Chapter 5. Molecular Basis of Inheritance

The DNA and RNA World

1 Mark Questions

1.What will happen if DNA replication is hot followed by cell division in a eukaryotic cell? [All India 2014 c]

Ans.If cell division is not followed after DNA replication then replicated chromosomes (DNA) would not be distributed to daughter nuclei. A repeated replication of DNA without any cell division results in the accumulation of DNA inside the cell.
This would increase the volume of the cell nucleus, thereby causing cell expansion,

2.Name the specific components and the linkage between them that form deoxyadenosine. [Delhi 2013c]

Ans.Adenine (N-glycosidic Linkage) + Deoxyribose -> Deoxyadenosine

3.Which one out of rho factor and sigma factor act as an initiation factor during transcription in a prokaryote? [Delhi 2013 C]

Ans.Sigma factor acts as an initiation factor during transcription in prokaryotes

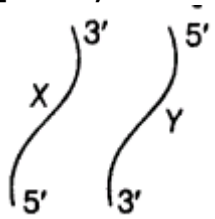
4.Name the enzyme involved in continuous replication of DNA strand. Mention the polarity of the template strand. [All India 2012]

Ans.Enzyme involved in continuous replication of DNA strand is DNA polymerase. Template strand has 3'->5' polarity

5.Name the positively charged protein around which the negatively charged DNA wrapped.[All India 2012 C]

Ans. Histones are the positively charged proteins around which the negatively charged DNA wrapped.

6.A structural gene has two DNA strands X and Y shown below. Identify the template strand.
[HOTS; All India 2010 C]



Ans.'X' is template strand. It is because the template strand has the polarity in 3' -> 5' direction.

7.Why is hnRNA required to undergo splicing? [HOTS; Delhi 2009]

Ans.hnRNA is required to undergo splicing because of the introns (the non-coding sequences). These are needed to be removed and the exons (the coding sequences) have to be joined in a specific sequence.

8.Mention the two additional processes, which hnRNA needs to undergo after splicing so, as to become functional. [Delhi 2009]

Ans.The additional processes bnRNA needs to undergo after splicing are capping and tailing.

9.When and at what end does the tailing of hnRNA takes place?[All India 2009]

Ans.When hnRNA is processed to make mRNA, tailing takes place at the 3′-end.

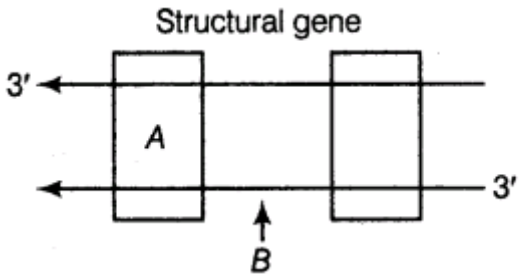
10.At which ends do capping and tailing of hnRNA occur respectively? [Foreign 2009]

Ans.Capping – At 5′-end Tailing -At 3′-end

11.How is the length of DNA usually Calculated? [All India 2009 C]

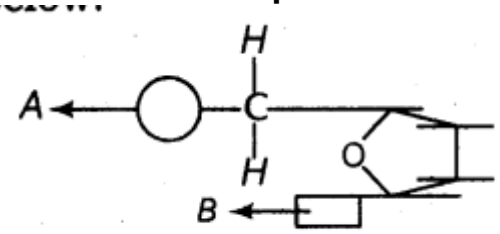
Ans.Length of DNA can be calculated by simply multiplying the total number of base pair with distance between two consecutive bp,
i.e.6.6x 10^{9}bpx 0.34x 10^{-9}m/bp.
It comes about 2.2 m. (0.34 x 10^{-9} m is the distance between two consecutive base pairs)

12.Name the parts A and B of the transcription unvit given below.



Ans.A -Promoter, 8-Coding strand.

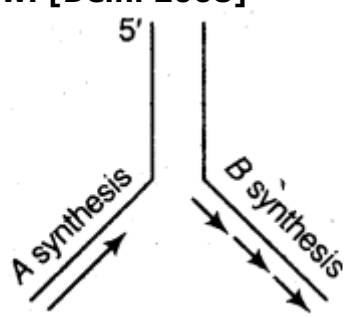
13.Name the components A and B in the nucleotide with a purine, given below.



[Delhi 2008; Foreign 2008]

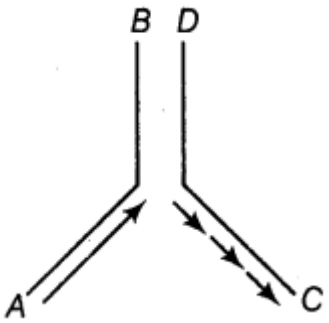
Ans.A – Phosphate B-Any nitrogenous base (e.g. adenine, guanine, cytosine or thymine).

14.Name the type of synthesis A and B occurring in the replication fork of DNA as shown below. [Delhi 2008]



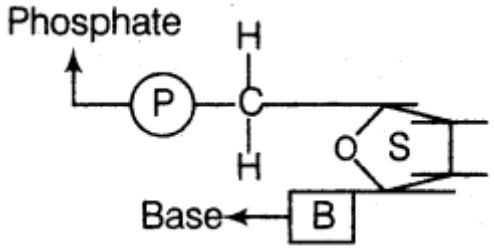
Ans.A – Continuous synthesis (Leading strand) B – Discontinuous synthesis (Lagging strand)

15.Mention the polarity of the DNA strands A-B and C – D shown in the replicating fork given below.
[Ail India 2008]



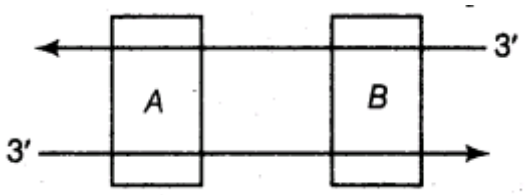
Ans. A – B = 3′ -> 5′ C – D = 5′ -> 3′

16.Mention the carbon positions to which nitrogenous base and the phosphate molecule are respectively linked in the nucleotide given below. [All India 2008]



Ans.Nitrogenous base at first C Phosphate molecule at 5thC

17.What are A and B in the transcription unit represented below?[Foreign 2008]



Ans.A – Promoter B – Terminator

2 Marks Questions

18.Explain the two factors responsible for conferring stability to double helix structure of DNA. [All India 2014]

Ans.Two factors responsible for conferring stability to double helix structure of DNA are

(i) Stacking of one base pair over other.

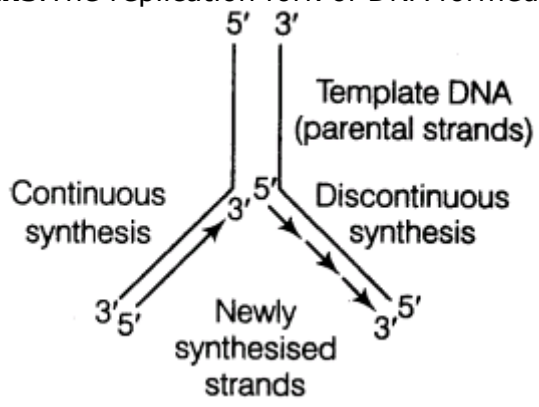
(ii) H-bond between nitrogenous base

19.State the difference between the structural genes in a transcription unit of prokaryotes and eukaryotes. [All India 2014]

Ans. Prokaryotic structural genes are found continuously with any non-coding region, while eukaryotic structural genes are divided into exons (coding DNA) and introns (non-coding DNA).

20.Show DNA replication with the help of a diagram only.[All India 2014 C; Delhi 2012]

Ans.The replication fork of DNA formed during DNA replication.

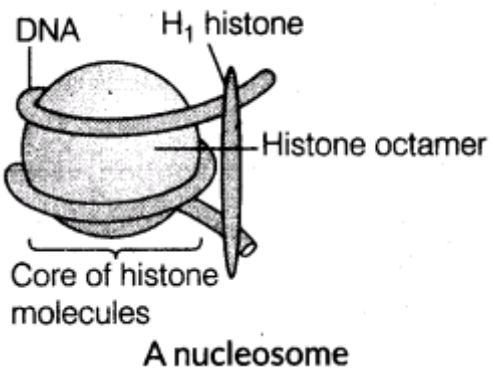


21.A template strand is given below. Write down the corresponding coding strand and the m-RNA strand that can be formed, along with their polarity.
3′ ATGCATGCATGCATGCATGCATGC 5′ [Foreign; 2014]

Ans.For the given template strand 3′ATGCATGCATGCATGCATGC A T G C 5′
Coding strand is
5′TACGTACGTACGTACGTACG T A C G 3′
And mRNA strand is
5′UACGUACGUACGUACGUA C G UA C G 3′

22.Draw a labelled diagram of a nucleosome. Where is it found in a Cell? [Foreign 2014, All India 2012]
or
How do histones acquire positive charge? [Delhi 2011]

Ans.Structure of a nucleosome

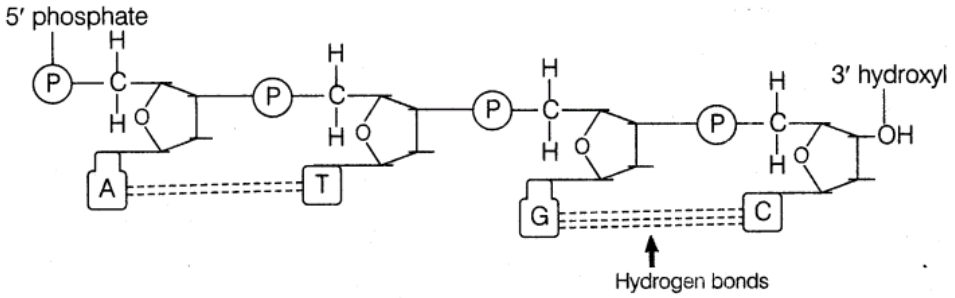


A nucleosome

A nucleosome is found in the nucleus of the cell. It contains histone proteins acquiring positive charge depending upon the abundance of amino acid residues, i.e. lysine and arginines, with charged side chains. Both these amino acids carry positive charges in their side chains.

