CBSE Class 12 Biology
NCERT Exemplar Solutions
CHAPTER 6
MOLECULAR BASIS OF INHERITANCE

Multiple Choice Questions (MCQs)

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

Explanation: (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

Explanation: (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

Explanation: Ribose is the pentose sugar in RNA, while deoxyribose is the pentose sugar in DNA.

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

(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

Explanation: (c) uniform width throughout DNA

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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

Explanation: The negatively charged DNA is wrapped around positively charged histone; making a structure called nucleosome. This explains the efficient packing of DNA in such a

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small space inside the nucleus.

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

Explanation: (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

Explanation: Sickle cell anaemia is a genetic disorder and hence cannot be treated with iron supplements. Altered shape of RBCs confer resistance to malaria in people suffering from sickle cell anaemia.

8. One of the following is true with respect to AUG

(a) It codes for methionine only

(b) It is also an initiation codon

(c) It codes for methionine in both prokaryotes and eukaryotes

(d) All of the above

Ans. (d) All of the above

Explanation: (d) All of the above

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9. The first genetic material could be:

(a) protein

(b) carbohydrates

(c) DNA

(d) RNA

Ans. (d) RNA

Explanation: There are many conclusive proofs which show that RNA was the first genetic material. But RNA being a catalyst was reactive and unstable. So, this paved the way for DNA as genetic material in the living world.

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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

Explanation: (b) exons appear but introns do not appear in the mature RNA

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

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respectively:

(a) Chromosome 21and Y

(b) Chromosome 1 and X

(c) Chromosome 1 and Y

(d) Chromosome X and Y

Ans. (c) Chromosome 1 and Y

Explanation: Chromosome 1 has 2968 genes, while chromosome Y has 231 genes.

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12. Who amongst the following scientists had no contribution in 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

Explanation: (d) Meselson and Stahl

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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 deoxy ribose

(c) Remove/Replace 2' OH group with some other group in deoxy ribose

(d) Both ‘B’ and ‘C’

Ans. (b) Remove/Replace 3' OH group in deoxy ribose

Explanation: (b) Remove/Replace 3' OH group in deoxy ribose

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

(a) DNA molecule being synthesised is very long

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

(c) it is a more efficient process

(d) DNA ligase has to have a role

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

Explanation: (b) DNA dependent DNA polymearse catalyses polymerisation only in one direction (5’ →3’)

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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. (d) All of the above

Explanation: RNA polymerase facilitates initiation, elongation and termination during transcription. Option ‘d’ is correct answer.

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

(a) DNA-replication

(b) Transcription

(c) Translation

(d) None of the above

Ans. (b) Transcription

Explanation: Transcription is the first step of gene expression. In this process, a particular segment of DNA is copied into mRNA. Thus, it controls gene expression.

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17. Regulatory proteins are the accessory proteins that interact with RNA polymerase and affect its role in transcription. Which of the following statements is correct about regulatory protein?

(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

Explanation: Regulatory proteins affect the ability of RNA to recognize initiation sites. Regulatory proteins have both negative (repressor) and positive (activator) role.

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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

Explanation: (a) Chromosome 1

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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.

Explanation: (d) All of the above.

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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

Explanation: Chargaff's rules states that DNA from any cell of all organisms should have a 1:1 ratio (base Pair Rule) of pyrimidine and purine bases. This means that the amount of guanine is equal to cytosine and the amount of adenine is equal to thymine. This pattern is found in both strands of the DNA. In this case, percentage of adenine is not equal to that of guanine and same holds true for cytosine and thymine. Hence, it is a single stranded DNA.

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

(a) A-DNA

(b) B-DNA

(c) c DNA

(d) r DNA

Ans. (c) c DNA

Explanation: Complementary DNA (cDNA) is double-stranded DNA synthesized from a messenger RNA (mRNA) template in a reaction catalysed by the enzyme reverse transcriptase.

