genetic code into the sequence of amino acids in the polypeptide. It takes place in cytoplasm in both eukaryotes and prokaryotes.

(d) Bioinformatics: The science which deals with handling, storing of huge information of genomics as databases, analysing, modeling and providing various aspects of biological information especially the molecules connected with genomics and proteomics is called bioinformatics.

(B) PREVIOUS YEAR QUESTIONS

1. Given below is the restriction site of a restriction endonuclease Pst-I and the cleavage sites on a DNA molecule. **[CBSE 2023]**

5' C – T – G – C – A ↓ G 3'
3' G ↑ A – C – G – T – C 5'

Choose the option that gives the correct resultant fragments by the action of the enzyme Pst-I.

(1) 5' C – T – G C – A – G 3'
3' G – A – C – G – T C 5'

(2) 5' C – T G – C – A – G 3'
3' G – A – G – C T – C 5'

(3) 5' C – T – G – C A – G 3'
3' G – A – C – G T – C 5'

(4) 5' C – T – G – C – A G 3'
3' G A – C – G – T – C 5'

Ans. (4) 5' C – T – G – C – A_____ G 3'
3' G _____ A – C – G – T – C 5'

2. Given below is a sequence of bases in mRNA of a bacterial cell. Identify the amino acid that would be incorporated at codon position 3 and codon position 5 during the process of its translation. **[CBSE 2023]**

3' AUCAGGUUUGUGAUGGUACGA 5'

(1) Phenylalanine, Methionine
(2) Cysteine, Glycine
(3) Alanine, Proline
(4) Serine, Valine

Ans. (1) Phenylalanine, Methionine

3. Human Genome Project (HGP) was a mega project launched in the year 1990 with some important goals. **[CBSE 2023]**

(a) Enlist any four prime goals of HGP.

(b) Name any one common non - human animal model organism which has also been sequenced thereafter.

Ans. (a) (i) Identify all the approximately 20,000-25,000 genes in human DNA;
(ii) Determine the sequences of the 3 billion chemical base pairs that make up human DNA;
(iii) Improve tools for data analysis;
(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.
(b) Many non-human model organisms, such as bacteria, yeast, *Caenorhabditis elegans* (a free living non-pathogenic nematode), *Drosophila* (the fruit fly), plants (rice and *Arabidopsis*),

4.(a) (i) How and why is charging of tRNA essential in the process of transition

(ii) State the function of ribosome as a catalyst in bacteria during the process of translation

(iii) Explain the process of binding of ribosomal units to mRNA during protein synthesis.

[CBSE 2023]

OR

(b) (i) Describe the dihybrid cross upto F_2 generation as conducted by Gregor Mendel using pure lines of Garden Pea for characters seed shape and seed colour. [CBSE 2023]

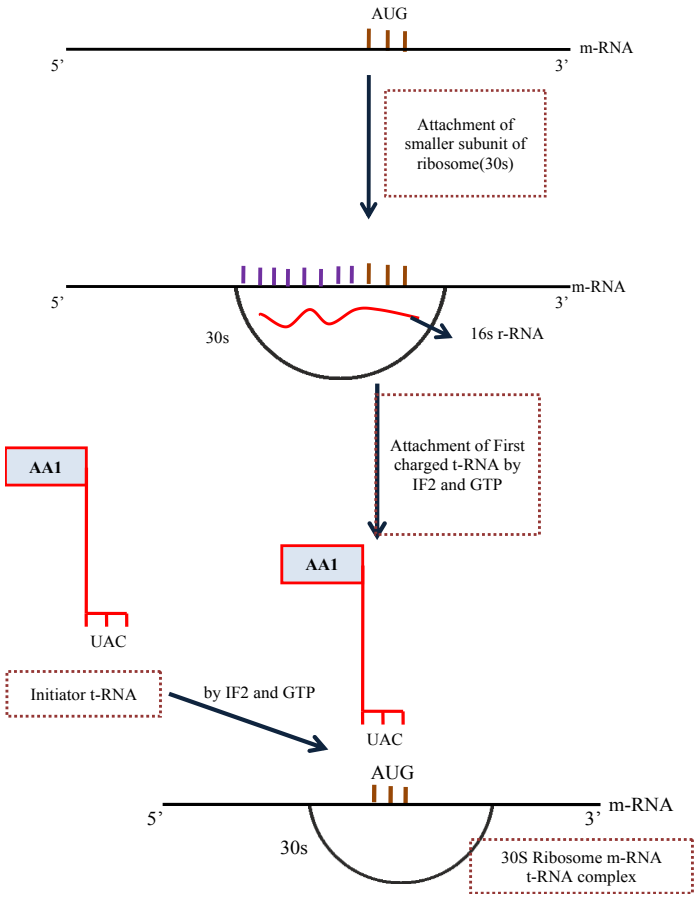
Ans. (a) (i) The amino acids are joined by a bond which is known as a peptide bond. Formation of a peptide bond requires energy. Therefore, in the first phase itself amino acids are activated in the presence of ATP and linked to their cognate tRNA–a process commonly called as charging of tRNA or aminoacylation of tRNA to be more specific.

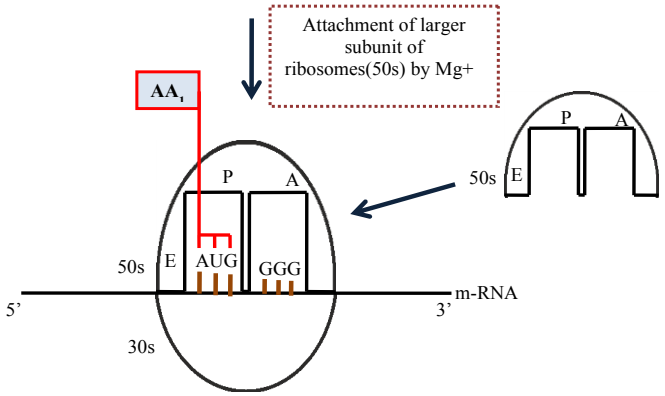
Amino acid + ATP $\xrightarrow{\text{enzyme}}$ Amino acyl AMP enzyme complex + PP(Pyrophosphate)

Amino acyl AMP enzyme complex + t-RNA $\longrightarrow$ Amino acyl t-RNA complex

(ii) The ribosome consists of structural RNAs and about 80 different proteins. In its inactive state, it exists as two subunits; a large subunit and a small subunit. When the small subunit encounters an mRNA, the process of translation of the mRNA to protein begins. There are two sites in the large subunit, for subsequent amino acids to bind to and thus, be close enough to each other for the formation of a peptide bond. The ribosome also acts as a catalyst (23S rRNA in bacteria is the enzyme- ribozyme) for the formation of peptide bond.