23.Draw a schematic diagram of a part of double stranded dinucleotide DNA chain having all the four nitrogenous bases showing the correct polarity. [Delhi 2012]

Ans. Schematic diagram of a double stranded dinucleotide DNA chain having all the four nitrogenous bases (A,T,G,C) with polarity



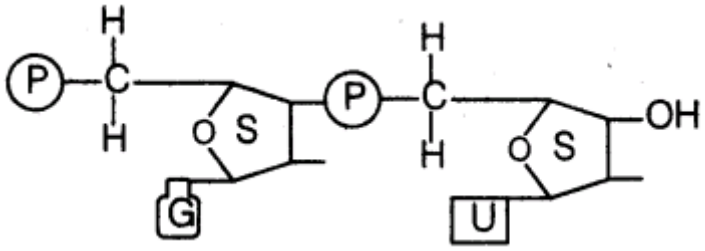
Double-stranded dinucleotide DNA

24.State the dual role of deoxyribonucleoside triphosphates during DNA replication. [Delhi 2011]

Ans. (i)The deoxyribonucleoside triphosphates are the building blocks for the DNA strand (polynucleotide chain) i.e. they act as substrates.

(ii) These also serve as energy source in the form of ATP and GTP.

25.Answer the questions based on the dinucleotide shown below



(i)Name the type of sugar guanine base is attached to.

(ii)Name the linkage connecting the two nucleotides.

(iii)Identify the 3′ end of the dinucleotide. Give a reason for your answer. [All India 2010c]

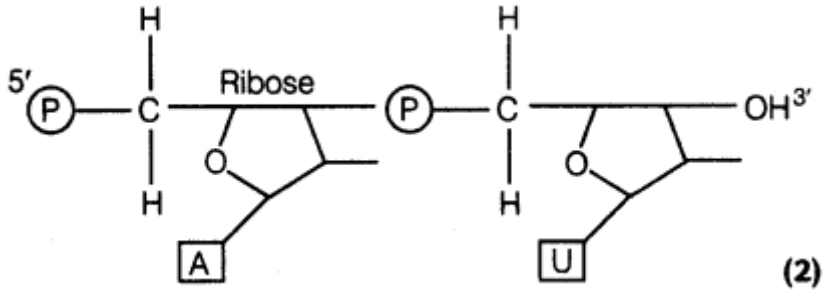
Ans.(i)Pentose sugar or deoxyribose sugar.

(ii) Two nucleotides are linked through 3′-5′ phosphodiester linkage to form a dinucleotide.

(iii) The polymer ribose has a free 3′ — OH group which is referred to as 3′ – end of the polynucleotide chain.

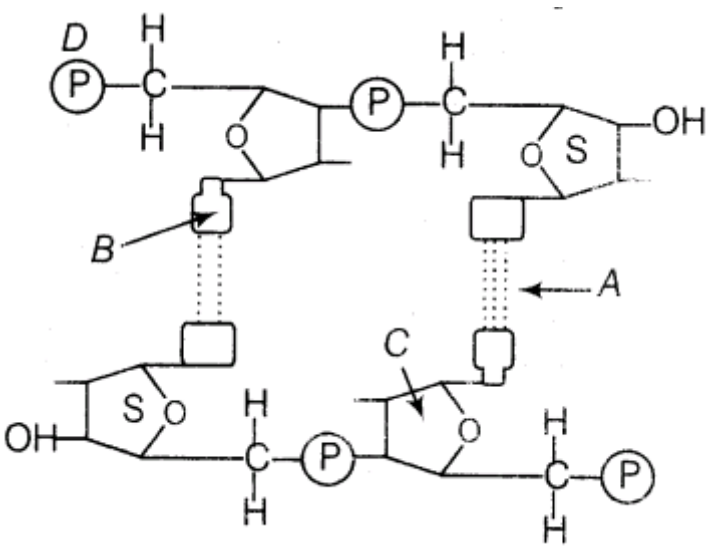
26.Make a labelled diagram of an RNA dinucleotide showing its 3′ ->5′ polarity. [All India 2010 c]

Ans.RNA dinucleotide.



(2)

27.Study the given portion of double stranded polynucleotide chain carefully. Identify A, B, C and the 5′ end of the chain. [All India 2009]



Ans.**A** – hydrogen bonds, **B** – purine base,
C – pentose (deoxyribose) sugar, **D – 5'** end.

28.Differentiate between a template strand and a coding strand of DNA.[Foreign 2009]

Ans.Differences between template strand and coding strand of DNA are:

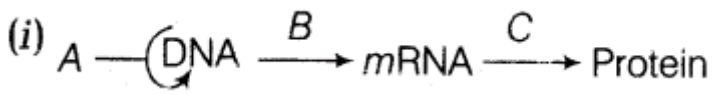
Template strand	Coding strand
It is a DNA strand with 3′→5′polarity.	DNA strand with 5′→3′ polarity.
Acts as template for transcription and codes for RNA.	Does not code for any region of RNA during transcription.

29.Give one function each of histone protein and non-histone chromosomal protein in an eukaryotic nucleus,[All India 2009 C]

Ans.(i)**Histone proteins** help in packaging of DNA. These are organised to form a unit of eight molecules called as histone octamer. The negatively charged DNA is wrapped around the positively charged histone octamer to from a structure called nucleosome.

(ii) **Non-histone chromosomal proteins** helps in packaging of chromatin at higher levels.

30.



Look at the above sequence and mention the event A,B and C
(ii)What does central dogma state in molecular biology? How does it differ in some viruses?[Delhi 2009 c]

Ans.(i) A – Replication of DNA B – Transcription C – Translation

(ii) Central dogma states that the genetic information flows from DNA to RNA to Proteins. In some viruses the flow of information is reverse in direction, i.e. RNA to DNA.

31.Compare the roles of the enzymes DNA polymerase and DNA ligase in the replication fork of DNA.[All India 2008 C]

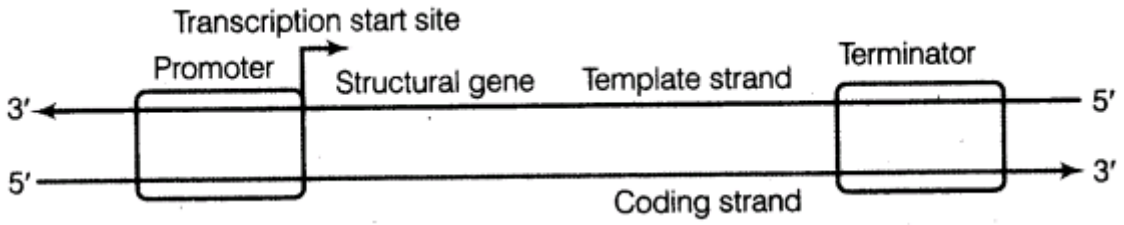
Ans. Differences between the roles of DNA polymerase and DNA ligase are:

DNA Polymerase	DNA Ligase
It is the main enzyme in the replication of DNA.	It is an additional enzyme in replication.
It uses a DNA template to catalyse the polymerisation of deoxynucleotides only, in one direction, i.e. 5′→3′, leading to one strand replication continuous and the other one as discontinuous.	DNA ligase joins the fragments of strand later which are discontinuously synthesised.

3 Marks Questions

32.With the help of a schematic diagram , explain the location and role of the following in a transcription unit.Promoter structural gene, terminator[All India 2014 c]

Ans.Structure of a transcription unit



The promoter and terminator flank the structural gene in a transcription unit. The promoter is located towards 5′-end (upstream) of the structural gene. The terminator is located toward 3′-end (downstream) of the coding strand and it usually defines the end of the process of transcription

33.(i) What are the transcriptional products of RNA polymerase III?
(ii)Differentiate between'capping' and 'tailing'.
(iii)Expand ZmRNA. [All India 2014C]

Ans.(i)RNA polymerase III is responsible for transcription of tRNA, 55 rRNA and snRNAs (small nuclear RNAs).(ii) In capping process, an unusual nucleotide (methyl guanosine triphosphate) is added to 5′-end ofbnRNA.In tailing process, 200-300 adenylate residues are added at 3′-end in a template independent manner. It is now called as mRNA

(iii)**hn** RNA is heterogenous nuclear RNA.

34.It is established that RNA is the first genetic material. Explain giving three reasons [Delhi 2012,2008 C]

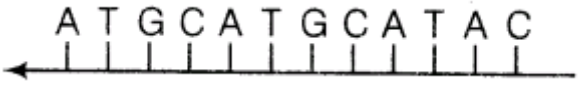
Ans.RNA is the first genetic material in cells because

(i) RNA is capable of both storing genetic information and catalysing chemical reactions.

