Molecular Basis of Inheritance MCQ

Multiple-Choice Questions

1. **In a DNA strand, the nucleotides are linked together by:**

   a. glycosidic bonds

   b. phosphodiester bonds

   c. peptide bonds

   d. hydrogen bonds

   Ans b. phosphodiester bonds

2. **A nucleoside differs from a nucleotide. It lacks the:**

   a. base

   b. sugar

   c. phosphate group

   d. hydroxyl group

   Ans c. phosphate group

3. **Both deoxyribose and ribose belong to a class of sugars called:**

   a. trioses

   b. hexoses

   c. pentoses

   d. polysaccharides

   Ans c. pentoses

4. **The fact that a purine base always pairs through hydrogen bonds with a pyrimidine base in the DNA double helix leads to:**

   a. the antiparallel nature

   b. the semiconservative nature

   c. uniform width throughout DNA

   d. uniform length in all DNA

   Ans c. uniform width throughout DNA

5. The net electric charge on DNA and histones is:

a. both positive

b. both negative

c. negative and positive, respectively

d. zero

Ans c. negative and positive, respectively

6. The promoter site and the terminator site for transcription are located at:

a. 3′ (downstream) end and 5′ (upstream) end, respectively of the transcription unit

b. 5′ (upstream) end and 3′ (downstream) end, respectively of the transcription unit

c. the 5′ (upstream) end

d. the 3′ (downstream) end

Ans b. 5′ (upstream) end and 3′ (downstream) end, respectively of the transcription unit

7. Which of the following statements is the most appropriate for sickle cell anaemia?

a. It cannot be treated with iron supplements

b. It is a molecular disease

c. It confers resistance to acquiring malaria

d. All of the above

Ans d. All of the above

8. Which of the following is true with respect to AUG?

a. It codes for methionine only

b. It is an initiation codon

c. It codes for methionine in both prokaryotes and eukaryotes

d. All of the above

Ans d. All of the above

9. The first genetic material could be:

a. protein

b. carbohydrates

c. DNA

d. RNA

Ans d. RNA

10. With regard to mature mRNA in eukaryotes:

a. exons and introns do not appear in the mature RNA

b. exons appear but introns do not appear in the mature RNA

c. introns appear but exons do not appear in the mature RNA

d. both exons and introns appear in the mature RNA

Ans b. exons appear but introns do not appear in the mature RNA

11. The human chromosome with the highest and least number of genes in them are respectively:

a. Chromosome 21 and Y

b. Chromosome 1 and X

c. Chromosome 1 and Y

d. Chromosome X and Y

Ans c. Chromosome 1 and Y

12. Who amongst the following scientists had no contribution to the development of the double-helix model for the structure of DNA?

a. Rosalind Franklin

b. Maurice Wilkins

c. Erwin Chargaff

d. Meselson and Stahl

Ans d. Meselson and Stahl

13. DNA is a polymer of nucleotides which are linked to each other by 3'-5' phosphodiester bond. To prevent polymerisation of nucleotides, which of the following modifications would you choose?

a. Replace purine with pyrimidines

b. Remove/Replace 3′ OH group in deoxyribose

c. Remove/Replace 2′ OH group with some other group in deoxyribose

d. Both ‘b’ and ‘c’

Ans b. Remove/Replace 3′ OH group in deoxyribose

14. Discontinuous synthesis of DNA occurs in one strand, because:

a. DNA molecule being synthesised is very long

b. DNA dependent DNA polymerase catalyses polymerisation only in one direction (5’ → 3’)

c. it is a more efficient process

d. DNA ligase joins the short stretches of DNA

Ans b. DNA dependent DNA polymerase catalyses polymerisation only in one direction (5’ → 3’)

15. Which of the following steps in transcription is catalysed by RNA polymerase?

a. Initiation

b. Elongation

c. Termination

d. All of the above

Ans b. Elongation

16. Control of gene expression in prokaryotes takes place at the level of:

a. DNA-replication

b. Transcription

c. Translation

d. None of the above

Ans b. Transcription

17. Which of the following statements is correct about the role of regulatory proteins in transcription in prokaryotes?

a. They only increase expression

b. They only decrease expression

c. They interact with RNA polymerase but do not affect the expression

d. They can act both as activators and as repressors

Ans d. They can act both as activators and as repressors

18. Which was the last human chromosome to be completely sequenced:

a. Chromosome 1

b. Chromosome 11

c. Chromosome 21

d. Chromosome X

Ans a. Chromosome 1

19. Which of the following are the functions of RNA?

a. It is a carrier of genetic information from DNA to ribosomes synthesising polypeptides.

b. It carries amino acids to ribosomes.

c. It is a constituent component of ribosomes.

d. All of the above.