(iii) Translation refers to the process of polymerisation of amino acids to form a polypeptide.

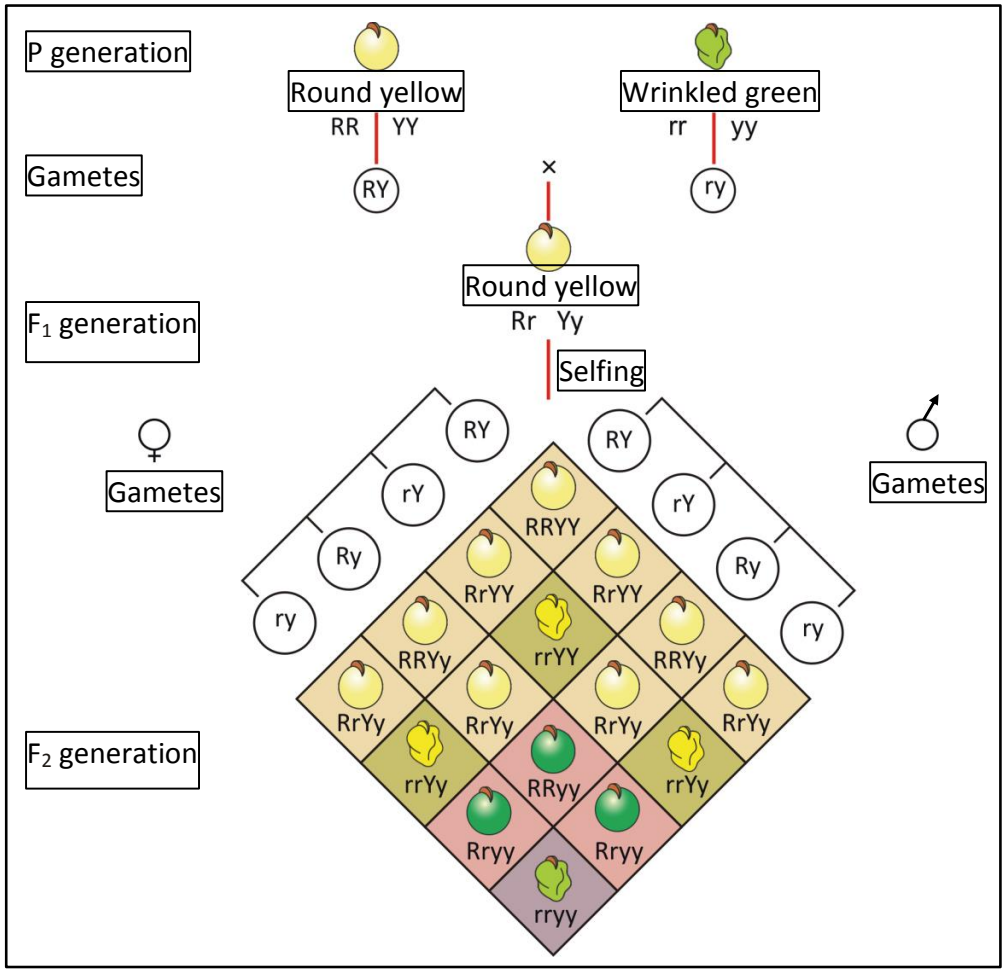




The process of binding of ribosomal units to mRNA

OR

(b) A cross in which there is study of inheritance of 2 character at a time. From this cross Mendel wanted to observe the effect of one character over another character during inheritance.



Phenotypic ratio

Round yellow	Round green	Wrinkled yellow	Wrinkled green
9	3	3	1

Genotypic ratio

RRYY	RRYy	RRyy	RrYY	RrYy	Rryy	rrYY	rrYy	rryy
1	2	1	2	4	2	1	2	1

LAW OF INDEPENDENT ASSORTMENT

- ☛ It is concluded from F_2 generation of Dihybrid cross.
- ☛ The law states that "When two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters."

  Assortment occurs when non alleles are located on different homologous chromosome.

5. (a) Name and describe the steps involved in the technique widely used in forensics that serves as the basis of paternity testing in case of disputes. [CBSE 2023]

Ans. (a) The technique widely used in forensics that serves as the basis of paternity testing in case of disputes in DNA profiling or DNA fingerprinting. The steps involved in this technique are as follows :

(i) isolation of DNA,

(ii) digestion of DNA by restriction endonucleases,

(iii) separation of DNA fragments by electrophoresis,

(iv) transferring (blotting) of separated DNA fragments to synthetic membranes, such as nitrocellulose or nylon,

(v) hybridisation using labelled VNTR probe, and

(vi) detection of hybridised DNA fragments by autoradiography.

6. (i) Explain the process of aminoacylation of tRNA and its role in the process of translation.

(ii) How does initiation of the translation process occur in prokarotes? Explain.

(iii) Where are the untraslated regions located on mRNA and why? [CBSE 2023]

Ans. (i) in the first phase itself amino acids are activated in the presence of ATP and linked to their cognate tRNA–a process commonly called as charging of tRNA or aminoacylation of tRNA to be more specific.

1. Activation of amino acid :-

$$\text{Amino acid + ATP} \xrightarrow{\text{enzyme}} \underset{\text{enzyme complex}}{\text{Amino acyl AMP}} + \text{PP(Pyrophosphate)}$$

2. Charging of t-RNA

$$\underset{\text{enzyme complex}}{\text{Amino acyl AMP}} + \text{t-RNA} \longrightarrow \underset{\text{complex}}{\text{Amino acyl t-RNA}}$$