(ii) Essential life processes (such as metabolism, translation, splicing, etc.), were evolved around RNA.

(iii) It shows the power of self-replication.

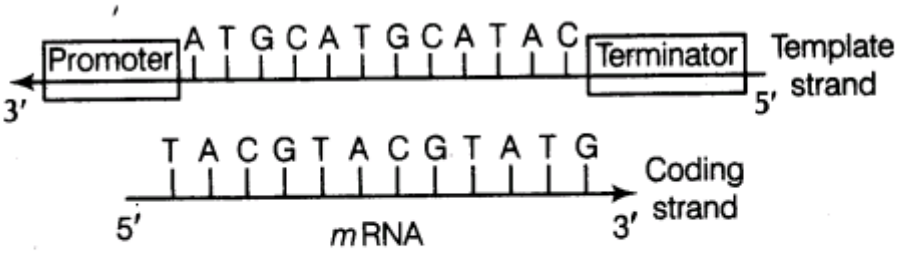
35.(i) Construct a complete transcription unit with promoter and terminator on the basis of hypothetical template strand given below,



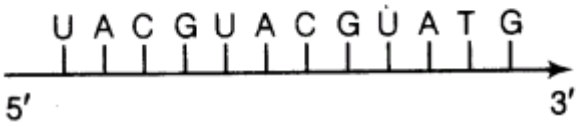
(ii)Write the RNA strand transcribed from the above transcription unit along with its polarity. [Delhi 2012]

Ans.

(*i*) Transcription unit



(*ii*) RNA transcribed



36.List the salient features of double helix structure of DNA.[All India 2012]

Ans.Salient features of DNA double helix

(i) It is made up of two polynucleotide chains containing the backbone of sugar- phosphate and the bases project inside.

(ii) The two chains have anti-parallel polarity one of them is 5′-»3′, the other has 3′-* 5′ polarity.

(iii) The bases in two strands are paired through hydrogen bond (H—bonds) forming base pairs (bp). Adenine pairs through two hydrogen bonds with thymine from opposite strand and vice-versa. In the same way, guanine is bonded with cytosine through three H—bonds. Due to which, purine always comes opposite to a pyrimidine.

(iv)The two chains are coiled in a right-handed fashion. The pitch of the helix is 3.4 nm and there are roughly 10 bp in each turn. Consequently, the distance between base pair in a helix is about 0.34 nm.

(v)The plane of one base pair stacks over the other in double helix. This confers stability to the helical structure

37.How is hit RNA processed to form mRNA? [Foreign 2012,2008]

Ans.The precursor of mRNA transcribed by RNA polymerase II is called heterogenous nuclear RNA (hnRNA). It undergoes following changes:

(i) Splicing In this process, the non-coding introns are removed and coding sequences called exons are joined in a definite order. This is required because primary transcript contain introns and exons. (ii) Capping RNA polymerase III is responsible for transcription of tRNA, 55 rRNA and snRNAs (small nuclear RNAs).

(a) In capping process, an unusual nucleotide (methyl guanosine triphosphate) is added to 5′-end ofbnRNA.In tailing process, 200-300 adenylate residues are added at 3′-end in a template independent manner. It is now called as mRNA

(b)**hn** RNA is heterogenous nuclear RNA.

(iii) Tailing RNA polymerase III is responsible for transcription of tRNA, 55 rRNA and snRNAs (small nuclear RNAs).

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(iv) The fully processed mRNA is released from the nucleus into cytoplasm for translation.

38.Why is DNA considered a better hereditary material than RNA?[Foreign 2012]

Ans.DNA is considered as a better genetic material because it is stable and does not change with age or change in physiology due to its double-stranded nature and presence of thymine.RNA is not considered as a better genetic material because

(i)2—-OH group of RNA nucleotide is a reactive group that make RNA labile and easily degradable.

(ii) RNA (23S r-RNA) is catalytic, i.e. it is reactive.

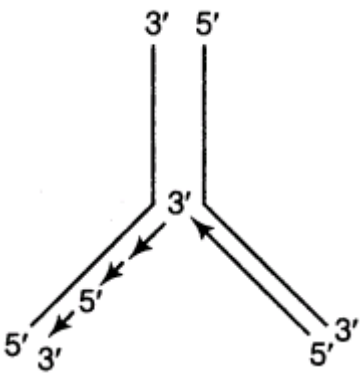
39.The base sequence in one of the strands of DNA is TAGCATGAT.
(i) Give the base sequence of the complementary strand.
(ii)How are these base pairs held together in a DNA molecule?
(iii)Explain the base complementarity rule. Name the scientist who framed this rule[Hots;Delhi 2011]

Ans.(i)ATCGTACTA

(ii) Base pairs are held together by weak hydrogen bonds, adenine pairs with thymine by two H—bonds and guanine pairs with cytosine forming three H—bonds.

(iii) Base complementarity rule For a double-stranded DNA, the ratios between adenine and thymine and guanine and cytosine are constant and equal to one. Erwin Chargaff framed this rule.

40.Why do you see two different types of replicating strands in the givenDNA replication fork? Explain.Name these strands, [hots; Delhi 2011]



Ans.Two different types of parent strands function as template strands.
On the template strand with 3′ ->5′ polarity, the new strand is synthesised as a continuous strand. The enzyme DNA polymerase can carry out polymerisation of the nucleotides only in 5′ -» 3′ direction. This is called continuous synthesis and the strand is called leading strand.
On the other template strand with 5′ -> 3′ polarity, the new strand is synthesised from the point of replication fork, also in 5′ -> 3′ direction. But, in short stretches, they are later joined by DNA ligases to form a strand, called lagging strand.

41.(i)Name the enzyme that catalyses the transcription of hnRNA.
(ii) Why does the hnRNA needs to undergo changes? List the changes hnRNA undergoes and [1] where in the cell such changes take place. [HOTS; All India 2011]

Ans.(i) RNA polymerase II catalyses the transcription of hnRNA.

(ii) hnRNA undergoes changes because it contains introns and exons and is non-functional.
Changes in hnRNA are:
The precursor of mRNA transcribed by RNA polymerase II is called heterogenous nuclear RNA (hnRNA). It undergoes following changes:

(i) Splicing In this process, the non-coding introns are removed and coding sequences called exons are joined in a definite order. This is required because primary transcript contain introns and exons. (ii) Capping RNA polymerase III is responsible for transcription of tRNA, 55 rRNA and snRNAs (small nuclear RNAs).

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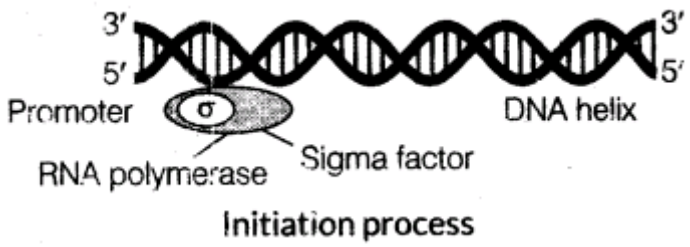
42.Answer the following questions based on Meselson and Stahl's experiment.
(i) Write the name of the chemical substance used as a source of nitrogen in the experiment by them.
(ii) Why did the scientists synthesise the light and the heavy DNA molecules in the organism used in the experiment?
(iii) How did the scientists make it possible to distinguish the heavy DNA molecule from the light DNA molecule? Explain.
(iv) Write the conclusion the scientists arrived at, after completing the experiment. [All India 2011]

Ans.(i)NH_4CI (Ammonium chloride).
(ii) It is to show that after one generation **E.coli** with ^{15}N-DNA in a medium of ^{14}N, has DNA of intermediate density between the light and heavy DNAs. It shows that of the two strands, only one strand is synthesised newly, using the ^{14}N-nitrogen source in the medium.
(iii)The heavy and light DMA molecules can be differentiated by centrifugation in a cesium chloride (CsCI) density gradient. The ^{15}N-DNA was heavier than ^{14}N -DNA and the hybrid ^{15}N ^{14}N -DNA was intermediate between the two.
(iv)Scientists concluded that the DNA replication is semiconservative, i.e. of the two strands of DNA, one is the parental strand while the other is newly synthesised.

43. Describe the initiation process of transcription in bacteria. [Delhi 2010]

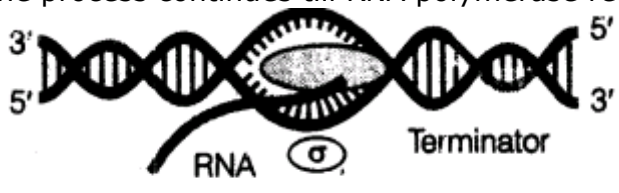
Ans.Initiation process of transcription in bacteria RNA polymerase becomes associated transiently to an initiation factor (o) **and** binds to specific sequence on DNA **called** promoter to initiate transcription (initiation).



Initiation process

44. Describe the elongation process of transcription in bacteria. [Delhi 2010]

Ans.Elongation process of transcription in bacteria RNA polymerase facilitates opening of the DNA helix after binding to promoter it uses nucleoside triphosphates as substrate and polymerises the nucleotides in a template dependent fashion following complementarity.
The process continues till RNA polymerase reaches the terminator region on the DNA strand.