Ans d. All of the above.

20. While analysing the DNA of an organism a total number of 5386 nucleotides were found out of which the proportion of different bases were: Adenine = 29%, Guanine = 17%, Cytosine = 32%, Thymine = 17%.

Considering the Chargaff's rule, it can be concluded that:

a. it is a double-stranded circular DNA

b. It is single-stranded DNA

c. It is a double-stranded linear DNA

d. No conclusion can be drawn

Ans b. It is single-stranded DNA

21. In some viruses, DNA is synthesised by using RNA as a template. Such a DNA is called:

a. A-DNA

b. B-DNA

c. cDNA

d. rDNA

c. cDNA

22. If Meselson and Stahl's experiment is continued for four generations in bacteria, the ratio of N15/N15: N15/N14: N14/N14 containing DNA in the fourth generation would be:

a. 1:1:0

b. 1:4:0

c. 0:1:3

d. 0:1:7

Ans d. 0:1:7

23. If the sequence of nitrogen bases of the coding strand of DNA in a transcription unit is: 5′ – A T G A A T G – 3′, the sequence of bases in its RNA transcript would be;

a. 5′ – A U G A A U G – 3′

b. 5′ – U A C U U A C – 3′

c. 5′ – C A U U C A U – 3′

d. 5′ – G U A A G U A – 3′

Ans a. 5′ – A U G A A U G – 3′

24. The RNA polymerase holoenzyme transcribes:

a. the promoter, structural gene and the terminator region

b. the promoter and the terminator region

c. the structural gene and the terminator region

d. the structural gene only

Ans d. the structural gene only

25. If the base sequence of a codon in mRNA is 5′-AUG-3′, the sequence of tRNA pairing with it must be:

a. 5′ – UAC – 3′

b. 5′ – CAU – 3′

c. 5′ – AUG – 3′

d. 5′ – GUA – 3′

Ans b. 5′ – CAU – 3′

26. The amino acid attaches to the tRNA at its:

a. 5′ – end

b. 3′ – end

c. Anticodon site

d. DHU loop

Ans b. 3′ – end

27. To initiate translation, the mRNA first binds to:

a. The smaller ribosomal sub-unit

b. The larger ribosomal sub-unit

c. The whole ribosome

d. No such specificity exists.

Ans a. The smaller ribosomal sub-unit

28. In E. coli, the lac operon gets switched on when:

a. lactose is present and it binds to the repressor

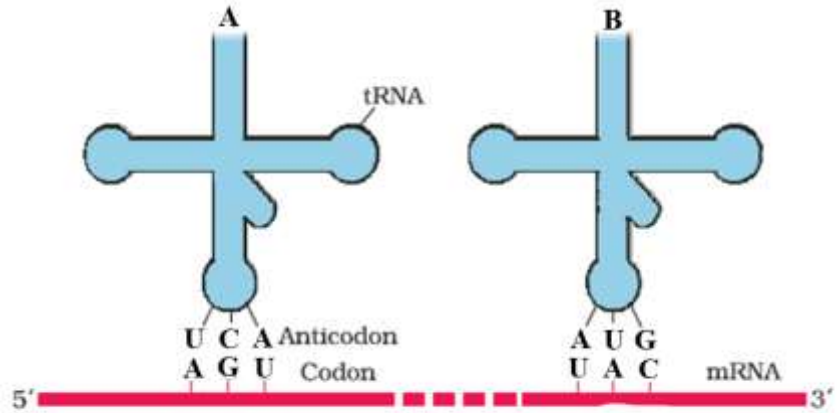
b. repressor binds to operator

c. RNA polymerase binds to the operator

d. lactose is present and it binds to RNA polymerase

Ans a. lactose is present and it binds to the repressor

29. The tRNAs shown below transfer the following aminoacids during translation.



tRNA - Adapter Molecule

a. Alanine and Threonine

b. Alanine and Valine

c. Serine and Tyrosine

d. Serine and Threonine

Ans. c. Serine and Tyrosine

30. Name the enzymes produced from mRNA coded by the structural genes 'z, y a' in the following sites labelled as A, B, C.