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

(a) 1:1:0

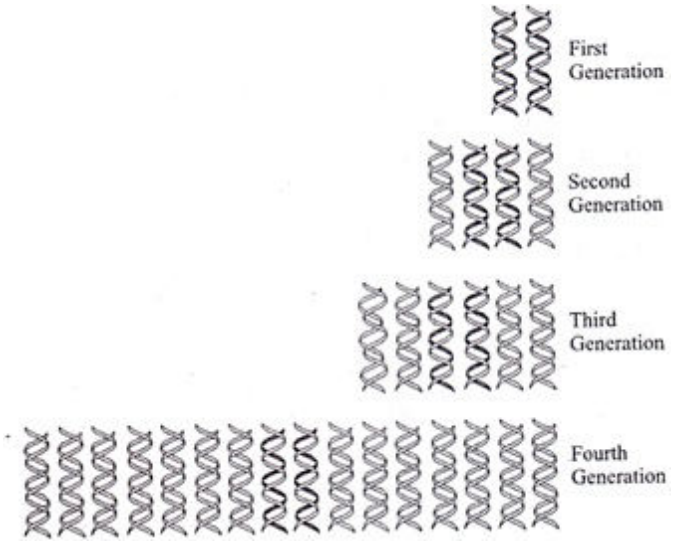
(b) 1:4:0

(c) 0:1:3

(d) 0:1:7

Ans. (d) 0:1:7

Explanation: The ratio of $^{15}N/^{15}N$ remains zero in subsequent generation. The ratio of $^{15}N/^{14}N$ remains constant (remains one) and that of $^{14}N/^{14}N$ increases. Following figure illustrates this.



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'

Explanation: (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 regions

(d) the structural gene only.

Ans. (c) the structural gene and the terminator regions

Explanation: (c) the structural gene and the terminator regions

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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'

Explanation: (b) 5' - CAU - 3'

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

(a) 5' - end

(b) 3' - end

(c) Anti codon site

(d) DHU loop

Ans. (b) 3' - end

Explanation: (b) 3' – end

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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

Explanation: (a) The smaller ribosomal sub-unit

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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

Explanation: (a) lactose is present and it binds to the repressor

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Very Short Answer Type Questions

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

Ans. Histone acts like a spool around which DNA is wrapped.

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

Ans.

Heterochromatin	Euchromatin
(i) They are darkly staining and are scattered or accumulated near the nuclear envelope.	(i) Euchromatin is not readily stainable and is dispersed.
(ii) These are transcriptionally less active or inactive.	(ii) These are transcriptionally active.

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 synthesised. Explain. Discuss the dual polymerase.

Ans. DNA polymerase uses DNA template to catalyse the polymerization of deoxynucleotides and hence it is called DNA – dependent. When a new strand of DNA is being processed, this enzyme moves along to hasten the speed of polymerization. While doing so, it “proof reads” the strand being formed. By doing so, it helps in speeding up the process. Hence, its nature

can be said as dual, i.e. of reading the template and then proof reading the new strand.

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 synthesised DNA?

Ans. DNA polymerase catalyses polymerization in only one direction, i.i. 5' – 3'. Due to this, replication is continuous on one strand (3'-5'), while it is discontinuous on another strand (5' – 3'). The fragments which is discontinuous is later joined by DNA ligase.

5. Given below is the sequence of coding strand of DNA in a transcription unit

3'-A A T G C A C T A T T A G G – 5'

Write the sequence of

(a) its complementary strand

(b) the mRNA

Ans. (a) 5' – T T A C G T C G A T A A C C – 3'

(b) 5' – U U A C G U C G A U A A C C – 3'

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

Ans. If an inheritable mutation appears in a population at high frequency, this is known as DNA polymorphism. Since inheritable mutations finally lead to evolution, hence study of DNA polymorphism is important from the evolutionary perspective.

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

Ans. Normally human beings have following types of hemoglobin, Hb^{A}, Hb^{A2} and Hb^{F}. Alteration in genes for beta chain on hemoglobin results in formation of Hb^{S} type of hemoglobin. This type of hemoglobin molecule is responsible for sickle cell anemia.

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 eye(s) etc. Comment.

Ans. Presence of any different sets of organ in an animal is due to disturbance in co-ordinated regulation of expression of sets of genes.