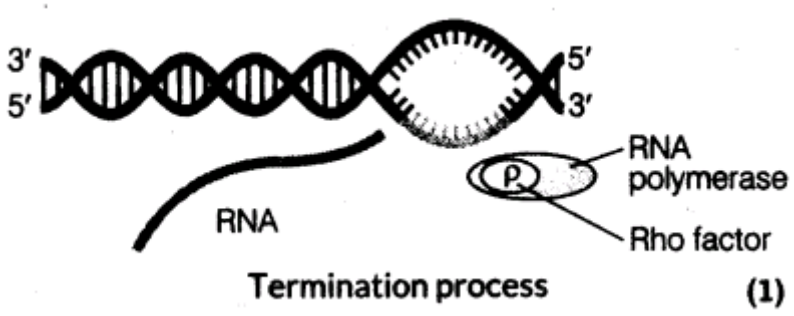


Elongation process

(1)

45.Describe the termination process of transcription in bacteria. [Delhi 2010]

Ans.Termination occurs when RNA polymerase reaches the terminator region and the nascent RN A falls off. The RNA polymerase becomes transiently associated with termination factor (p) and falls off the transcription unit



Termination process (1)

46.In a series of experiments with Streptococcus and mice, F Griffith concluded that R-strain bacteria had been transformed. Explain.[All India 2010]

Ans.F Griffith's Experiment

(i) The two strains of bacterium Streptococcus pneumoniae (causing pneumonia) one forming smooth colonies with capsule (S-type) and the other forming rough colonies without capsule (R-type) were taken for the experiment.

(ii) The S-type cells were virulent and R-types were not virulent.

(iii) When live S-type cells were injected into the mice, they died.

(iv) When live R-type cells were injected into mice, they did not show pneumonia.

S-strain —– > Injected into mice ———- >Mice died

R-strain —– > Injected into mice ———- >Mice lived

(v)When S-strain bacteria were killed by heating and injected into the mice, they did not develop disease.

S-strain —– > (heat-killed) —– > Injected into mice—-> Mice lived

(vi)When a mixture of heat-killed S-type cells and live R-cells were injected into the mice, the mice died of pneumonia.

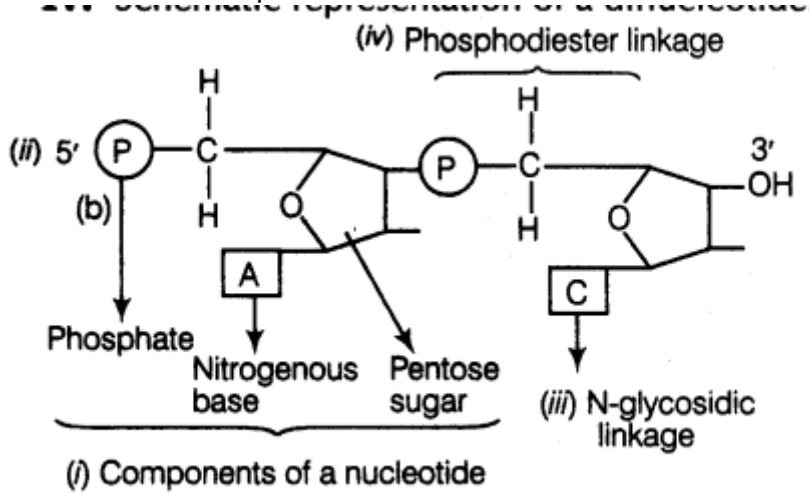
(vii)Griffith recovered living S-strain cells from the dead mice..

(viii) According to him, R-strain bacteria had somehow been transformed by the heat-killed S-strain bacteria. This may be due to some transforming principle. A factor may be transferred from the heat-killed S-strain, which enabled the R-strain to synthesise a smooth capsule and become virulent.

(ix) This transforming principle must be the genetic material.

47.Draw a schematic representation of a dinucleotide. Label the following.
(i)The component of a nucleotide
(ii)5′ end
(iii)N-glycosidic linkage
(iv)Phosphodiester linkage[Foreign 2010]

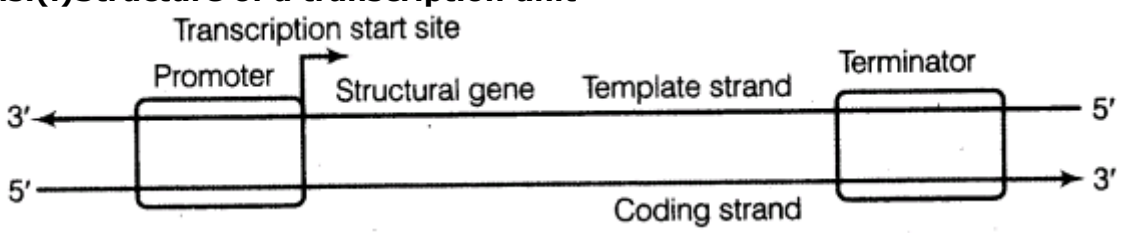
Ans. Schematic representation of a dinucleotide.



A dinucleotide (3)

48.(i) Draw a schematic representation of transcription unit showing the polarity of both the strands. Label the promoter gene and the template strand.
(ii)Mention the condition when template strand becomes coding strand.
(iii)Give the function of the promoter gene. [All India 2009 C]

Ans.(i)Structure of a transcription unit



The promoter and terminator flank the structural gene in a transcription unit. The promoter is located towards 5′-end (upstream) of the structural gene. The terminator is located toward 3′-end (downstream) of the coding strand and it usually defines the end of the process of transcription

(ii) The two strands in DNA have opposite polarity and the DNA-dependent RNA polymerase catalyses the polymerisationin only one direction, i.e. 5′-> 3′. The strand that has the polarity 3′-> 5′ acts as a template, called as template strand. The other strand which has the polarity (5′-» 3′) and the sequence same as RNA I (except thymine in place of uracil), is displaced during transcription. This strand which does not code for anything) is . called coding strand.

(iii) The promoter gene defines the template and coding strands. By switching its position with terminator, the definition of coding and template strands can be reversed

49.(i) Why does DNA replication occur in small replication fork and not in its entire length?
(ii)Why is DNA replication continuous and discontinuous in a replication fork?
(iii)Explain the importance of origin of replication in a replication fork.[HOTS; All India 2009 C]

Ans.(i)Because DNA molecule is very long, so two strands cannot be separated in its entire length, as it requires very high energy. The replication occurs within a small opening of I the helix called as replication fork.

(ii) DNA polymerase can catalyse the polymerisation of nucleotides only in 5′ —> 3′ direction. So, on the template strand with 3′ ->5′ polarity, DNA replication is continuous .On the template strand with 5′-> 3′ polarity, DNA synthesis occurs in short stretches as the opening of replication for,continues. Later, these short stretches are joined by the action of DNA ligases

(iii) Replication of DNA does not initiate randomly, and DNA polymerases on their own cannot initiate replication.So,there is a need of specific sequence can DNA, called origin of replication. DNA polymerase bind to it and continues the process.

50.The length of a DNA molecule in a typical mammalian cell is calculated to be approximately 2.2 m. How is the packaging of this long molecule done to accomodate it within the nucleus of the cell?[Delhi 2009,2008]

Ans.Eukaryotic cells have a set of positively charged basic proteins called histones. They are rich in lysine and arginine. The histones are organised to form a unit of eight molecules called histone octamer. The negatively charged DNA is wrapped around the positively charged histone octamer to form a nucleosome. The nucleosome contains 200 bp of the DNA helix and nucleosomes form the repeating units of a structure of the nucleolus, called chromatin.

5 Marks Questions

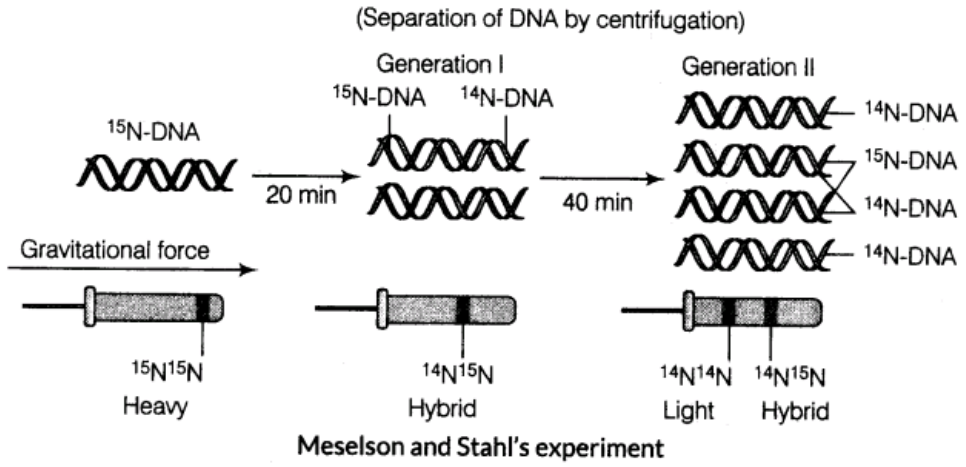
51.'DNA replication is semiconservative'. Name the scientists who proposed it and who proved it. How was it proved experimentally?[All India 2014C; Delhi 2008; Foreign 2008]
or
Who proposed that DNA replication is semiconservative? How did Meselson and Stahl prove it.
[Delhi 2008C]
or
Describe Meselson and Stahl's experiment and write the conclusion they arrived at.
[Foreign 2014; Delhi 2012]

Ans. Watson and Crick proposed that DNA replication is semiconservative. Later in the year 1958, Meselson and Stahl proved this. The semiconservative nature of DNA suggests that, after the completion of replication, each DNA molecule will have one parental and one newly-synthesised strand.