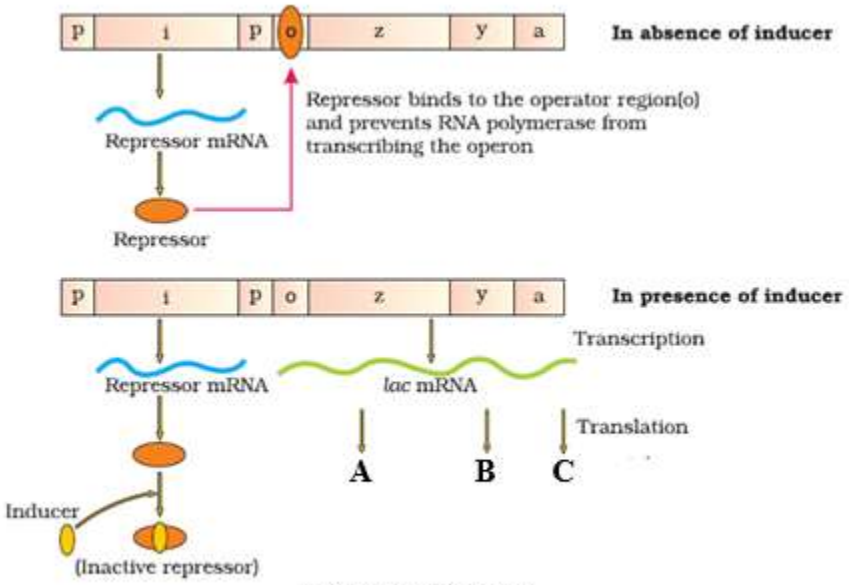
a. Beta galactosidase, Permease, Transacetylase

b. Beta galactosidase, Transacetylase, Permease

c. Lactase, Permease, Transacetylase

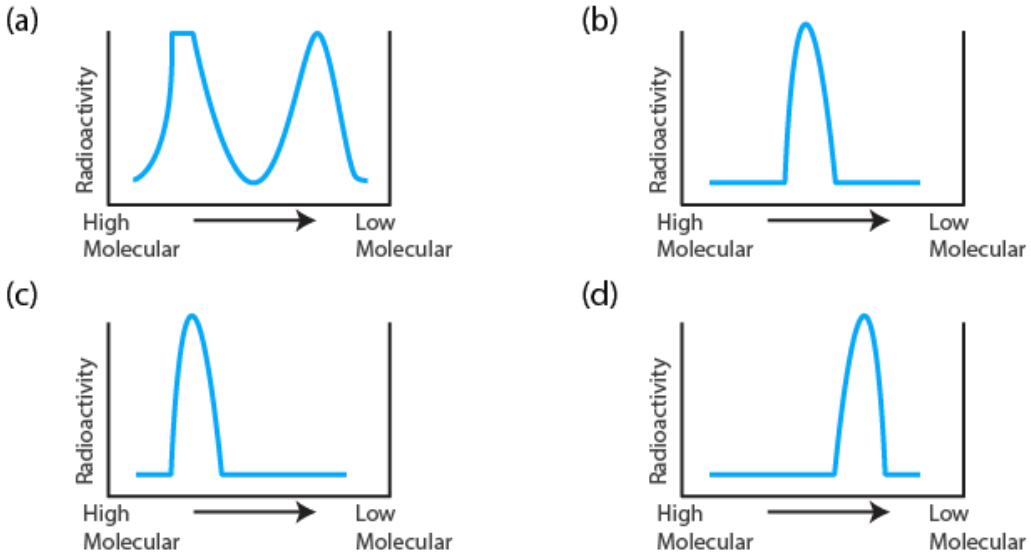
d. Lactase, Transacetylase, Permease

Ans: a. Beta galactosidase, Permease, Transacetylase



The Lac Operon

31. Replication was allowed to take place in the presence of radioactive deoxynucleotides precursors in E. coli that was a mutant for DNA ligase. Newly synthesized radioactive DNA was purified and strands were separated by denaturation. These were centrifuged using density gradient centrifugation. Which of the following would be a correct result?



Ans: (d) is the correct result

Very Short Answer Type Questions

1. What is the function of histones in DNA packaging?

DNA wraps itself around a protein called histone. Histones pack into structural units called nucleosomes.

2. Distinguish between heterochromatin and euchromatin. Which of the two is transcriptionally active?

Heterochromatin is a highly packed form of DNA in the chromosomes and stains dark.

Euchromatin is a loosely packed form of DNA in the chromosomes and stains lightly.