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

Ans. DNA polymerase is highly specific to recognise only deoxyribonucleoside triphosphates. Therefore, it cannot hold RNA nucleotides.

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

Ans. Following are some other enzymes and their key functions:

- Primase: It adds RNA primers to template strands.
- RNAse: Removes the RNA primer.
- Exonuclease: Initiate cleaving of nucleotides one at a time.

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

Ans. Following viruses have RNA as genetic material:

- Ebola virus
- Tobacco Mosaic Virus
- SARS

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Short Answer Type Questions

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

Ans. During the course of Griffith's experiment, bacteria changed its physical form. This was termed as transformation. In this experiment, the DNA of the S strain bacteria survived heating of bacteria. When a mice was injected with mixture of killed S strain and R strain, the mice died of pneumonia. This showed that DNA had the capability of surviving adverse circumstances and manifesting itself on return of favourable conditions. Stability and survival are key considerations for a material to be classified as genetic material. Thus, transformation in Griffith's experiment helped in identification on DNA as genetic material.

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

Ans. Oswald Avery, Colin MacLeod and Maclyn McCarty (1933 – 1944) conducted experiments to reveal the biochemical nature of the transforming principle. They purified biochemical (proteins, DNA and RNA) form the heat-killed S cells. They wanted to see which one of them was able to transform the R strain. So, they discovered that protein digesting enzymes (proteases) and RNA-digesting enzymes (RNases) did not affect transformation but DNase inhibit transformation. Thus, they concluded that it was the DNA which was able to transform the R strain.

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

Ans. The heavy isotope of nitrogen was used in Meselson and Stahl's experiment for various reasons. The heavy DNA molecule (containing ^{15}N) could be easily distinguished from the normal DNA by centrifugation in a Cesium chloride (CsCl) density gradient. It could be easily

separated from lighter nitrogen (^{14}N) on the basis of density. Use of lighter and heavier nitrogen made the task of identifying transfer of DNAs through subsequent generation quite easier.

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

Ans. A segment of DNA coding for 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 monocystronic, 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.

Ans. Six features of the human genome are as follows:

- The human genome contains 3164.7 million nucleotides.
- The average gene in the human genome contains 3000 bases.
- The total number of genes is estimated to be 30,000.
- Almost all (about 99.9%) of nucleotides are same in all human beings.
- Less than 2 percent of the genome codes for protein.
- Chromosome 1 has the most genes (2968) and chromosome Y has the least (231).

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

Ans. DNA replication is an energy-intensive process and requires very high amount of energy. So, the practical solution is to replicate a DNA segment by segment. Due to this, the entire DNA molecule does not open in one go.

Replication Fork: DNA replication happens in a small opening of DNA helix. This opening is called replication fork.

Monomers like nucleotide triphosphate (NTPs) is a molecule containing a nucleotide bound to three phosphates. The NTPs present in DNA are called dNTP. They are basic building

blocks of life. They play important role in various metabolic functions.

7. Retroviruses do not follow central Dogma. Comment.

Ans. Francis and Crick proposed the central dogma in molecular biology. According to this, genetic information flows from DNA → RNA → Protein. In retroviruses, genetic information flows in reverse direction, i.e. Protein → RNA → DNA. Hence, it is said that retroviruses do not follow central dogma. The process followed by retroviruses is also called reverse transcription because of the opposite sequence of the process involved.

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 2×10^9 bp) in the presence of saturating amount of this compound.

Ans. The length of DNA double helix can be calculated by multiplying the distance between two consecutive base pairs with total number of base pairs.

0.44×10^{-9} m x 2 x 10^9 bp

= 0.88 m

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?

Ans. Aspartic and glutamic acid are acidic amino acids, while lysine and arginine are basic amino acids. Lysine and arginine carry positive charge on their side chains which is not the case with aspartic acid and glutamic acid. DNA is negatively charged and hence is wrapped around the positively charge histone octamer. If acidic amino acids are present in histone because of mutation, DNA won't be able to wrap around itself. Thus, long strand of DNA will not be able to fit inside the small space in the nucleus. This will mean an end to nuclear organization which is possible because of efficient packaging.