Experimental Proof

(i) E. coli was grown in a medium containing $^{15}NH_4CI$ (^{15}N is the heavy isotope of nitrogen) as the only nitrogen source for many generations. As a result, ^{15}N was incorporated into the newly-synthesised DNA. This heavy DNA could be distinguished by centrifugation in CsSI density gradient.

(ii) Then, these E. coli cells were transferred to a medium with normal $^{14}NH_4CI$ and the DNA was extracted as double stranded helix. The various samples were separated on CsCI gradients for measuring the density of DNA (after 20 min).
The hybrid had intermediate density.



Meselson and Stahl's experiment

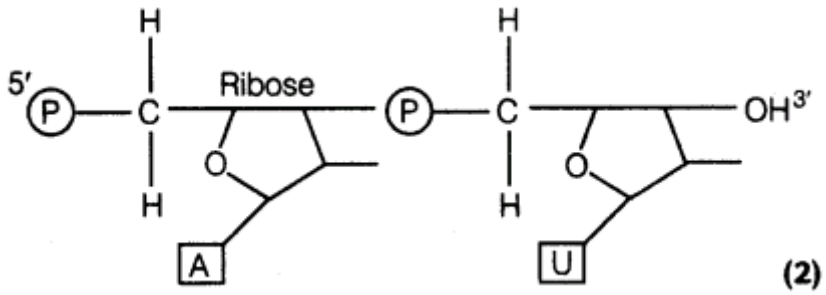
(iii)After 40 min, the DNA of the second generation was extracted from the $^{14}NH_4CI$ medium and was found to have equal amounts of hybrid and light DNA.

(iv) This proves that after replication, each DNA molecule has one parental strand and one newly synthesised strand.

52.(i) Describe the various steps of Griffith's experiment that led to the conclusion of the 'transforming principle'.

(ii)How did the chemical nature of the 'transforming principle' get established? [All India 2014]
or
(i)Write the conclusion drawn by Griffith at the end of his experiment with Streptococcus pneumoniae.
(ii)How did O Avery, C MacLeod and M McCarty prove that DNA was the genetic material? Explain.
[All India 2013,2009]
or
Describe Frederick Griffith's experiment on Streptococcus pneumoniae. Discuss the conclusion he arrived at. [All India 2012]
or
(i)Write the scientific name of the bacterium used by Frederick Griffith in his experiment.
(ii)How did he prove that some transforming principle is responsible for transformation of the non-virulent strains of bacteria into the virulent form?
(iii)State the biochemical nature of the transforming principle.
(iv)Name the scientists who proved it [Foreign 2011,2009,2008;Delhi 2009 C, 2008 C]

Ans.(i)RNA dinucleotide.



(2)

(ii)**Biochemical nature of transforming principle of Griffith's experiment.**

- Oswald Avery, Colin MacLeod and Maclyn McCarty (1933-44) worked to determine the biochemical nature of transforming principle in Griffith's experiment.
- They purified biochemicals (proteins, DNA, RNA, etc) from the heat-killed S-cel Is to see which ones could transform live R-cells into S-cel Is.
- 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 enzyme (RNAse) did not affect transformation.
- Digestion with DNAase did inhibit transformation. It suggested that the DNA causes the transformation.
- They thus, finally concluded that DNA is the genetic material

53.Describe the Hershey and Chase's experiment. Write the conclusion drawn by the scientists after their experiment. [All India 2014]
or
Name the scientists, who proved experimentally that DNA is the genetic material. Describe their experiment.
or
(i)Describe Hershey and Chase's experiment.
(ii)Write the aim of the experiment. [Delhi 2010 C; All India 2010,2008 C]

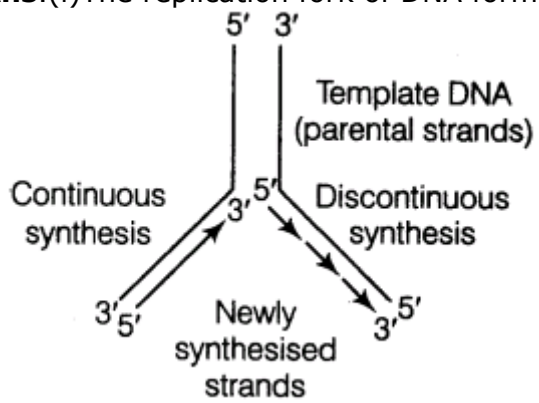
Ans.Hershey and Chase's experiment Their experiment is to prove unequivocally that DNA is the genetic material and not the protein .They worked with T_2 bacteriophage, which attacks bacterium E. coli. They grew some viruses on a medium that contained radioactive phosphorus (^{32}P) and some others on medium that contained radioactive sulphur ($^{32}5$).

(i) Radioactive phages were allowed to attack E.coli bacteria. The infection proceeded, the viral coats were removed form the bacteria by agitating them in a blender. The virus particles were separated from the bacteria by spinning them in a centrifuge.

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

(iii) 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. Hence, DNA is genetic material that is passed from virus to bacteria.

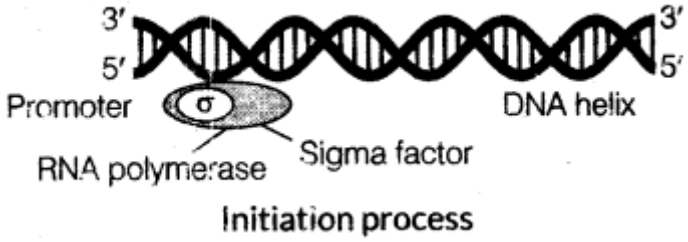
54.(i) Explain the process of DNA replication with the help of a schematic diagram.
(ii) In which phase of the cell cycle does replication occur in eukaryotes? What would happen if cell division is not followed after DNA replication. [Delhi 2014]
Ans.(i)The replication fork of DNA formed during DNA replication.



(ii)DNA replication occurs in S-phase of cell cycle in eukaryotes. Refer to answer.

55.Name the major types of RNAs and explain their role in the process of protein synthesis in a prokaryote. [Foreign 2014]
Ans.There are major three types of RNAs in prokaryotes which helps in protein synthesis as follows:
(i) Messenger RNA (mRNA) It is formed as a complementary strand on one of the two strands of DNA inside nucleus. Soon after its formation, mRNA comes out in cytoplasm. Formation of mRNA from DNA is called transcription. Function of mRNA is to carry the genetic information present in DNA (inside nucleus) to cytoplasm for protein synthesis.
(ii) Ribosomal RNA (rRNA) It is formed in nucleolus and it forms 80% of total RNA present inside the cell. It is also the moststable type of RNA. rRNA is associated with structural organisation of ribosomes (rRNA forms about 60% of weight of ribosomes), which are seats of protein synthesis.
(iii) Transfer RNA (tRNA) It is also called soluble RNA (sRNA) or adapter RNA or adaptive RNA. tRNA forms 10-15% of total RNA present in the cell. It acts as adapter molecule which carries amino acids to the site of protein synthesis i (i.e. ribosomes).

56.Describe the process of transcription in bacterium. [All India 2014 C]
Ans.Initiation process of transcription in bacteria RNA polymerase becomes associated transiently to an initiation factor (o) **and** binds to specific sequence on DNA **called** promoter to initiate transcription (initiation).

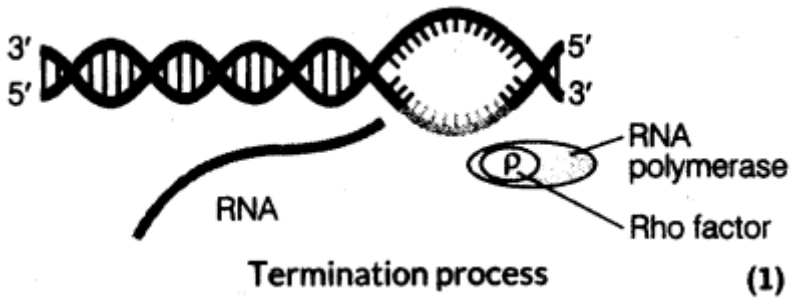


Initiation process

Elongation process of transcription in bacteria RNA polymerase facilitates opening of the DNA helix after binding to promoter it uses nucleoside triphosphates as substrate and polymerises the nucleotides in a template dependent fashion following complementarity.
The process continues till RNA polymerase reaches the terminator region on the DNA strand.

Elongation process

Termination occurs when RNA polymerase reaches the terminator region and the nascent RN A falls off. The RNA polymerase becomes transiently associated with termination factor (p) and falls off the transcription unit



Termination process (1)

57.(i)Explain the role of DNA dependent RNA polymerase in initiation, elongation and termination during transcription in bacterial cell.
(ii) How is transcription a more complex process in eukaryotic cells? Explain. [Foreign 2011]

Ans.(i)Role of DNA dependent RNA polymerase.

(a) RNA polymerase becomes associated transiently with initiation factor and binds to the promoter site on DNA and initiates transcription.

(b) It uses the nucleoside triphosphate as substrates and polymerises them in a template-dependent fashion following the base complementarity rule in the 5'-> 3'direction.

(c) It also facilitates the opening of the DNA helix and continues the elongation process.