Euchromatin has transcriptionally active regions of DNA. Heterochromatin has transcriptionally inactive regions of DNA.

3. The enzyme DNA polymerase in E. coli is a DNA dependent polymerase and also has the ability to proof-read the DNA strand being synthesized. Explain. Discuss the dual polymerase.

There are three types of DNA polymerase present in the bacteria which add nucleotides in 5'-3' direction.

DNA III polymerases can proofread the newly formed strand and can sense the wrong base insertions.

4. What is the cause of discontinuous synthesis of DNA on one of the parental strands of DNA? What happens to these short stretches of synthesized DNA?

DNA III polymerases can proof read the newly formed strand and can sense the wrong base insertions.

An additional complication will be created at the replicating fork.

The left-out strand of the DNA which was 5'-3' has to be synthesized in the opposite direction as short stretches in a discontinuous manner.

5. Given below is the sequence of the coding strand of DNA in a transcription unit 3 'A A T G C A G C T A T T A G G – 5' write the sequence of a) its complementary strand b) the mRNA.

a) Complementary strand: 5'-T T A C G T C G A T A A T C C-3'

b) the mRNA: 5' A A U G C A G C U A U U G G-3'

6. What is DNA polymorphism? Why is it important to study?

The difference in the nucleotide sequence between the individuals is called as DNA polymorphism.

It is important for genetic variation and very useful for criminal cases to find the culprit.

7. Based on your understanding of genetic code, explain the formation of any abnormal haemoglobin molecule. What are the known consequences of such a change?

The defect is caused by the substitution trans version of Glutamic acid Glu by Valine Val at the sixth position of the beta-globin chain of the haemoglobin molecule.

The substitution of amino acid in the in protein results due to the single base substitution at the sixth codon of the beta globin gene from GAG to GUG.

The mutant haemoglobin molecule undergoes polymerisation under low oxygen tension causing the change in the shape of the RBC from biconcave disc to elongated sickle -shaped red blood cells.

This obstructs the capillaries and restricts blood flow to the organs resulting in ischaemia pain necrosis and often organ damage.

8. Sometimes cattle or even human beings give birth to their young ones that are having extremely different sets of organs like limbs/position of the eye(s) etc. Comment.

It happens due to uncoordinated regulation of gene expression in the gene sets associated with organ development.

9. In a nucleus, the number of ribonucleoside triphosphates is 10 times the number of deoxy ribonucleoside triphosphates, but only deoxyribonucleotides are added during the DNA replication. Suggest a mechanism.

The number of ribonucleoside triphosphates is 10 times the number of deoxyribonucleoside triphosphates, but only deoxyribonucleotides are added during the DNA replication.

The DNA polymerase is highly specific to recognize only deoxyribonucleoside triphosphates.

10. Name a few enzymes involved in DNA replication other than DNA polymerase and ligase. Name the key functions for each of them.

The enzymes involved in DNA replication other than DNA polymerase and ligase are listed below with their functions.

Helicase: Unwinds the DNA helix.

Primase: It adds RNA primers to template strands

Topoisomerases: Removes the super coiling of DNA

11. Name any three viruses which have RNA as the genetic material.

1. Tobacco Mosaic Virus
2. Human- Immuno Deficiency Virus
3. Influenza Virus

Short Answer Type Questions

1. Define transformation in Griffith's experiment. Discuss how it helps in the identification of DNA as the genetic material.

When *Streptococcus pneumoniae* (pneumococcus) bacteria are grown on a culture plate, some produce smooth shiny colonies (S) while others produce rough colonies (R).

This is because the S strain bacteria have a mucous (polysaccharide) coat, while R strain does not.

Mice infected with the S strain (virulent) die from pneumonia infection but mice infected with the R strain do not develop pneumonia.

Griffith was able to kill bacteria by heating them.

He observed that heat-killed S strain bacteria injected into mice did not kill them.

When he injected a mixture of heat-killed S and live R bacteria, the mice died.

Moreover, he recovered living S bacteria from the dead mice.

He concluded that the heat-killed S strain bacteria transformed R strain bacteria into virulent.

2. Who revealed the biochemical nature of the transforming principle? How was it done?

Oswald Avery and Co-workers purified biochemicals (proteins, DNA, RNA, etc.) from the heat-killed S cells to see which ones could transform live R cells into S cells.

They discovered that DNA alone from S bacteria caused R bacteria to become transformed.

They also discovered that protein-digesting enzymes (proteases) and

RNA-digesting enzymes (RNases) did not affect transformation, so the transforming substance was not a protein or RNA.