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.

Ans. RNA is less stable than DNA and hence, DNA replaced RNA as the genetic material in the living world. If RNA was the genetic material in Griffith's experiment, it would have been destroyed by heat. Thus, the heat killed strain of Pneumococcus could not have transformed the R-strain into virulent strain.

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

Ans. Selection of phosphorus and Sulphur was based on the facts that DNA contains phosphorus while protein contains Sulphur. In this experiment, phosphorus was used as a marker for DNA. Similarly, Sulphur was used as a marker for 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 DNA as well as in protein. Hence, use of ^{15}N will not help in finding whether the DNA or protein is the genetic material.

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

Ans. There are 61 codons and 20 amino acids. Hargobind Khorana and Marshall Neirenberg worked on this principle. It was proposed that a codon for an amino acid is made up of 3 nucleotides. It was also seen that one codon codes for only one amino acid (unambiguous and specific). Some amino acids are coded by more than one codon (degeneracy of codon). In simple terms, it can be said that there is only one possible sequence of amino acids when deduced from a given set of nucleotides. But multiple nucleotides sequence can be deduced from a single amino acid sequence.

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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.

Ans. A single base mutation in a gene may not always results in loss or gain of function. We know that a codon is composed of three nucleotides. In simple terms, a codon can be taken as a word which is composed of 3 letters. For making any meaningful sentence we need a complete word. Addition or deletion of a single letter may not result in a meaningful word. Hence, in most of the cases, there is a need of mutation in three bases to affect loss or gain of function. This can be illustrated by following example of a sentence being altered:

RAM HAS RED CAP

RAM HAS BRE DCA P

RAM HAS BIR EDC AP

RAM HAS BIG RED CAP

It is clear that a meaningful sentence is made only when at least three letters are inserted in this sequence.

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

Ans. A very low level of expression of lac operon has to be present in the cell all the time, otherwise lactose cannot enter the cells.

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

Ans. Sequencing of human genome has opened new windows for treatment of various genetic disorders. We know that genetic disorders are caused by some alteration in genes. At present, we do not have exact information about the base pair sequence where this alteration takes place. Hence, we are unable to devise any tool to prevent genetic disorders. By proper understanding of the particular sequence responsible for a particular genetic disorder, the scientist may be able to devise some tools to prevent genetic disorders. A future may come when nobody will be suffering from genetic disorders; especially those which

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create serious disability.

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

Ans. When scientists began estimating the number of human genes, they began with a very high figure, i.e. more than 100,000. At that time, the technology for studying human genes was not sophisticated enough and the estimate was more qualitative in nature as it was mainly based on assumptions. With gradual progress of technology and knowledge about the human genes, the estimated number began to come down. The present knowledge tells us that total number of genes in humans is between 20,000 to 25,000.

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

Ans. Advantages of Affordable Genome Sequencing: It can help in settling disputes which may arise in case of parentage of a child. This can also help in disputes of property inheritance by finding the bonafide beneficiary. Human genome can also help in preparing a database on people with criminal record. It can help in identifying the chances of genetic disorders in a family.

Disadvantages: Genome sequencing can have serious issues of privacy. Some employers may misuse the data to blackmail their employees. Many private matters may leak into public domain; creating embarrassment for the affected person.

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

Ans. VNTR (Variable Number Tandem Repeat) is a location in genome where a short nucleoside is organized as tandem repeat. Analysis of VNTR is used for many purposes; including DNA finger printing. But bacteriophage does not have too many DNAs rather only a few strands of DNA are available in bacteriophage. This does not leave scope for repeating sequence in DNA. Hence, VNTR cannot be used in DNA finger printing of a bacteriophage.

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

Ans. 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 management of HIV. If 2', 3'- dideoxy cytidine triphosphate is used as a raw nucleotide in place of 2' – deoxy cytidine, it will stop DNA replication. The researcher will not be able to proceed on his experiment because of contrary effect of his chosen reagent.