(d) When the polymerase falls off a terminator region on the DNA, the nascent RNA separates. This results in termination.

(ii) Reasons that transcription is more complex in eukaryotes are:

(a)The three types of RNA polymerases in [r] the nucleus show division of labour

- RNA polymerase I transcribes rRNAs (28S, 18S and 5.8S).
- RNA polymerase II transcribes the precursor of mRNA, called hnRNA
- RNA polymerase III transcribes tRNA, 5 srRNA and snRNAse.

(b)hnRNA contains both coding sequences called exons and non-coding sequences called introns. So, it undergoes a process called splicing, in which the non-coding sequences (introns) are removed and the coding sequences (exons) are joined together in a defined order.

(c)In capping, unusual nucleotide,methyl guanosine triphosphate residues are added at the 5-end of the hnRNA.

(d)In tailing, 200-300 adenylate residues are added at the 3-end of the hnRNA.

58.Study the flow chart given below and answer the questions that follow :

(*i*) S-strain ⟶ into mice ⟶ mice die
(*ii*) R-strain ⟶ into mice ⟶ mice live
(*iii*) Heat killed S-strain + live R-strain ⟶ into mice ⟶ A
(*iv*) Heat killed S-strain + DNase + live R-strain ⟶ into mice ⟶ B

(a)Name the organism and differentiate between, its two strains R and S respectively.

(b)Write the result A and B obtained in step (iii) and (iv) respectively.
(c)Name the scientist who performed the steps (i), (ii) and (iii)
(d)Write the specific conclusion drawn from the step (iv).[Ail India 2010 C]
Ans.(a)The organism is bacterium Streptococcus pneumoniae. Differences between S-type cells and
R-type cells are:

S-type Cells	R-type Cells
They form smooth colonies protected by a capsule	They form rough colonies without a capsule
They are virulent	They are non-virulent

(b) A – Mice died B – Mice lived.
(c)Frederick Griffith performed these steps.
(d)This indicates that DNA is the transforming principle. When DNase is added to the medium, the DNA of the heat killed cells get denatured and is unable to carry transformation.

59.(i)What did Meselson and Stahl observed? When
(a)They cultured coli in a medium containing $^{15}NH_4Cl$ for a few generations and centrifuged the content?
(b)They transferred one such bacterium to the normal medium of NH_4Cl and cultured for two generations.
(ii)What did Meselson and Stahl conclude from his experiment? Explain with the help of diagrams.
(iii)Which is the first genetic material? Give reasons in support of your answer.
[Delhi 2009; Foreign 2009 ;Delhi 2008 C]

Ans.(i) (a)Meselson and Stahl observed that the ^{15}N was incorporated into the newly synthesised strand of DNA and also other nitrogen containing compounds. This heavy DNA could be distinguished from the normal DNA by centrifugation in a cesium chloride (CsCI) density gradient.

(b) DNA from such bacterium had a hybrid or intermediate density, one generation after the transfer from ^{15}N to ^{14}N. After another generation, it is composed of equal amount of this hybrid DNA and of light DNA

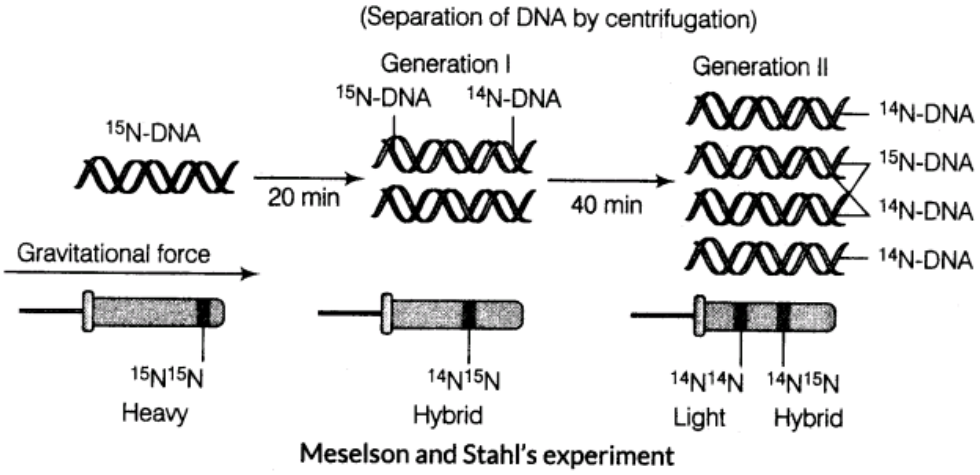
(ii)Meselson and Stahl concluded that replication of DNA is semiconservative.
Watson and Crick proposed that DNA replication is semiconservative. Later in the year 1958, Meselson and Stahl proved this. The semiconservative nature of DNA suggests that, after the completion of replication, each DNA molecule will have one parental and one newly-synthesised strand.

Experimental Proof

(i) E. coli was grown in a medium containing $^{15}NH_4CI$ (^{15}N is the heavy isotope of nitrogen) as the only nitrogen source for many generations. As a result, ^{15}N was incorporated into the newly-synthesised DNA. This heavy DNA could be distinguished by centrifugation in CsSI density gradient.

(ii) Then, these E. coli cells were transferred to a medium with normal $^{14}NH_4CI$ and the DNA was extracted as double stranded helix. The various samples were separated on CsCI gradients for measuring the density of DNA (after 20 min).

The hybrid had intermediate density.



Meselson and Stahl's experiment

(iii)After 40 min, the DNA of the second generation was extracted from the $^{14}NH_4CI$ medium and was found to have equal amounts of hybrid and light DNA.

(iv) This proves that after replication, each DNA molecule has one parental strand and one newly synthesised strand.

(iii)RNA is the first genetic material in cells because

(a) RNA is capable of both storing genetic information and catalysing chemical reactions.

(b) Essential life processes (such as metabolism, translation, splicing, etc.), were evolved around RNA.

(c) It shows the power of self-replication.

60.Why is DNA molecule more stable genetic material than RNA? Explain. [All India 2008]

Ans.DNA is more stable genetic material because

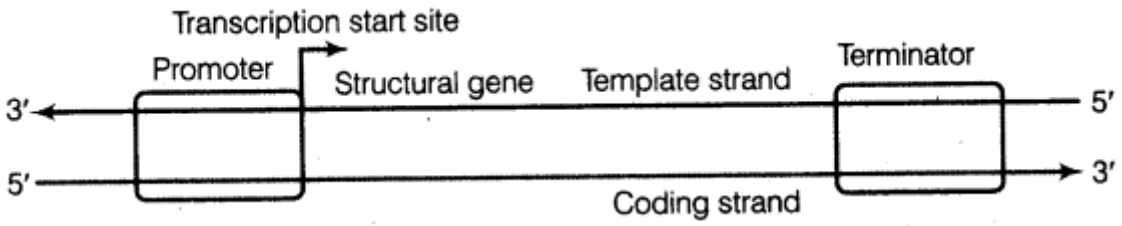
(i) The 2′— OH group in the nucleotides of RNA is a reactive group and makes RNA labile and easily degradable. But, DNA is chemically less reactive and structurally more stable.

(ii) The presence of thymine in place of uracil also confers more stability to DNA.

(iii)Two strands of DNA are complementary to each other and even if separated by heat, come together, when suitable conditions are created on the other hand, RNA is usually single stranded

61.Draw the labelled schematic structure of a transcription unit. Explain the function of each component of the unit in the process of transcription. [All India 2008]

Ans.Structure of a transcription unit



The promoter and terminator flank the structural gene in a transcription unit. The promoter is located towards 5′-end (upstream) of the structural gene. The terminator is located toward 3′-end (downstream) of the coding strand and it usually defines the end of the process of transcription
Functions of components of transcription unit

(i) **Promoter** (DNA sequence) Provides binding site for the RNA polymerase.

(ii) **Structural genes** Code for enzymes/ proteins and transcribe the mRNA for the same.

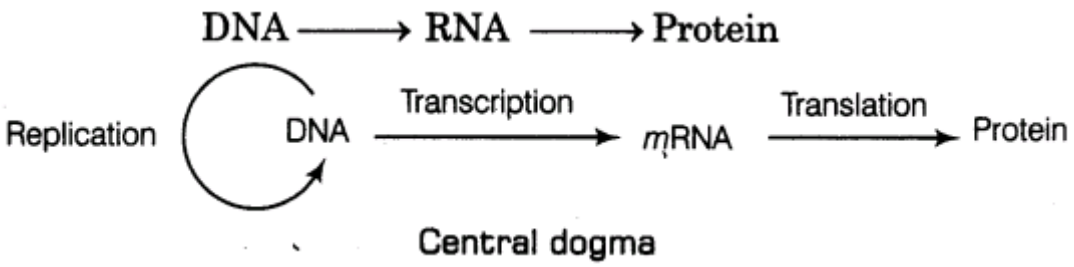
(iii)**Terminator** (sequence of bases) Defines the end of transcription process

(iv)DNA strand with 3′ – 5′ polarity – Acts as the template for transcription of mRNA.