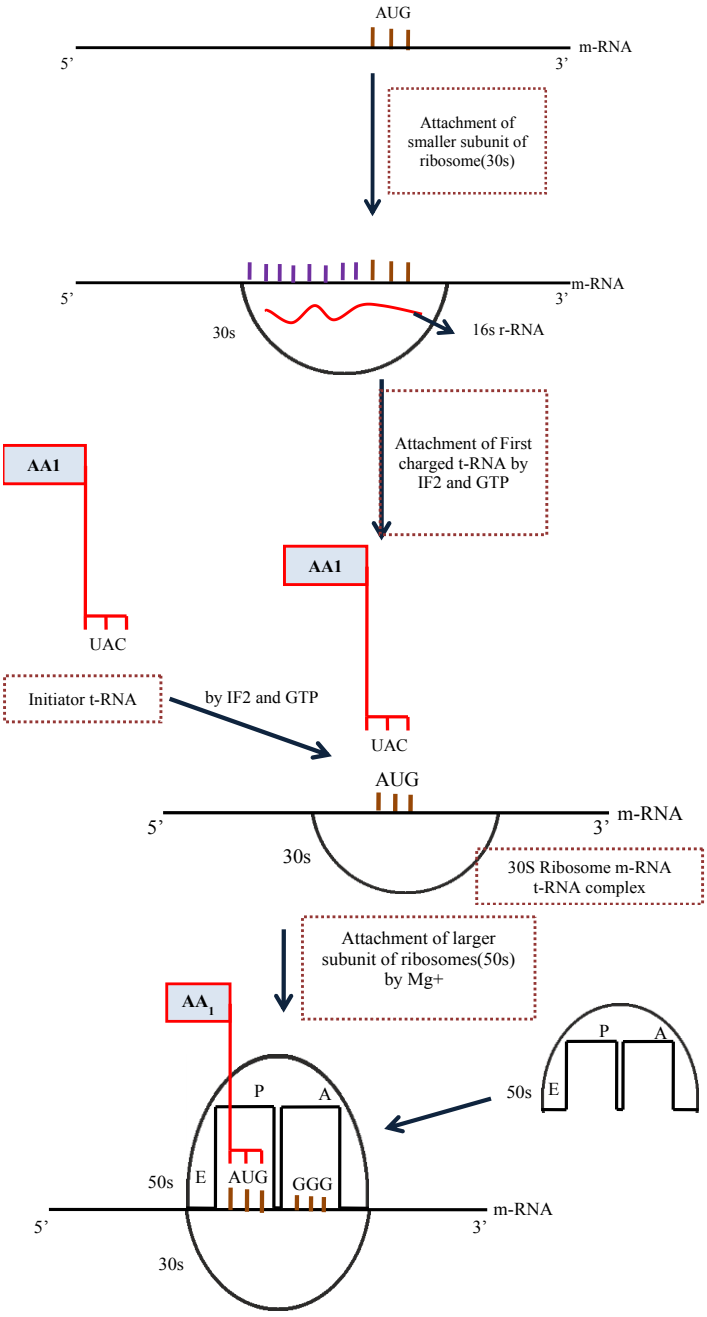
(ii) (1) m-RNA (2) Charged t-RNA,

(3) 30s and 50s sub units of ribosome

(4) GTP

(5) Mg^{+2}

(6) Initiation factors - In prokaryotes 3 factors:- IF1, IF2, IF3



(iii) mRNA also has some additional sequences that are not translated and are referred as untranslated regions (UTR).

☛ The UTRs are present at both 5'end (before start codon) and at 3'end (after stop codon).

☛ The UTR (untranslated regions) present on mRNA are required for efficient translation process (by recognising the smaller subunit of ribosome by mRNA).

7. Given below are the observation drawn in HGP. Select the options that shows the correct observations. **[CBSE Term – I 2022]**

(i) The human genome contains 3164.7 billion base pairs.

(ii) The average gene consists of 3000 bases.

(iii) Less than 2% of the genome codes for proteins.

(iv) Chromosome one has most genes (2698)

(1) (i) and (ii) (2) (ii) and (iii) (3) (iii) and (iv) (4) (i) and (iii)

Ans. (2) (ii) and (iii)

8. The phosphoester linkage in the formation of a nucleotide involves the bonding

[CBSE Term – I 2022]

(1) Phosphate group and OH of 3′C of a nucleoside

(2) Phosphate group and OH of 5′C of a nucleoside

(3) Phosphate group and H of 3′C of a nucleoside

(4) Phosphate group and H of 5′C of a nucleoside

Ans. (2) Phosphate group and OH of 5′C of a nucleoside

9. The switching 'on' and 'off' of the lac operon in prokaryotes is regulated by

[CBSE Term – I 2022]

(1) Glucose (2) Galactose (3) Lactose (4) Fructose

Ans. (3) Lactose

10. For 'in-vitro' DNA replication, which one of the following substrates need to be added along with the necessary enzymes the DNA template and specific conditions? **[CBSE Term – I 2022]**

(1) Ribonucleotide triphosphate (2) Deoxyribonucleoside triphosphate

(3) Deoxyribonucleotide triphosphate (4) Ribonucleoside triphosphate

Ans. (2) Deoxyribonucleoside triphosphate

11. Which one of the following factor will associate transiently with RNA polymerase to terminate transcription in prokaryotes? **[CBSE Term – I 2022]**

(1) sigma factor (2) RHO factor (3) delta factor (4) theta factor

Ans. (2) RHO factor

12. Choose the correct pair of codon with its corresponding amino acid from the following list:

[CBSE Term – I 2022]

(1) UAG : Glycine (2) AUG : Arginine (3) UUU : Phenylalanine (4) UGA : Methionine

Ans. (3) UUU : Phenylalanine

13. During elongation process of translation, the peptide bond formation between amino acids is catalysed :– **[CBSE Term – I 2022]**

(1) ribosomal RNA (2) protein in small subunit of ribosome

(3) protein in large subunit of ribosome (4) transfer RNA

Ans. (1) ribosomal RNA

14. A region of coding strand of DNA has the following nucleotide sequence:

5′–TGCGCCA – 3′

The sequence of bases on mRNA transcribed by this DNA stand would be:

[CBSE Term – I 2022]

(1) 3′ – ACGCGGT – 5′ (2) 5′ – ACGCGGT – 3′

(3) 5′ – UGCGCCA – 3′ (4) 3′ – UGCGCCA – 5′

Ans. (3) 5′ – UGCGCCA – 3′

15. A DNA molecule is 160 base pairs long. It has 20% adenine. How many cytosine bases are present in this DNA molecule? **[CBSE Term – I 2022]**

(1) 192 (2) 96 (3) 64 (4) 42

A

16. A templated strand in a bacterial DNA has the following base sequence :

5′ – TTTAACGAGG – 3′ **[CBSE Term – I 2022]**

(1) 5′ – AAATTGCTCC – 3′ (2) 3′ – AATTGCTCC – 5′

(3) 3′ – AAAUUGCUCC – 3′ (4) 5′ – CCUCGUUAAA – 5′

Ans. (4) 5′ – CCUCGUUAAA – 5′

17. tRNA has an _____ that has bases complementary to the codon. Its actual structure is a compact molecule which looks like _____. **[CBSE Term – I 2022]**

Select the option that has correct choices for the two 'blanks'

(1) amino acid acceptor end, clover-leaf (2) anticodon loop, clover-leaf

(3) amino acid acceptor end, inverted L (4) anticodon loop, inverted L

Ans. (4) anticodon loop, inverted L

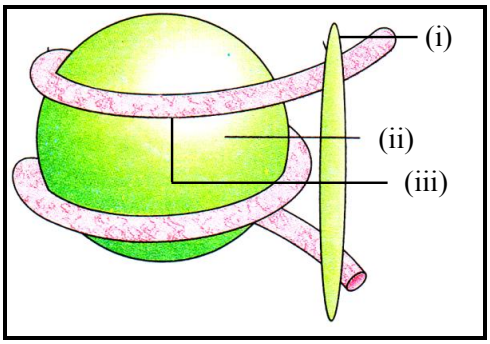
18. Which type of RNA is correctly paired with its function? **[CBSE Term – I 2022]**