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

Ans. Watson and Crick made following background information available for developing a model of DNA:

- Pairing between the two strands of polynucleotide chains.
- Base pairing of polynucleotide chains is complementary in nature.
- If base sequence of one strand is known, then the base sequence of another strand can be predicted.
- If each strand from a DNA acts like a template, then both the daughter DNAs would be similar to the mother DNA.

Contributions of Watson and Crick:

- A simple model of DNA was available because of them.
- Genetic implications of DNA replication could be easily understood.
- The model brought revolution in understanding of biology at a molecular level.

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

Ans. Function of Methylated Guanosine Cap: It regulates nuclear export of mRNA. It promotes translation. (Fully processed hnRNA is called mRNA).

Function of Poly-A Tail: Protects RNA from degradation by exonucleases. Plays important role in transcription termination.

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

Ans. In humans about 95% of multi-exonic genes are alternatively spliced. Alternative splicing helps in generating many proteins from one and the same gene. In this process, a particular exon may be excluded from or included in a specific RNA. Splicing which results in a single gene coding for multiple proteins is called alternative splicing.

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

Ans. Variability in number of tandem repeats (VNTR) is highly useful in DNA finger printing. DNA sample is subjected to gel electrophoresis or Southern blotting. After that VNTR manifests as a pattern of lines of different lengths. The variability in lengths of lines and their respective arrangement varies from one individual to another. This is more or less unique the way a person's finger print is. Thus, VNTR helps in establishing exact identity of an individual through DNA finger printing.

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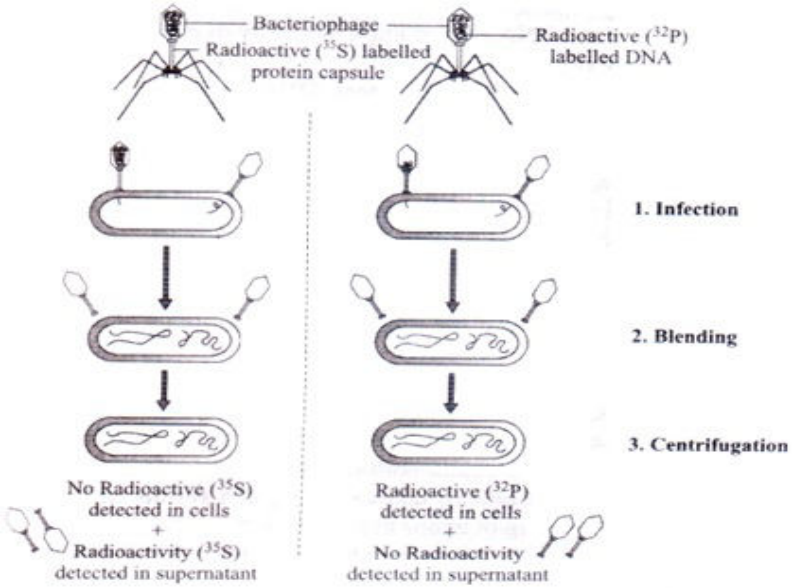
Long Answer Type Questions.

1. Give an account of 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?

Ans. Hershey and Chase Experiment:

- Viruses were grown on two media. One medium contained radioactive phosphorus and another contained radioactive Sulphur.
- Viruses grown on radioactive phosphorus contained radioactive DNA but no such protein because protein does not contain phosphorus.
- Viruses grown on radioactive Sulphur contained radioactive protein but no such DNA because DNA does not contain Sulphur.
- Radioactive phages were allowed to attach to E.coli bacteria. One the infection proceeded, the viral coat was removed from bacteria and then viral particles were separated from bacteria for further analysis.



Observation:

- Radioactive DNA was seen in only those bacteria which were infected with phages grown on radioactive phosphorus.
- Radioactive DNA was not seen in those bacteria which were infected with phages grown on radioactive Sulphur.

Conclusion: DNA was found to be the genetic material.

If both the DNA and proteins contained Sulphur and phosphorus, it would have not been possible to pinpoint the exact genetic material, i.e. DNA or proteins.

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2. During the course of 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.

Ans. Following are the desired criteria in a molecule that can act as genetic material:

- It should have the capability of replication.
- It should chemically and structurally stable.
- It should be able to incorporate slow changes (mutation) which are required for evolution.
- It should be able to express itself in the form of Mendelian characters.