(v)DNA strand with 5′ – 3′ polarity – Coding strand; it does not code for RNA, but all reference points regarding transcription are made with this strand

62.(i) State the central dogma in molecular biology. Who proposed it? Is it universally applicable? Explain.
(ii)List any four properties of a molecule to be able to act as a genetic material. [All India 2008 C]

Ans.(i) Francis Crick proposed the central dogma in molecular biology, which states that the genetic information flows from



Central dogma

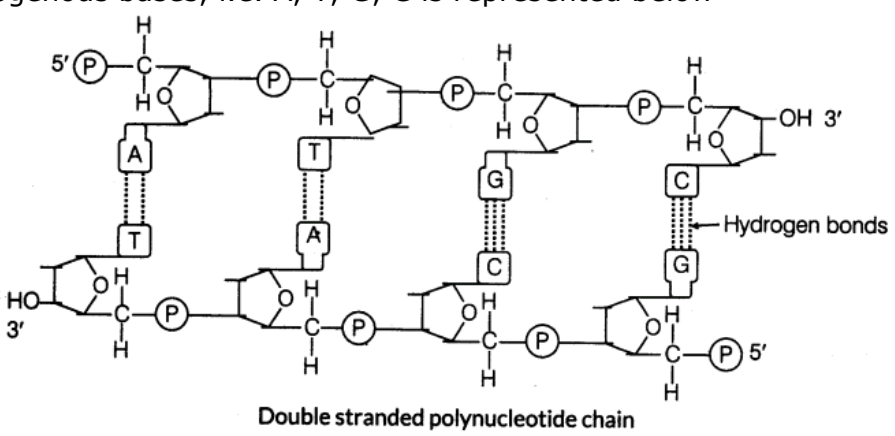
It is not universally applicable. In some viruses, the flow of information is in reverse direction, that is from RNA to DNA.

(ii) Properties of a molecule to act as a genetic material

- It should be able to generate its replica.
- It should chemically and structurally be stable.
- It should provide scope for slow changes (mutation) that are required for evolution.
- It should be able to express itself in the form of Mendel ian characters

63.Diagrammatically represent a portion of the double stranded polynucleotide chain sequence in a DNA molecule involving all the four nitrogenous bases.[All India 2008 C]

Ans. Double stranded polynucleotide chain sequence in a DNA molecule involving all the four nitrogenous bases, i.e. A, T, G, C is represented below



Double stranded polynucleotide chain

A nucleotide has three components a nitrogenous base, a pentose sugar and a phosphate group. **(5)**

Genetic Code, Human Genome Project and DNA Fingerprinting

1 Mark Questions

1.How is repetitive/satellite DNA separated from bulk genomic DNA for various genetic experiments. [Delhi 2014]

Ans.Satellite DNA is separated from bulk genomic DNA by density-gradient centrifugation technique

2.Mention the role of the codons AUG and UGA during protein synthesis. [Delhi 2011,2010]

Ans.AUG Acts as initiation codon and codes for amino acid methionine.

UGA Acts as stop/termination codon that signals termination of polypeptide synthesis.

3.Mention the contribution of genetic maps in human genome project. [Ml India 2011]

Ans.Genetic maps are used as a starting point in the sequencing of whole genomes.

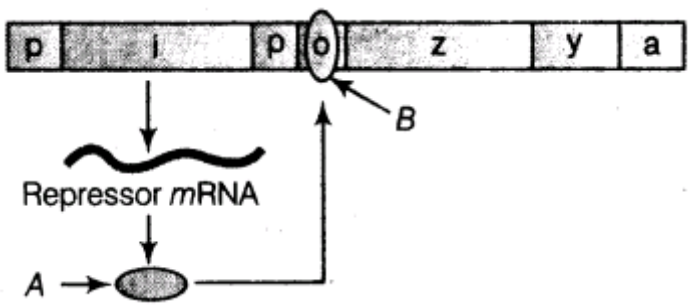
4.Mention any two ways in which Single Nucleotide Polymorphisms (SNPs) identified in human genome, can bring out revolutionary changes in biological and medical sciences? [Ml India 2011 C]

Ans.(i)By tracing human history.
(ii) By finding chromosomal locations for disease associated sequences.

5.State which human chromosome has [Foreign 2011]
(i)the maximum number of genes and
(ii)the one which has the least number of genes
Ans.(i)Chromosome 1

(ii) Chromosome Y

6.Given below is a schematic representation of a lac operon in the absence of an inducer. Identify 'A' and 'B' in it. [Foreign 2008]



Ans.**A-** Repressor

B- Repressor bound to the operator region and prevent transcription of structural genes.

2 Marks Questions

7. How would lac operon operate in E.coli growing in a culture medium where lactose is present as source of sugar? [All India 2014C]

Ans. When lactose is present in a medium having **E. coli,** it will act as a substrate for enzyme beta-galactosidase and switches on the operon. Hence, it is also termed as an inducer.

8.Where does peptide bond formation occur in a bacterial ribosome and how? [Foreign 2014]

Ans.A peptide bond is formed between carboxyl group (—COOH) of amino acid at P-site and amino groun (—NH) of amino acid at A-site by the enzyme peptidyl transferase in a bacterial ribosome.

9.(i) Name the scientist who suggested that the genetic code should be made of a combination of three nucleotides.
(ii) Explain the basis on which he arrived at this conclusion.[Delhi 2014]

Ans.(i) George Gamow suggested that the genetic code should be made of a combination of three nucleotides.

(ii) This is because the code must be of three bases in order to code for 20 amino acids since there, are only four bases (i.e. 4^3 or 4 x4 x4=64) which code for 20 amino acids.

10.Explain aminoacylation of tRNA.[All India 2014 C]

Ans.Aminoacylation of the tRNA It is also, called as charging of tRNA. It is the first phase of translation where amino acids are activated in the presence of ATP and linked to their cognate tRNA.
Enzyme and AMP are released. tRNA complexed with amino acid is sometimes called charged fRNA. The amino acid is linked to 3'—OH end of tRNA through its —COOH group.
AA— AMP + t + tRNA-> AA—tRNA+ AMP+ E (aminoacyl adenylate enzyme

11.Why is charging of fRNA necessary during translation process?[All India 2014 C; Delhi 2008]

Ans.Process of Charging of FRNA

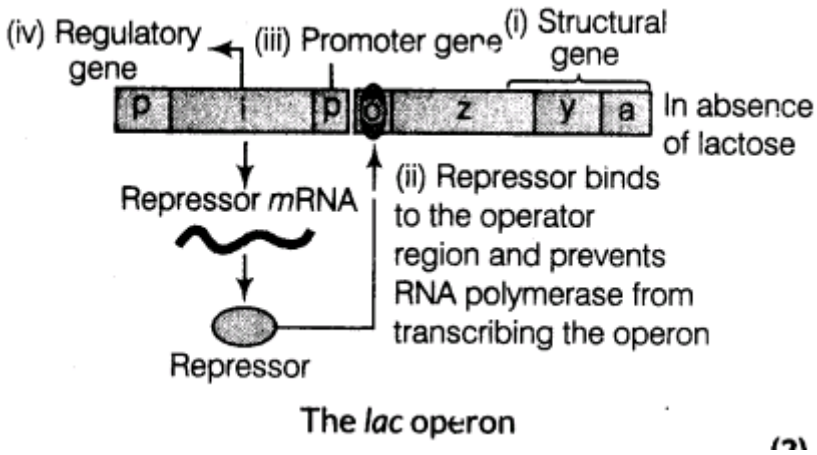
Amino acids are activated in the presence of ATP and linked to their cognate tRNA. This is called charging of tRNA (amino acylation).
The process is required as the formation of peptide bond between the amino acids is favoured energetically, when they are brought together. Activation of amino acids by ATP provides the energy for the formation of peptide bond.

12.One of the salient features of the genetic code is that it is nearly universal from bacteria to humans. Mention two exceptions to this rule, Why are some codes said to be degenerated? [Foreign 2014]

Ans.Genetic code is nearly universal except in mitochondrial codons and in some protozoans. Some amino acids are coded by more than one codon, hence somes codes are said to be degenerated

13.Draw a schematic diagram of lac operon in its switched off position. Label the following,
(i)Structural genes
(ii)Repressor bound to its correct positions
(iii)Promoter gene
(iv)Regulatory gene [Foreign 2012]

Ans.



The *lac* operon

14.Write the full form of VNTR. How is VNTR different from Probe?[All India 2011]

Ans.VNTR—Variable Number Tandem Repeat. Difference between VNTR and Probe

VNTR	Probe
It is a class of satellite DNA, where a small sequence is arranged tandemly in many copy numbers.	It is a radio labelled VNTR, used for hybridisation with DNA segments in question.

15.Mention the role of ribosome in peptide bond formation. How does ATP facilitate it? [All India 2010]

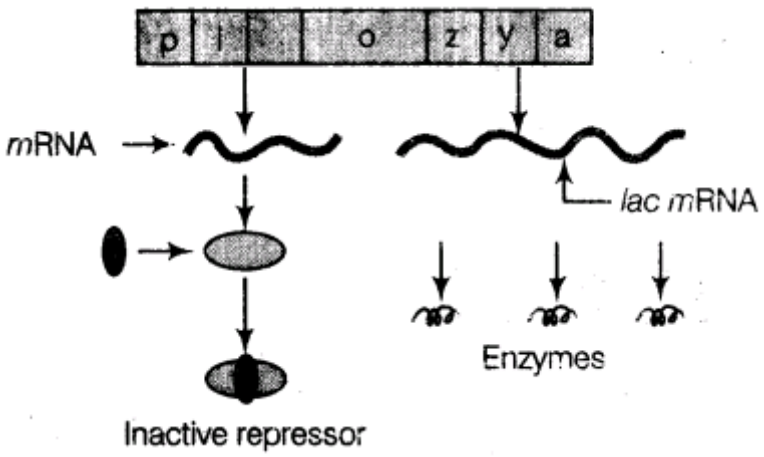
Ans.(i)Ribosomes are main cellular site of protein synthesis. They also act as catalyst (23S rRNA) in prokaryotes for formation of peptide bonds.