Digestion with Dnase did inhibit transformation, suggesting that the DNA caused the transformation.

They concluded that DNA is the genetic material.

3. Discuss the significance of heavy isotope of nitrogen in the Meselson and Stahl's experiment.

The significance of the heavy isotope of nitrogen in this experiment was crucial.

It allowed the researchers to distinguish between the original DNA strands (heavy) and the newly synthesized strands (light) after replication.

This provided strong evidence for the semi-conservative model of DNA replication, where each new DNA molecule consists of one old strand and one new strand.

4. Define a cistron. Giving examples differentiate between monocistronic and polycistronic transcription unit.

A segment of DNA coding for a polypeptide is called cistron.

A cistron is basically a gene. If a stretch of replicating DNA contains a single cistron (or gene), it is called monocistronic. e.g. eukaryotes.

If a stretch of replicating DNA contains more than one cistron, it is called polycistronic, e.g. bacteria and prokaryotes.

5. Give any six features of the human genome.

1. The genome has around 3164.7 million nucleotide bases.
2. 99.9 % of the nucleotide bases are same in all humans.
3. The largest gene is Dystrophin having 2.4 million bases.
4. Chromosome 1 has most genes (2968) and Y has the least genes (231).
5. Less than 2% of the genome has the coding sequence for proteins.
6. Only 50% of the total discovered genes have known functions.

6. During DNA replication, why is it that the entire molecule does not open in one go? Explain the replication fork. What are the two functions that the monomers (d NTPs) play?

Since the two strands of the long DNA molecule 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**.

Unwinding also creates tension in the molecule as uncoiled parts start forming super coils due to the interaction of exposed nucleotides.

7. Retroviruses do not follow central Dogma. Comment.

Genetic material of retrovirus is RNA.

During protein synthesis, RNA is reverse transcribed to its complementary DNA first by reverse transcriptase enzyme, then transcribed to RNA and proteins.

Hence, retrovirus do not follow central dogma.

8. In an experiment, DNA is treated with a compound which tends to place itself amongst the stacks of nitrogenous base pairs. As a result of this, the distance between two consecutive base increases from 0.34nm to 0.44 nm calculate the length of DNA double helix (which has 2×109 bp) in the presence of saturating amount of this compound.

Distance between two consecutive base pairs: 0.44 nm or 0.44×10^{-9}.

Length of the DNA: $2 \times 10^{9} \times 0.44 \times 10^{-9}$

Length of DNA = 0.88m

9. **What would happen if histones were to be mutated and made rich in acidic amino acids such as aspartic acid and glutamic acid in place of basic amino acids such as lysine and arginine?**

   This mutation would make the histones acidic and negatively charged and histones would not be able to bind to DNA because both would be negatively charged.

   Hence, the DNA would not be packed and chromatin would not be formed.

10. **Recall the experiments done by Frederick Griffith, Avery, MacLeod and McCarty, where DNA was speculated to be the genetic material. If RNA, instead of DNA was the genetic material, would the heat-killed strain of Pneumococcus have transformed the R-strain into virulent strain? Explain.**

    If RNA were the genetic material, the heat-killed strain of Pneumococcus would not have transformed the R-strain into a virulent strain in Frederick Griffith's experiment.

    This is because 2′-OH group present at every nucleotide in RNA is a reactive group and makes RNA labile and easily degradable.

    Heat denatures RNA more readily, breaking it down into smaller, non-functional fragments.

11. **You are repeating the Hershey-Chase experiment and are provided with two isotopes: 32P and 15N (in place of 35S in the original experiment). How do you expect your results to be different?**

    DNA contains phosphorus while protein contains sulphur supported the selection of phosphorus and sulphur.

    In Hershey-Chase experiment, phosphorus 32P was used to labell the DNA and Sulphur 35S was used to labell the protein.

    By tracing the movement of sulphur and phosphorus; it was easier to trace the movement of DNA and protein through subsequent generations.

    But nitrogen is present in both DNA and in protein. Hence, the use of 15N will not help in finding whether the DNA or protein is the genetic material.

12. **There is only one possible sequence of amino acids when deduced from given nucleotides. But multiple nucleotides sequence can be deduced from a single amino acid sequence. Explain this phenomenon.**

    Some amino acids are coded by more than one codon. This phenomenon is called as the degeneracy of codon.

Hence, from such amino acids, multiple nucleotide sequence would be obtained.