Biochemistry of DNA and RNA:

- Both DNA and RNA show complementarity of base pairs and hence are capable of replication.
- As shown by Griffith's experiment, DNA is more stable than RNA because it could survive even heat-killing during the experiment.
- 2'-OH group is present in RNA. This makes RNA labile and degradable; which is not the case with DNA.
- Both RNA and DNA can carry on mutations. But DNA being more stable is better suited for long term storage of mutations.

Hence, DNA was preferred as the genetic material during the course of evolution.

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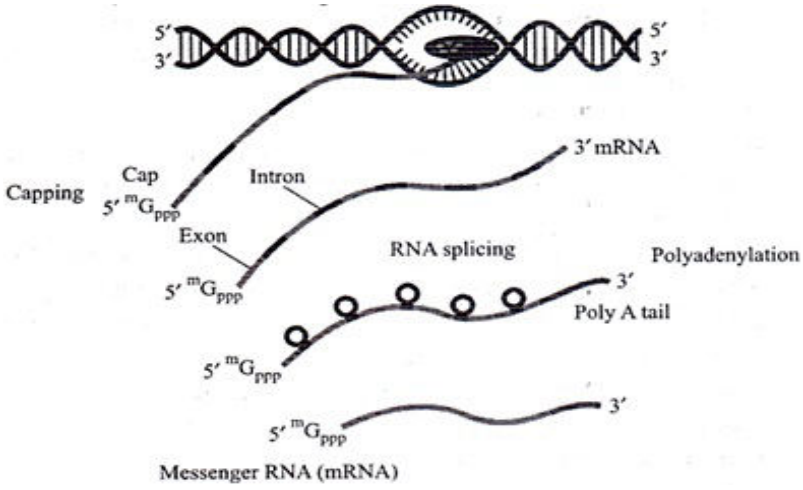
3. Give an account of post transcriptional modifications of a eukaryotic mRNA.

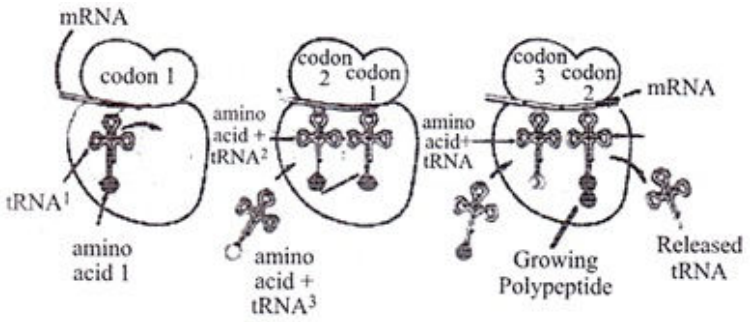
Ans. Following events happen during transformation of hnRNA (precursor of mature mRNA):

- Polymerase II facilitates transcription of hnRNA into mature mRNA.
- Primary transcripts cotain both the introns and exons and these are non-functional. Splicing takes place which results in removal of introns and joining of exons in define order.
- Capping and tailing happens in hnRNA. It acquires a cap of methyl guanosine and a tail of poly adenylate. Cap is added at 5' end and Poly-A tail is added at 3' end of hnRNA.
- Now, the hnRNA changes into mature mRNA.



4. Discuss the process of translation in detail.

Ans. The process of polymerization of amino acid to form a polypeptide is called translation. Thus, the biological process through which protein is synthesized is called translation. Translation happens in following main steps:



Initiation: Ribosome assembles around the target mRNA and we know that ribosome is the site of protein synthesis. The first tRNA gets attached at the start codon. A codon is a triplet of amino acids.

Elongation: The tRNA transfers an amino acid to the tRNA corresponding to the next codon. This phase involves addition of subsequent amino acids to form a long chain. This step forms the bulk of the protein synthesis.

Translocation: The ribosome then moves to the next mRNA codon and continues the process. This creates an amino acid chain.

Termination: When a stop codon is reached, the ribosome releases the polypepite.