(1) small nuclear RNA Processes rRNA (2) transfer RNA : attaches to amino acid

(3) ribosomal RNA : involved in transcription (4) micro RNA : involved in translation

Ans. (2) transfer RNA : attaches to amino acid

19. The figure given below has labellings (i), (ii) and (iii), which two labellings in the given figure are components of a nucleosome? Select the correct option. **[CBSE Term – I 2022]**



(1) (i) – HI histone, (ii) – DNA

(2) (i) – DNA, (ii) – Histone Octamer

(3) (ii) – DNA, (iii) – HI Histone

(4) (ii) – Histone octamer, (ii) – DNA

Ans. (4) (ii) – Histone octamer, (ii) – DNA

20. In molecular biology who proposed that genetic information flows in one direction?

[CBSE Term – I 2022]

(1) Har gobind Khorana (2) Francis Crick

(3) Watson and Crick (4) Marshall Nirenberg

Ans. (2) Francis Crick

21. Predict the effect if, the codon UAU coding for an amino acid at the 25th position of a polypeptide of 50 amino acids, is mutated to UAA. [CBSE IMP. Question]

Ans. A polypeptide of 24 amino acids will be formed as UAA is a stop codon which will prevent further translation.

22. **Assertion (A) :** Primary transcripts in eukaryotes are nonfunctional. **[CBS]**

Reason (R) : Methyl guanosine triphosphate is attached to 5' end of hnRNA.

(1) Both assertion and reason are true, and reason is the correct explanation of assertion.

(2) Both assertion and reason are true, but reason is not the correct explanation of assertion.

(3) Assertion is true but reason is false.

(4) Both assertion and reason are false.

OR

Assertion (A) : An organism with lethal mutation may not even develop beyond the zygote stage.

Reason (R) : All types of gene mutations are lethal. **[CBSE IMP. Question]**

(1)Both assertion and reason are true, and the reason is the correct explanation of the assertion.

(2)Both assertion and reason are true, but the reason is not the correct explanation of the assertion.

(3)Assertion is true but reason is false.

(4)Both assertion and reason are false

Ans. (2)Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.

OR

(2) Both Assertion and Reason are true but Reason, is not the correct explanation of Assertion.

23. Evaluate the suitability of DNA and RNA as genetic material and justify the suitability of the one that is preferred as an ideal genetic material. [CBSE IMP. Question]

OR

Explain the mechanism of DNA replication as suggested by Watson and Crick.

[CBSE IMP. Question]

Ans. Evaluation of DNA and RNA on the basis of the properties of the genetic material:

1. It should be able to generate its replica (Replication): As per the rule of base pairing and complementarity, both the nucleic acids (DNA and RNA) have the ability to direct their duplications.
2. The genetic material should be chemically and structurally stable enough not to change with different stages of life cycle, age or with change in physiology of the organism.
   Presence of 2'-OH group and uracil make RNA more reactive and structurally less stable than DNA. Therefore, DNA is a better genetic material than RNA.
3. It should provide the scope for slow changes (mutation) that are required for evolution: Both DNA and RNA are able to mutate. In fact, RNA being unstable, mutates at a faster rate. Consequently, viruses having RNA genome and having shorter life span mutate and evolve faster.
4. It should be able to express itself in the form of 'Mendelian Characters': RNA can directly code for the synthesis of proteins, hence can easily express the characters. DNA, however, is dependent on RNA for synthesis of proteins. The protein synthesising machinery has evolved around RNA.

5. The above discussion indicate that both RNA and DNA can function as g t
DNA being more stable is preferred for storage of genetic information

OR

Mechanism of Replication of DNA suggested by Watson and Crick

- The two strands of DNA would separate and act as a template for the synthesis of new complementary strands. After the completion of replication, each DNA molecule would have one parental and one newly synthesised strand. This scheme was termed as semiconservative DNA replication.
- In living cells, such as *E. coli*, the process of replication requires a set of catalysts (enzymes). The main enzyme is referred to as DNA-dependent DNA polymerase, since it uses a DNA template to catalyse the polymerisation of deoxynucleotides.
- Furthermore, energetically replication is a very expensive process. Deoxyribonucleoside triphosphates serve dual purposes. In addition to acting as substrates, they provide energy for polymerisation reaction.
- For long DNA molecules, since the two strands of DNA cannot be separated in its entire length (due to very high energy requirement), the replication occur within a small opening of the DNA helix, referred to as replication fork.
- The DNA-dependent DNA polymerases catalyse polymerisation only in one direction, that is 5' ⟶ 3'.
- Consequently, on one strand (the template with polarity 3' ⟶ 5'), the replication is continuous, while on the other (the template with polarity 5' ⟶ 3'), it is discontinuous. The discontinuously synthesised fragments are later joined by the enzyme DNA ligase.

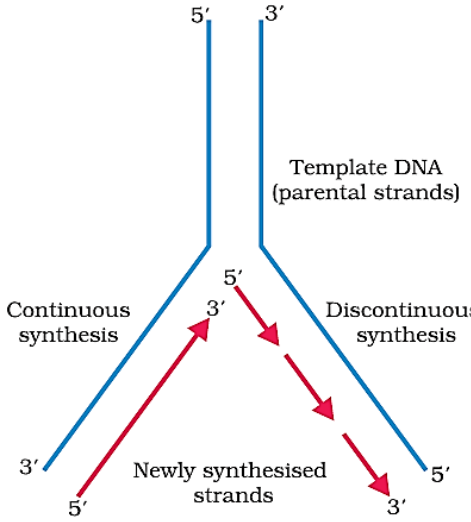


Figure: replication Fork

- The DNA polymerases on their own cannot initiate the process of replication.
- There is a definite region in *E. coli* DNA where the replication originates. Such regions are termed as origin of replication.
- In eukaryotes, the replication of DNA takes place at S-phase of the cell- cycle.
- The replication of DNA and cell division cycle should be highly coordinated.
A failure in cell division after DNA replication results into polyploidy.

24. Meselson & Stahl carried out centrifugation in $CsCl_2$ density gradient to separa

[CBSE 2020]

(1) DNA from RNA (2) DNA from protein

(3) The normal DNA from ^{15}N-DNA (4) DNA from tRNA

Ans. (C) The normal DNA from ^{15}N-DNA

25. Give below is one the strands of a DNA segment: **[CBSE 2020]**

$$3' \xrightarrow{\text{TACGTACGTACGTACG}} 5'$$

(a) Write its complementary strand

(b) Write a Possible RNA strands that can be transcribed from the above DNA molecule formed.