13. A single base mutation in a gene may not 'always' result in loss or gain of function. Do you think the statement is correct? Defend your answer.

Yes. The statement is correct. if mutation takes place at the third base pair, it does not lead to a phenotypic change, because they do not change the amino acid sequence of the protein and thus have no effect on its function.

These mutations are known as silent mutations. Some mutations occur in non-coding regions of the gene and do not affect the gene's expression or the protein's function.

14. A low level of expression of lac operon occurs at all the time. Can you explain the logic behind this phenomenon?

Lactose present in the external medium can enter the bacterium only when the bacterium has the enzyme permease within it.

Lactose acts as an inducer, binding with repressor protein and letting the RNA polymerase to bind with the operator to initiate gene expression.

In the complete absence of gene expression of lac operon, permease will not be synthesized.

Hence, Low level of expression of the lac operon is required for permease to form within the bacteria.

15. How has the sequencing of the human genome opened new windows for the treatment of various genetic disorders? Discuss amongst your classmates.

The sequencing of the human genome opened new windows for the treatment of various genetic disorders because it led to a better knowledge of genetic disorders. A better understanding on diagnosis, treatment and prevention of genetic disorders is possible.

16. The total number of genes in humans is far less (< 25,000) than the previous estimate (up to 1,40,000 gene). Comment.

When scientists began estimating the number of human genes, they began with a very high figure, i.e. 80,000 to 1,40,000 genes.

At that time, the technology for studying human genes was not advanced enough, and the estimate was qualitative in nature as it was mainly based on assumptions.

With the gradual advancement of technology and knowledge about human genes, the estimated number began to come down.

The present knowledge tells us that the total number of genes in humans is between 20,000 to 25,000.

This is also because of the presence of large portions of repetitive sequencing regions in the human genome.

Repetitive sequences are stretches of DNA sequences that are repeated many times, sometimes hundred to thousand times.

17. Now, the sequencing of total genomes is getting less expensive day by the day. Soon it may be affordable for a common man to get his genome sequenced. What is your opinion could be the advantage and disadvantage of this development?

Advantages:

- It would lead to better diagnosis, treatment and prevention of genetic disorders.
- A better understanding of the DNA gene sequence would lead to a better understanding of biological systems.

Disadvantages:

- It creates the problem of patenting of genes. (ii) Persons becomes more careless.
- People may misuse the knowledge obtained from HGP

18. Would it be appropriate to use DNA probes such as VNTR in DNA fingerprinting of a bacteriophage?

Bacteriophage does not have repetitive sequence such as VNTR in its genome as it has a small genome all with coding sequences.

Therefore, DNA fingerprinting cannot not be done for bacteriophages.

19. During in vitro synthesis of DNA, a researcher used 2', 3' – dideoxy cytidine triphosphate as raw nucleotide in place of 2'-deoxycytidine. What would be the consequence?

2', 3' - dideoxy cytidine triphosphate is a reverse transcriptase inhibitor.

Reverse transcriptase is a viral DNA polymerase which facilitates DNA replication in HIV and other retroviruses.

The commercial name of ddC is Zalcitabine, and it is sold as a pharmaceutical product for the management of HIV.

If 2', 3'- dideoxy cytidine triphosphate is used as a raw nucleotide in place of 2' - deoxycytidine, it will stop DNA replication as the 3'OH group on the sugar is not present to add a nucleotide for forming ester bonds.

20. What background information did Watson and Crick have made available for developing a model of DNA? What was their contribution?

1. Chargaffs law showed Adenosine forms bond with Thymine (A&T) and Guanine bonds with Cytosine (G & C).
2. Wilkin's and Franklin's state DNA has a diameter of 20 Å, a regular helix structure with 34Å distance and 10 base pairs of nucleotides in each turn of the spiral.

   They discovered DNA was a double helix structure. They also discovered the complementary base pairing by hydrogen bonds.

21. What are the functions of (i) methylated guanosine cap, (ii) poly-A "tail" in a mature on RNA?

Methylated guanosine cap helps the mRNA to bind with the smaller sub unit of the ribosome during translation.

Poly-A tail protects the mRNA from degradation by exonucleases.

22. Do you think that the alternative splicing of exons may enable a structural gene to code for several isoproteins from the same gene? If yes, how? If not, why so?

The alternate splicing of exons could be either gender-specific, developmental stage-specific etc. This can lead to encoding of various proteins from a single gene. In the absence of such splicing, there is a requirement of a new gene for every protein or protein.