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

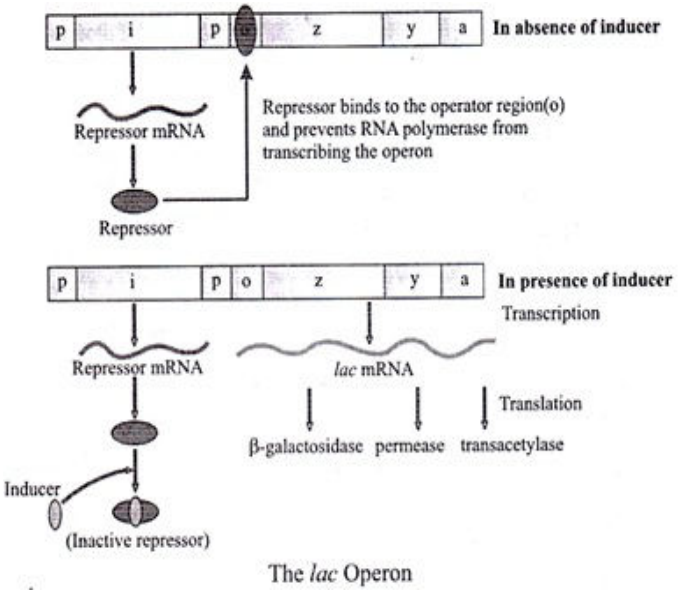
Ans. A functioning unit of genomic DNA containing a cluster of genes under the control of a single promoter is called operon. An operon is generally transcribed into polycistronic mRNA. A single mRNA which codes for more than one protein is called polycistronic mRNA. An operon is made up of 3 basic DNA components:

(a) **Promoter:** A nucleotide sequence that enables a gene to be transcribed is called promoter. It is recognized by RNA polymerase, which then initiates transcription.

(b) **Operator:** A segment of DNA to which a repressor binds is called operator.

(c) **Structural genes:** The genes that are co-regulated by the operon are called structural genes.

Inducible Operon: When the operon is regulated by an inducer, it is called inducible operon. An inducer can switch on or off the operon. Lac operon is an example of inducible operon. Lactose is a substrate of enzyme beta-galactosidase and is the inducer of lac operon.



The *lac* Operon

The given diagram shows the working of lac operon. In the absence of an inducer the repressor binds to the operator region and prevents transcription.

In the presence of an inducer, repressor becomes inactive. This allows transcription in the operator region which results in release of mRNA. Subsequently, mRNA promotes translation and protein synthesis is accomplished.

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

Ans. Dispute regarding paternity for a child can be resolved by using DNA fingerprinting. DNA fingerprinting is based on following principle:

DNA fingerprinting: This involves identifying difference in some specific regions of DNA. The sequence in such regions is called repetitive DNA. A small stretch of DNA is repeated many time in such sequences.

During density, gradient centrifugation, these sequences are separated from bulk DNA as different peaks. The bulk DNA forms major peaks and other small peaks are called satellite DNA. Satellite DNA can be classified into various types, depending on base composition, length of segment and number of repetitive units. Base composition reveals whether the sequence is A: T rich or G: C rich. These sequences show high degree of polymorphism and hence form the basis of DNA fingerprinting.

In case of and individual, DNA from every tissue shows the same degree of polymorphism. Hence, DNA from any tissue can be utilized to analyse DNA fingerprinting of an individual. Moreover, polymorphism is inheritable from parents to children. Hence, DNA fingerprinting can be utilized to assess paternity for a child.

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

Ans. Two approaches were involved in sequencing the Human genome.

Using Expressed Sequence Tags (ESTs): In this approach, all the genes that are expressed as RNA are identified and then sequenced.