Ans. (a) 5' ATGCATGCATGCATGC 3'

(b) 5' AUGCAUGCAUGCAUGC 3'

Note : 3' – 5' is tamplate strand

5' – 3' is coding strand

26. Explain the role of regulatory gene in a *lac* operon. Why is regulation of lac operon called as negative regulation? **[CBSE 2019]**

Ans. Regulatory gene / i gene codes for the repressor of the lac operon, the repressor protein (synthesised by i gene, binds to the operator site of the operon, and prevents the RNA polymerase from transcribing the operon

The repressor of lac operon is synthesised constitutively / all the time, and thus the operon is in 'switched off' position generally, it is switched on only when lactose is present in the culture medium of the *E.coli* when the operon gets 'switched on'

27. Compare the processes of DNA replication and transcription in prokaryotes. **[CBSE 2019]**

Ans. Similarities - Both the processes involve -

i. Unwinding of the helix and separating the two DNA strands

ii. Breaking the hydrogen bonds between the bases / pairs

iii. Follow complimentary base pair rule

iv. Polymerization occurs in 5' 3' direction

v. Linking / Polymerization of nucleotides.

Dissimilarities

DNA replication	Transcription
1. DNA nucleotides added are dATP, dGTP, dCTP, dTTP	1. RNA nucleotides added are ATP, GTP, CTP, UTP
2. Deoxyribose sugar is the part of nucleotide	2. Ribose sugar is the part of nucleotide
3. Adenine pairs with Thymine	3. Adenine with Uracil
4. Both strands copied	4. Only one strand copied.
5. Resulting into two DNA molecules	5. Resulting in formation of an RNA molecule

28. (a) Explain Griffith's 'transforming principle' experiment.

(b) In the above experiment, ''heat which killed one type of bacteria, did not destroy the properties of genetic material.'' Justify **[CBSE 2019]**

Ans. (a)

S strain ⟶ Inject into mice ⟶ Mice die

R strain ⟶ Inject into mice ⟶ Mice live

S strain ⟶ Inject into mice ⟶ Mice live
(heat-killed)

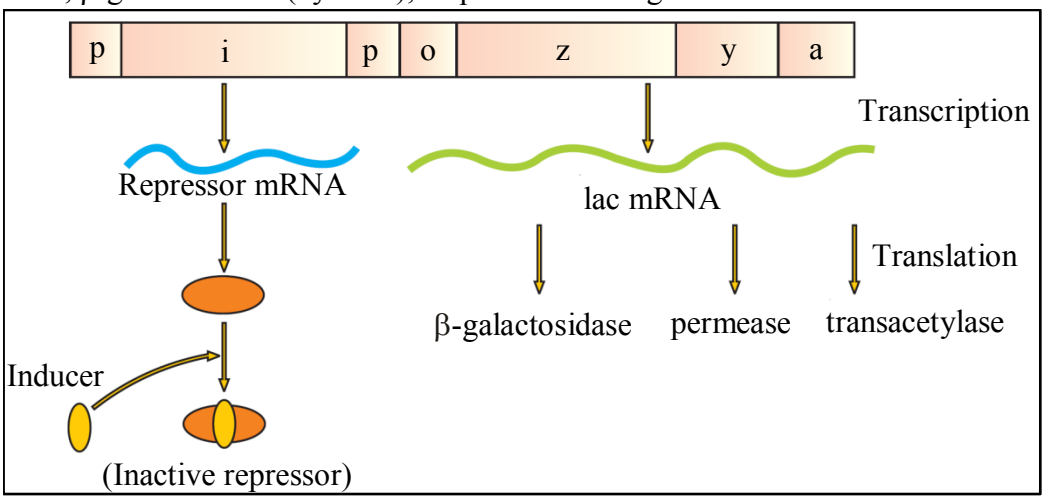
S strain
(heat-killed)
\+ ⟶ Inject into mice ⟶ Mice die
R strain
(live)

(b) The two DNA strands complementary get separated by heating come together, when appropriate conditions are provided heat did not destroy the genetic properties.

29. What is an operon ? Explain the functioning of lac operon when in an open state.
[CBSE 2018]

Ans. The arrangement where a (Polycistronic) structural gene is regulated by a common promoter and regulatory genes

Lactose acts as inducer , binds with repressor protein, RNA polymerase freely moves over the structural genes, transcribes lac mRNA, which in turn produce enzymes - transacetylase, permease, β-galactosidase (by lac z), responsible for digestion of lactose



30. (a) Hershey and Chase carried their experiment in three steps : infection, blending, centrifugation. Explain each step.

(b) Write the conclusion and interpretation of the result they obtained. **[CBSE 2017]**

Ans. (a) Infection - Radioactive phosphorus / phosphorus labelled bacteriophages were allowed to infect *E.coli* - growing in a culture medium, simultaneously radioactive sulphur / sulphur labelled bacteriophage was allowed to infect *E.coli* growing in another culture medium

Blending - As infection proceeds- the viral coats were removed from the bacteria by agitating in a blender.

Centrifugation - Virus particles were seperated from the bacteria by spinning them in a centrifuge.

(b) Conclusion - DNA is the genetic material.

Interpretation - Sulphur labelled viral protein did not enter the bacteria during infection, whereas phosphorus labelled viral DNA entered into the bacteria to cause infection.