23. Comment on the utility of variability in the number of tandem repeats during DNA fingerprinting.

Tandems are a region in a chromosome which the sequence of DNA stretch is repeated for several times.

The number of repeats can vary greatly between individuals, making these regions highly **polymorphic** (variable).

It forms a pattern of bands which is unique for each individual and is used in DNA fingerprinting in the forensic department.

Long Answer Type Questions

1. Give an account of the Hershey and Chase experiment. What did it conclusively prove? If both DNA and proteins contained phosphorus and sulphur do you think the result would have been the same?

Alfred Hershey and Martha Chase grew some viruses on a medium that contained radioactive phosphorus and some others on medium that contained radioactive sulfur.

Viruses grown in the presence of radioactive phosphorus contained radioactive DNA but not radioactive protein because DNA contains phosphorus but protein does not.

Similarly, viruses grown on radioactive sulfur contained radioactive protein but not radioactive DNA because DNA does not contain sulfur.

Radioactive phages were allowed to attach to *E. coli* bacteria.

Then, as the infection proceeded, the viral coats were removed from the bacteria by agitating them in a blender.

The virus particles were separated from the bacteria by spinning them in a centrifuge.

Bacteria which was infected with viruses that had radioactive DNA were radioactive, indicating that DNA was the material that passed from the virus to the bacteria.

Bacteria that were infected with viruses that had radioactive proteins were not radioactive.

This indicates that proteins did not enter the bacteria from the viruses. DNA is therefore the genetic material that is passed from virus to bacteria

2. During evolution why DNA was chosen over RNA as genetic material? Give reasons by first discussing the desired criteria in a molecule that can act as genetic material and in the light of biochemical differences between DNA and RNA.

The desired criteria in a molecule that can act as genetic material are

1. It should be chemically and structurally stable.
2. It should be able to replicate so that replication should take place.
3. Mutation or gradual and slow changes should take place.
4. It should be able to express itself in Mendelian characters.

5. For further evolution, it should transfer from parent to progeny.

The biochemical difference between DNA and RNA are

i. DNA is less reactive and more stable chemically and structurally whereas RNA is more reactive and less stable chemically and structurally.

ii. Thymine in the place of Uracil also makes stability in DNA whereas the Uracil in the place of Thymine decrease the stability of RNA

iii. Slow mutation takes place in DNA whereas, in RNA, rapid mutations take place

iv. DNA is double-stranded and RNA is single-stranded

These biochemical differences between the DNA and RNA make DNA a desired genetic material.

3. Give an account of post-transcriptional modifications of a eukaryotic mRNA.

In Eukaryotes, the primary transcripts contain both the coding exons and the non-coding introns and are non-functional.

Hence, it is subjected to a process called **splicing** where the introns are removed and exons are joined in a defined order.

hnRNA undergo two additional processing called as capping and tailing.

In **capping** an unusual nucleotide (methyl guanosine triphosphate) is added to the 5′-end of hnRNA.

In **tailing**, adenylate residues (200-300) are added at 3′-end in a template independent manner.

It is the fully processed hnRNA, now called mRNA, that is transported out of the nucleus for translation.

4. Discuss the process of translation in detail.

Translation:

The synthesis of protein (polypeptide) from mRNA is called translation.

The order and sequence of amino acids are defined by the sequence of triplet codes in the mRNA. The amino acids are joined together by peptide bonds.

Activation of tRNA (Charging of tRNA or Aminoacylation of tRNA)

The process of formation of peptide bonds requires energy.

So, the amino acids are activated in the presence of ATP and get linked to their respective tRNAs.

This process is commonly called as activation of tRNA, charging of tRNA.

If two such charged tRNAs are brought together, formation of peptide bond occurs between them.

Ribosome as cellular factory of protein synthesis:

Ribosome acts as cellular factory for protein synthesis. The ribosome consists of structural RNAs and about 80 different proteins.

Sub Units of Ribosome:

Ribosome consists of two subunits; a smaller subunit and a larger subunit in its inactive state.

When the smaller subunit joins with the mRNA, translation begins.

There are two sites in the larger subunit of ribosome;

P-Site or Peptidyl Site

A-site, Accepter Site or Aminoacyl Site.

Initiation:

The smaller subunit with methionyl tRNA (Met-tRNA) attaches to the larger subunit in such a way that the start codon (AUG) comes in the P-site.

Elongation:

The ribosome moves from codon to codon along the mRNA in 5′ to 3′ direction. tRNAs transfer amino acids to the A- site of ribosome as per the triplet codes in the mRNA.