Blind Approach: This approach involved sequencing the whole set of genome and then assigning different regions in the sequence with functions. This is referred to as sequence annotation. This approach is comprised of following steps:

- Total DNA from a cell is isolated and converted into random fragments of smaller sizes.
- These fragments are cloned in a suitable host by using specialized vectors. The cloning results into amplification of each fragment, and makes it easy to sequence the fragment. Bacteria and yeast are the commonly used hosts for this purpose. The vectors were called as BAC (bacterial artificial chromosomes) and YAC (yeast artificial chromosomes).
- Automated DNA sequencers were used to sequence the fragments. Then these sequences were arranged on the basis of some overlapping regions present in them.
- For generating overlapping fragments in these sequences; help of computer programmes was taken because it was not possible for humans to do so.
- Then the sequences were annotated and assigned to each chromosome.
- Genetic physical mapping of genome was done on the basis of polymorphism in some segments of the DNA.

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8. List the various markers that are used in DNA finger printing.

Ans. A DNA marker is a gene sequence on a known chromosome which can be used to identify an individual or a species. A genetic marker or DNA marker can be a short sequence

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or a long sequence. Following are the commonly used markers for DNA fingerprinting.

- RFLP (Restriction fragment length polymorphism)
- SSLP (Simple sequence length polymorphism)
- AFLP (Amplified fragment length polymorphism)
- RAPD (Random amplification of polymorphic DNA)
- VNTR (Variable number tandem repeat)
- SSR Microsatellite polymorphism, (Simple sequence repeat)
- SNP (Single nucleotide polymorphism)
- STR (Short tandem repeat)
- SFP (Single feature polymorphism)
- DArT (Diversity Arrays Technology)
- RAD markers (Restriction site associated DNA markers)

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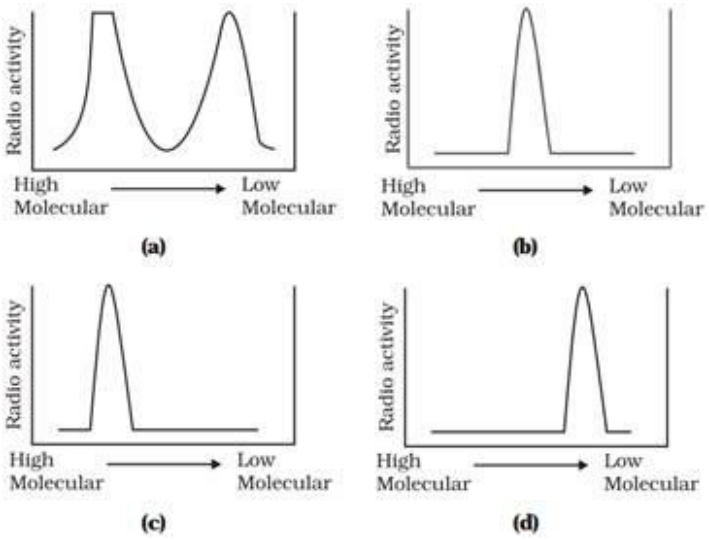
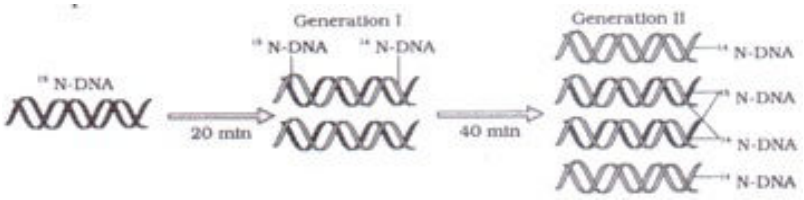
9. Replication was allowed to take place in the presence of radioactive deoxynucleotides precursors in E.coli that was a mutant for DNA ligase. Newly synthesised radioactive DNA was purified and strands were separated by denaturation. These were centrifuged using density gradient centrifugation. Which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



Ans. Option ‘a’ shown the correct result. The following diagram explains this:



Let us assume that heavier nitrogen was used in this experiment. This nitrogen molecule from parents' cell would be transmitted equally in daughter cells. Each daughter cell will have half of the DNA with heavier nitrogen and another half with lighter nitrogen.

In the F_2 generation, 50% of daughter cells will have a combination of radioactive and non-radioactive DNAs. The rest 50% of daughter cells will have non-radioactive DNAs.

This is the reason; the graph shows two peaks; each peak representing a particular form of nitrogen in DNA.