(C) MULTIPLE CHOICE QUESTIONS

1. In eukaryotic cell circular and double stranded DNA occurs in -

(1) Golgibody (2) Mitochondria (3) Nucleus (4) Ribosome

Ans. (2) Mitochondria

2. Double helix model of DNA which was proposed by watson and crick was of-

(1) C-DNA (2) B-DNA (3) D-DNA (4) Z-DNA

Ans. (2) B-DNA

3. If there are 10,000 nitrogenous base pairs in a DNA then how many nucleotides are there -

(1) 500 (2) 10,000 (3) 20,000 (4) 40,000

Ans. (3) 20,000

4. Double helix model of DNA is proposed by-

(1) Watson and Crick (2) Schleiden schwann

(3) Singer and Nicholson (4) Kornberg and Khurana

Ans. (1) Watson and Crick

5. Substance common in DNA and RNA -

(1) Hexose Sugar (2) Histamine (3) Thymine (4) Phosphate groups

Ans. (4) Phosphate groups

6. Nucleotide is -

(1) N_2 - base, pentose sugar and phosphoric acid

(2) Nitrogen, Hexose sugar and phosphoric acid

(3) Nitrogen base, pentose sugar

(4) Nitrogen base, trioses and phosphoric acid

Ans. (1) N_2 - base, pentose sugar and phosphoric acid

7. Unit of nucleic acids are-

(1) Phosphoric acid (2) Nitrogenous bases (3) Pentose Sugar (4) Nucleotides

Ans. (4) Nucleotides

8. Nucleic acid (DNA) is not found in-

(1) Nucleus & nucleolus (2) Peroxysome & ribosome

(3) Mitochondria & plastid (4) Chloroplast & nucleosome

Ans. (2) Peroxysome & Ribosome

9. A nucleic acid contains thymine or methylated uracil then it should be -

(1) DNA (2) RNA

(3) Either DNA or RNA (4) RNA of bacteria

Ans. (1) DNA

10. A nucleoside differs from a nucleotide is not having -

(1) Phosphate (2) Sugar (3) Phosphate & sugar (4) Nitrogen base

Ans. (1) Phosphate

11. The unequivocal proof that DNA is the genetic material came from the experiments of

(1) Hershey and Chase (1952) (2) Frederic Griffith (1928)

(3) Watson and Crick (1953) (4) Meselson and Stahl (1958)

Ans. (1) Hershey and Chase (1952)

12. Genetic information are transferred from nucleus to cytoplasm of cell through :-

(1) DNA (2) RNA (3) Lysosomes (4) ACTH

Ans. (2) RNA

13. Short DNA segment has 80 thymine and 90 guanine bases. The total number of nucleotides are-

(1) 160 (2) 40 (3) 80 (4) 340

Ans. (4) 340

14. Prokaryotic DNA is:-

(1) double stranded circular (2) single stranded circular

(3) double stranded linear (4) double stranded RNA as nucleic acid

Ans. (1) double stranded circular

15. DNA molecule has uniform diameter due to -

(1) Double stranded

(2) Presence of phosphate

(3) Specific base pairing between purine and pyrimidine

(4) Specific base pairing between purine and purine

Ans. (3) Specific base pairing between purine and pyrimidine

16. Which of the following sugar present in RNA ?

(1) Deoxyribose (2) Ribose (3) Sucrose (4) Maltose

Ans. (2) Ribose

17. In a nucleotide H_3PO_4 binds to which carbon atom of pentose sugar :-

(1) Only 1^{st} carbon (2) Only 3^{rd} carbon (3) Only 5^{th} carbon (4) Both 3^{rd} and 5^{th} carbon

Ans. (3) Only 5^{th} carbon

18. DNA is acidic due to :-

(1) Sugar (2) Phosphoric acid (3) Purine (4) Pyrimidine

Ans. (2) Phosphoric acid

19. If the sequence of bases in one strand of DNA is known then the sequence in other strand can be predicted on the basis of:-

(1) Antiparallel (2) Complementary (3) Polarity (4) Coiling

Ans. (2) Complementary

(D) ASSERTION & REASON QUESTIONS

Directions: In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as:

(1) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

(2) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

(3) If Assertion is true but Reason is false.

(4) If both Assertion and Reason are false.

1. **Assertion:** The sugar phosphate backbone of two chains in DNA double helix show anti-parallel polarity.
Reason: The phosphodiester bonds in one strand go from a 3' carbon of one nucleotide to a 5' carbon of adjacent nucleotide, whereas those in complementary strand go vice versa.
Ans. (1)

2. **Assertion:** DNA is considered to be better genetic material than RNA for most organisms.
Reason: 2'-OH group present in DNA makes it labile and less reactive.
Ans. (3)

3. **Assertion :** Histones are basic proteins of major importance in packaging of eukaryotic DNA.
Reason : Histones are of five major types H1,H2A H2B,H3 and H4 .
Ans. (2)

4. **Assertion:** Histones are basic in nature.
Reason: Histones are rich in the amino acids lysine and arginine.
Ans. (1)

5. **Assertion:** The unequivocal proof that DNA is the genetic material came from the experiments of Hershey and Chase.
Reason: They worked with viruses that infect bacteria called bacteriophages.
Ans. (2)

6. **Assertion:** DNA acts as a genetic material in all organisms.
Reason: It is a single-stranded biomolecule.
Ans. (4)

7. **Assertion:** In Griffith's experiment, a mixture of heat-killed virulent bacteria R and live non-virulent bacteria S, lead to the death of mice.
Reason: 'Transforming principle' got transferred from heat killed R strain to S strain and made virulent.
Ans. (4)

8. **Assertion:** The genetic material should be stable chemically and structurally.
Reason: It should be able to generate its replica.
Ans. (2)

9. **Assertion :** 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 : In retroviruses, reverse of central dogma occurs.
Ans. (2)

10. **Assertion:** DNA act as the genetic material in most of the organisms.
Reason: DNA is chemically and structurally a stable molecule; it has the power of replication.
Ans. (1)

(E) VERY SHORT ANSWER QUESTIONS

1. What is a cistron?

Ans. Cistron is a segment of gene which codes for a certain polypeptide or protein.

2. When and at what end does the 'tailing' of hnRNA take place?

Ans. 'Tailing' of hnRNA takes place during conversion of hnRNA into functional mRNA after transcription. It takes place at the 3′-end.

3. At which ends do 'capping' and 'tailing' of hnRNA occur, respectively?

Ans. Capping occurs at 5'-end and tailing occurs at 3'-end.

4. Mention two functions of the codon AUG.

Ans. Two functions of the codon AUG are:

(i) It acts as a start codon during protein synthesis.

(ii) It codes for the amino acid methionine.

5. How does a degenerate code differ from an unambiguous one?

Ans. Degenerate code means that one amino acid can be coded by more than one codon. Unambigous code means that one codon codes for one amino acid.

6. Mention the role of the codons AUG and UGA during protein synthesis.

Ans. The codon AUG initiates protein synthesis whereas the codon UGA stops protein synthesis.

7. Write the function of RNA polymerase II.

Ans. RNA polymerase II transcribes precursor of mRNA or hnRNA.

8. Give an example of a codon having dual function.

Ans. AUG acts as an initiator codon and also codes for methionine (met).

9. Mention how does DNA polymorphism arise in a population.

Ans. DNA polymorphism in a population arise due to presence of inheritable mutations at high frequency.

10. Suggest a technique to a researcher who needs to separate fragments of DNA.

Ans. Gel electrophoresis is used to separate DNA fragments.

(F) SHORT ANSWER QUESTIONS

1. Name the negatively charged and positively charged components of a nucleosome.

Ans. Negatively charged component is DNA, positively charged component is histone octamer.

2. Write the two specific codons that a translational unit of m-RNA is flanked by one on either sides.

Ans. Start codon – AUG

Stop codon – UAA/UGA/UAG.