Termination:

When the ribosome reaches the stop codon, termination of polypeptide occurs as the **stop codon doesn't code for any amino acid.**

The release factor enters the A-Site and releases the polypeptide from the ribosome.

The smaller and larger sub units of ribosome and mRNA dissociate.

5. Define an operon. Giving an example, explain an Inducible operon.

Francois Jacob and Jacque Monod discovered the Lac Operon.

A cluster of genes involved in lactose metabolism in E. coli is called Lac operon.

Genes of Lac Operon:

A cluster of genes involved in lactose metabolism in E. coli is called Lac operon.

Regulator Gene (*i*):

The *lac* operon consists of one regulatory gene (the *i* gene). Here the term *i* refers to inhibitor.

Structural Genes:

The *lac* operon consists of three structural genes (*z*, *y*, and *a*).

Repressor Gene:

The *i* gene codes for the repressor of the *lac* operon.

The repressor protein binds to the operator region of the operon and prevents RNA polymerase from transcribing the operon.

Substrate:

Lactose is the substrate for the enzyme beta-galactosidase and it regulates switching on and off of the operon.

Hence, lactose is termed as **inducer**.

In the absence of a preferred carbon source such as glucose, if lactose is provided in the growth medium of the bacteria, the lactose is transported into the cells through the action of permease.

The functioning of genes:

The repressor protein binds to the operator region of the operon and prevents RNA polymerase from transcribing the operon.

In the presence of an inducer, such as lactose or allolactose, the repressor is inactivated by interaction with the inducer.

This allows RNA polymerase access to the promoter and transcription proceeds.

Transcription and Translation:

The '*z'* gene codes for beta-galactosidase (β-gal), which catalyzes the hydrolysis of lactose into galactose and glucose.

The '*y'* gene codes for permease, which increases permeability of the cell for the transport of lactose into the bacterial cell.

The '*a'* gene encodes a transacetylase. It protects the cells from building of toxic products created by Beta-galactosidase.

Duration of Gene Expression:

The Lactose operon expresses as long as the Lactose is present.

When all lactose is converted into glucose and galactose, the reaction stops.

6. 'There is a paternity dispute for a child'. Which technique can solve the problem? Discuss the principle involved.

DNA fingerprinting can solve the paternity dispute.

In DNA fingerprinting a pattern of bands is formed due to small stretch of the DNA sequence which is repeated numerous times called as Variable Number of Tandem Repeats (VNTR'S), also known as Mini Satellites.

DNA fingerprints can be prepared from extremely minute amounts of blood, semen, hair bulb or certain other cells of the body.

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, involved is Southern blot hybridisation using radioactively labelled VNTR as a probe. It includes:

(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.

7. Give an account of the methods used in sequencing the human genome.

The methods involved two major approaches. One approach focused on identifying all the genes that expressed as RNA (referred to as **Expressed Sequence Tags** (ESTs).

The other took the blind approach of simply sequencing the whole set of genome that contained all the coding and non-coding sequence, and later assigning different regions in the sequence with functions (a term referred to as **Sequence Annotation**).

For sequencing, the total DNA from a cell is isolated and converted into random fragments of relatively smaller sizes (recall DNA is a very long polymer, and there are technical limitations in sequencing very long pieces of DNA) and cloned in suitable host using specialized vectors.

The cloning resulted into amplification of each piece of DNA fragment so that it subsequently could be sequenced with ease.

The commonly used hosts were bacteria and yeast, and the vectors were called as **BAC** (bacterial artificial chromosomes), and **YAC** (yeast artificial chromosomes).

The fragments were sequenced using automated DNA sequencers that worked on the principle of a method developed by Frederick Sanger.

(Remember, Sanger is also credited for developing method for determination of amino acid sequences in proteins).

These sequences were then arranged based on some overlapping regions present in them.

This required generation of overlapping fragments for sequencing.

Alignment of these sequences was humanly not possible.

Therefore, specialized computer-based programs were developed

8. List the various markers that are used in DNA fingerprinting.

A DNA marker is a sequence of a gene which can be used to identify an individual or a species. A genetic marker or DNA marker can be a short sequence or a long sequence. Following are the commonly used markers for DNA fingerprinting.

STR (Short Tandem Repeat)

VNTR (Variable Number Tandem Repeat)

SNP (Single Nucleotide Polymorphism)

SSR (Simple Sequence Repeat)

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