3. Length of a DNA is 1.36mm. Calculate the number of base pairs in this DNA?

Ans. Length of DNA = Total bp × 3.4A°

1.36mm = Total bp × 3.4 A°

1.36×10^{-3} = Total bp × 3.4×10^{-10}

$$\frac{1.36\times10^{-3}}{3.4\times10^{-10}} = \text{Total bp}$$

Total bp = 4×10^{6}

4. Calculate the number of nucleosomes in a diploid cell of human?

Ans. No. of nucleosomes = total bp/200

$= 6.6 \times 10^{9}/200$

$= 3.3 \times 10^{7}$

5. Write the conclusion Griffith arrived at the end of his experiment with *Streptococcus pneumoniae*.

Ans. He concluded that the R-strain bacteria had somehow been transformed the by the heat - killed S-strain bacteria, this must be due to transfer of genetic material.

6. Identify A, B, C, D, E and F in the following table

Sr. No.	Component-I	Component-II	Chemical linkage bonding the two components	Product
i.	A	B	C	Nucleoside
ii.	Nucleoside	D	E	Nucleotide
iii.	Nucleotide	Nucleotide	F	Dinucleotide

Ans. (i) A - Nitrogenous base / A - Pentose sugar

B - Pentose Sugar / B- Nitrogenous base

C - N glycosidic linkage.

(ii) D - phosphate group.

E - phospho ester linkage

(iii) F - (3 -'5') phosphodiester linkage.

(G) LONG ANSWER QUESTIONS

1. Why is DNA molecule considered as a better hereditary material than RNA molecule?

Ans. DNA molecule is a better hereditary material as

(i) It is more stable (due to presence of thymine)

(ii) Less reactive than RNA (as RNA has 2' - OH making it more reactive)

(iii) Being less reactive, DNA is not easily degradable (RNA being more reactive is easily degradable)

(iv) Rate of mutation is slow (Rate of mutation in RNA is faster)

2. Name the three RNA polymerases found in eukaryotic cells and mention their functions.

Ans. RNA polymerase - I, transcribes rRNAs (28S -18S and 5.8S)

RNA polymerase - II, transcribes precursor of mRNA / hnRNA / heterogeneous nuclear RNA

RNA polymerase - III , transcribes tRNA / 5s rRNA / snRNA

3. Explain the post transcriptional modifications the hn-RNA undergoes in eukaryotic cell.

Ans. Capping, 7 methyl guanosine triphosphate / 7 mGPPP is added to the 5' end of hnRNA

- Tailing, Polyadenylate residues are added to 3'-end in a template independent manner
- Splicing, Introns are removed and exons are joined.
- Splicing occurs with the help of SnRNA so introns are removed.

4. (a) Why does DNA replication occur in small replication forks and not in its entire length?

(b) Why is DNA replication continuous and discontinuous in a replication fork?

(c) State the importance of origin of replication in a replication fork.

Ans. (a) DNA being very long, requires high energy for opening along its entire length.

(b) DNA-dependent DNA polymerases catalyse polymerisation only in one direction, i.e. 5' $\rightarrow$ 3', Two strands of DNA are anti parallel and have opposite polarity.

(c) Site where replication originates

5. Give the answer of following questions :

(a) Describe aminoacylation of tRNA.

(b) Explain the process that takes place in the ribosomes when mRNA makes its entry into it in prokaryote.

(c) Due to transcription error, ATG codon of DNA is transcribed into UAG in mRNA which translate non-functional polypeptide chain in the ribosome. Justify the statement.

Ans. (a) Amino acids are activated in the presence of ATP and linked to their cognate tRNA

(b) Small subunit of ribosome binds to mRNA at start codon (AUG) at 5' end, in the two sites of large subunits of ribosome, the charged tRNA with the aminoacid corresponding to the codon on mRNA align, formation of peptide bond between the two closely placed aminoacids in the two sites occur, with the help of ribozyme in the ribosome, peptide chain elongation continues till the stop codon (UAG, UGA, UAA) on the mRNA reach the big unit of ribosome.

(c) UAG being a stop codon termination occur before the completion of the functional de**.**

6. Explain the steps of DNA fingerprinting that will help in processing of blood samples picked up from the crime scene.

Ans. The technique of DNA Fingerprinting was initially developed by Alec Jeffreys. He used a satellite DNA as probe that shows very high degree of polymorphism. It was called as Variable Number of Tandem Repeats (VNTR). The technique, as used earlier, involved Southern blot hybridisation using radiolabelled VNTR as a probe. It included

(i) Isolation of DNA,

(ii) Digestion of DNA by restriction endonucleases,

(iii) Separation of DNA fragments by electrophoresis,

(iv) Transferring (blotting) of separated DNA fragments to synthetic membranes, such as nitrocellulose or nylon,

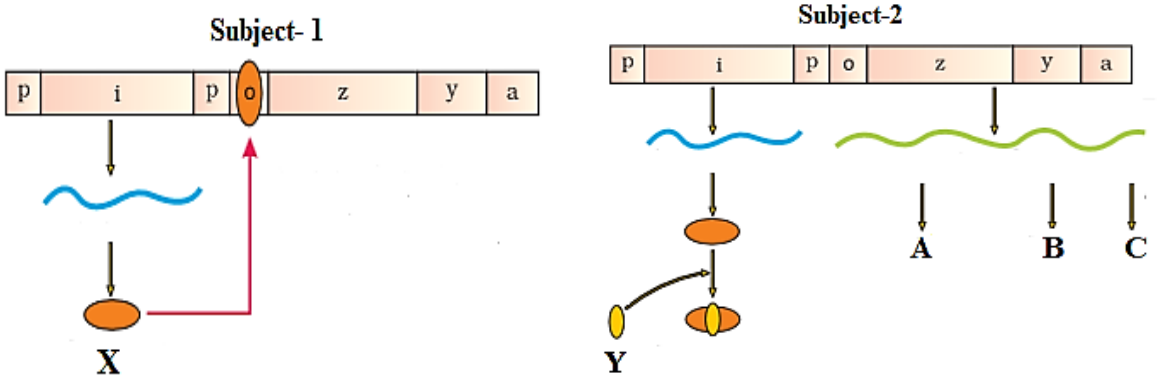
(v) Hybridisation using labelled VNTR probe, and

(vi) Detection of hybridised DNA fragments by autoradiography.

(H) CASE-STUDY BASED QUESTIONS

1. Study the following and answer the questions given below:-

Gene regulation is the mechanism of switching OFF and ON of the genes depending upon the requirement of cells and the state of development. Gene regulation is two type : negative and positive. The given gene diagram is Operon model of gene regulation study it and give the answer of asked questions.



(i) Identify the name the regulatory give in this operon?

Ans. Regularity gene in this process is i gene.

(ii) Why is Lac operon is regulation referred to as negative regulation?

Ans. The repressor binds to the operator, the operon is switched off and transcription is stopped. So it is a negative regulation.

(iii) Name the inducer Molecule and products of the genes 'A' and 'B' of the operon. write the function of these gene products.

Ans. Product of 'A' gene is β - galactosidase that helps in the hydrolysis of disacc o its monomeric units, galactose and glucose.

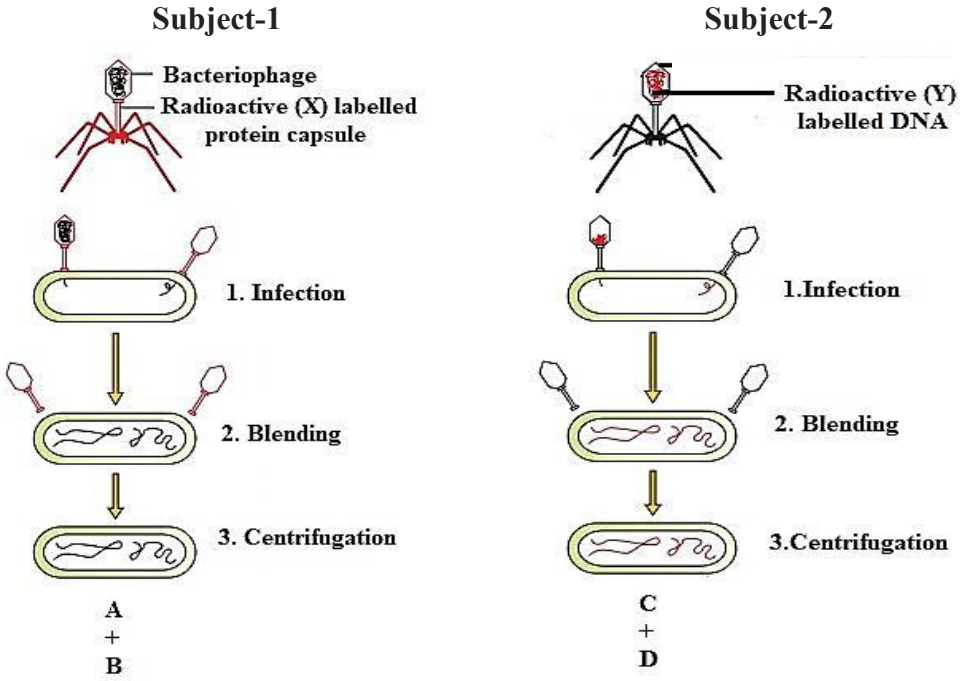
Product of B gene → Code for permease. That increase permeability of the cell to β - galactosides.

(iv) What are X and Y in subject - 1 and subject - 2 respectively?

Ans. X = Repressor, Y-Inducer

2. Study the following and answer the questions given below:-

The given case is an experiment related to the discovery of genetic material is DNA. The experiment is show in the subject-1 and subject-2. Studies it and give the answer of followed questions.



(i) Name the kind of virus they worked with and why?

Ans. They worked with bacteriophage eg = viruses that infect bacteria. These viruses were used because during infection they transfer their genetic material into bacteria.

(ii) What are 'X' and 'Y' in subject - 1 and subject - 2 respectively?

Ans. X - 35s, Y - 32p

(iii) The viral coat were removed from the bacteria by agitating them in a blender, process is called as -

Ans. Blending

(iv) State the conclusion drawn by them after the experiments.

Ans. The conclusion drawn by them after the experiment was that the DNA is the genetic material.

3. Read the following and answer the questions given below:-

Nucleic acids are long polymers of nucleotides. While DNA stores genetic information, RNA mostly helps in transfer and expression of information. Though DNA and RNA both function as genetic material, but DNA being chemically and structurally more stable is a better genetic material. However, RNA is the first to evolve and DNA was derived from RNA. The hallmark of the double stranded helical structure of DNA is the hydrogen bonding between the bases from opposite strands. The rule is that Adenine pairs with Thymine through two H-bonds, and Guanine with Cytosine through three H-bonds. This makes one strand complementary to the other. The DNA replicates semiconservatively, the process is guided by the complementary H-bonding. A segment of DNA that codes for RNA may in a simplistic term can be referred as gene.

(i) Write the name of components of a nucleotide.

Ans. Nitrogen base, pentose sugar, and phosphoric acid

(ii) Which is better genetic material out of RNA and DNA?

Ans. DNA being chemically and structurally more stable is a better genetic material as compare to RNA.

(iii) What is the nature of the 2 strands of a DNA double helix ?

Ans. The are anti - parallel and complementary to each other.

(iv) Write the appropriate name of nitrogenous base that correctly fill in the blanks.

Pyrimidines present in DNA are..... (A)..... and.....(B...) while pyrimidines present in RNA are.... (C)..... and ....(D).....

Ans. (A)- Cytosine, (B)- Thymine, (C)- Cytosine, (D)- Uracil

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

Ans: Cytosine 20% , therefore Guanine =20%

According to Chargaff's rule,

A+T =100-(G+C)

A+T =100-40. Since both adenine and thymine are in equal amounts

Thymine = Adenine = $\frac{60}{2}$= 30 %

4. Read the following and answer the questions given below:-

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. These repetitive DNA are separated from bulk genomic DNA as different peaks during density gradient centrifugation. The bulk DNA forms a major peak and the other small peaks are referred to as satellite DNA. Depending on base composition (A : T rich or G:C rich), length of segment, and number of repetitive units, the satellite DNA is classified into many categories, such as micro-satellites, mini-satellites etc. These sequences normally do not code for any proteins, but they form a large portion of human genome. These sequence show high degree of polymorphism and form the basis of DNA fingerprinting. Since DNA from every tissue (such as blood, hair-follicle, skin, bone, saliva, sperm etc.), from an individual show the same degree of polymorphism, they become very useful identification tool in forensic applications.

(i) What is satellite DNA?

Ans. It is the repetitive DNA sequences which form a large portion of genome and have high degree of polymorphism but do not code for any proteins.

(ii) What is the basis of genetic mapping of human genome as well as of DNA fingerprinting.

Ans. The polymorphism in DNA sequence.

(iii) Expand VNTR.

Ans. Variable Number of Tandem Repeats (VNTR).

(iv) Which of the DNA was used by Alec Jeffreys as probe that shows very high degree of polymorphism?

Ans. Satellite DNA

(v) What is the basis of classified satellite DNA into many categories, such as micro-satellites, mini-satellites etc ?

Ans. Its depend on base composition (A : T rich or G:C rich), length of segment, and number of repetitive units.