(ii) ATP provides energy for activation of amino acids.

16.How is the translation of mRNA terminated? Explain. [Delhi 2009]

Ans.Termination of translation of mRNA : When one of the termination codons (UAA, UAG, UGA), comes at the A-site, it does not code for any amino acid and there is no tRNA molecule for it. It leads to termination of polypeptide synthesis.
The synthesised polypeptide is released from the ribosome and is catalysed by a 'release factor

17.Study the figure given and answer the questions



(i)How does the repressor molecule get inactivated?
(ii)When does the transcription of lac mRNA stop?
(iii)Name the enzyme transcribed by the gene z [Delhi 2009]

Ans.(i)When the inducer binds to the repressor, the repressor is inactivated.

(ii) The transcription stops when lactose becomes exhausted or when there is no need for energy to the cells.

(iii) beeta-galactosidase

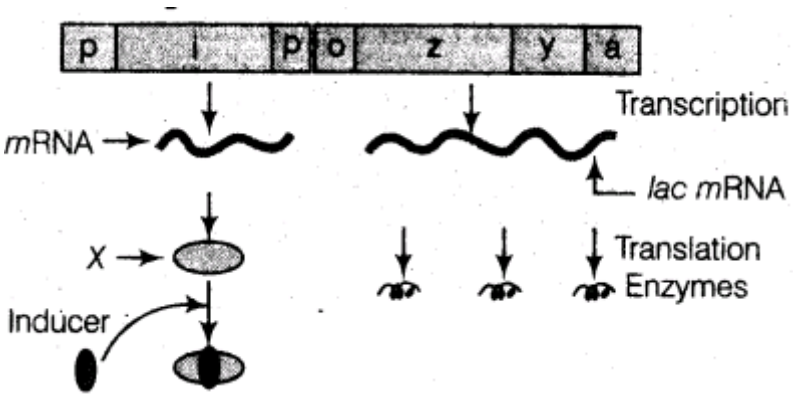
18.Explain the dual function of AUG codon. Give the sequence of bases if is transcribed from and its anticodon [All India 2009]

Ans. Dual function of AUG codons are:

(i) Codes for methionine (amino acid).

(ii) Functions as initiation codon.
It is transcribed by TAC on DNA. Anticodon-UAC

19.(i)Name the molecule X synthesised by i gene. How does this molecule get inactivated



(ii)Which one of the structural genes codes for beeta galactosidase?
(iii)When will the transcription of this gene stop? [All India 2009]

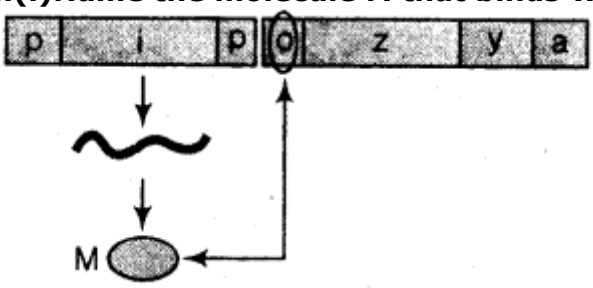
Ans.(i)Molecule X—Repressor protein. When an inducer combines with it, it is inactivated.
(ii) z gene
(iii) Transcription stops when

- Substrate lactose is not available.
- Energy source, glucose is available to the cells.

20.Name the category of codons UGA belongs to. Mention another codon of the same category. Explain their role in protein synthesis. [Foreign 2009]

Ans.It is a stop/termination codon. UAA or UAG are the other codons of same catego
Thesv codon terminate the translation proceso, they stop the elongation of polypeptide chain during translation,

21.(i)Name the molecule M that binds with the operator



(ii)Mention the consequences of such binding.
(iii)What will prevent the binding of the molecule M with the operator gene? Mention the event that follows. [Foreign 2009]

Ans.(i)M-Repressor

(ii) When repressor binds to the operator, transcription by RNA-polymerase is prevented.

(iii)An inducer prevents the binding of repressor to operator. The event that follow is RNA polymerase gets access to the promoter and transcription proceeds.

22.(i) Differentiate between unambiguous and degenerate codons.
(ii) Write two functions of the codon AUG. [All India 2010 C]

Ans.(i)Differences between unambiguous and degenerate codons are

Unambiguous	Degenerate
No ambiguity for a particular codon. For example, GGA is an ambiguous codon, it codes for glycine as well as glutamic acid.	Code is degenerate for a particular amino acid.
A particular codon will always code for the same amino acid, where it is found.	One amino acid often has more than one code triplet. e.g. pheny lalanine has two codons, i.e. UUU and UUC.

(ii)**Functions of Codon AUG** Codes for methionine and is the starting point of protein synthesis (initiation codon).

23.Genetic code is specific and nearly universal. Justify. [All India 2008 C]

Ans.In genetics, one codon codes for only one amino acid, hence it is unambiguous and specific. Since the codon codes for the same amino acid in any organism. It is universal.
For example, from bacteria to human UUU would code for phenylalanine (Phe). Some exceptions are found in mitochondrial codon and in some protozoans

3 Marks Questions

24.(i) Which human chromosome has

- **maximum number of genes and**
- **which one has fewest genes?**

(ii) Write the scientific importance of single nucleotide polymorphism identified in human genome. [All India 2014c]

Ans.(i) (a)Chromosome 1 has most genes,i.e. 2968.

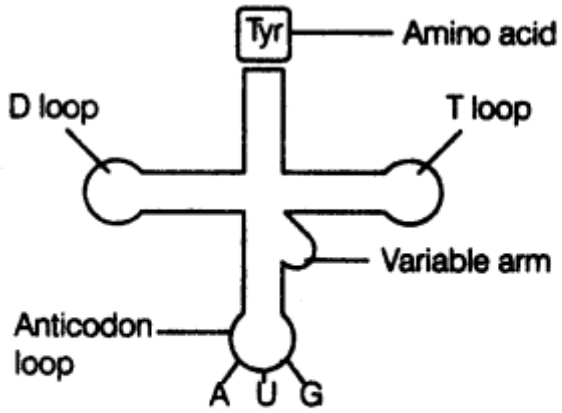
(b) Y-chromosome has the fewest genes, i.e. 231. (1K)

(ii) Scientists have identified about 1.4 million locations, where single base DNA differences, Single Nucleotide Polymorphism (SNPs) occur in humans.
Since, these sequences have high degree of polymorphism they form the basis of DNA fingerprinting.

25.(i) Name the scientist who postulated the presence of an adapter molecule that can assist in protein synthesis.
(ii) Describe its structure with the help of a diagram. Mention its role in protein synthesis.[Foreign 2014]

Ans.(i)Francis Crick proposed the presence of an adapter molecule which could read the code on one end and on the other end would bind to the specific amino acids.

(ii) A clover leaf structure of tRNA



A tRNA functions as carrier of amino acids and participates in protein synthesis. **(2)**

26.Following a severe accident, many charred-disfigured bodies are recovered from the site making the identification of the dead very difficult. Name and explain the technique that would help the authorities to establish the identity of the dead to be able to handover the dead to their respective relatives. [All India 2014 C]

Ans.To find out the identity of the dead person to handover him to his respective relatives we perform DNA fingerprinting of both, i.e. the dead person and their relatives. This is done because DNA fingerprinting uses short nucleotide repeats called Variable Number of Tandem Repeats (VNTRs) as markers. VNTRs vary from person to person and are inherited from one generation to the next. And only closely related individuals have similar VNTRs.

27.In a maternity clinic, for some reasons the authorities are not able to hand over the two newborns to their respective real parents. Name and describe the technique that you would suggest to sort out the matter. [HOTS; All India 2013]

Ans.DNA fingerprinting can sort out this dispute of maternity

The steps of this technique are:

Step I The technique involves Southern blot hybridisation using radiolabelled VNTR as a probe.

Step II The methodology includes

(i)DNA is isolated and digested by the restriction endonucleases.

(ii)DNA fragments are separated by electrophoresis.

(iii) Separated DNA fragments are transferred to synthetic membranes like nitrocellulase or nylon.

(iv) Hybridisation using labelled VNTR probe.

(v)Hybridised DNA fragments are detected by autoradiography.

28.(i) Explain DNA polymorphism as the basis of genetic mapping of human genome. (ii) State the role of VNTR in DNA fingerprinting. [All India 2013]

Ans.(i)Human genome project was launched in 1990. Methodologies of HGP is focused on two main lines, i.e. expressed sequence tags and sequence annonation. The genetic and physical maps of the genome were constructed by collecting information about certain repetitive DNA sequences and DNA polymorphism.

(ii) Variable Number of Tandem Repeats (VNTRs) belong to a class of satellite DNA called as minisatellite. VNTRs are used as probes in DNA fingerprinting.

29.Given below are the sequence of nucleoside in a particular mRNA and amino acids coded by it UUUAUGUU CGAGUUAGUGUAA Phe – Met – Phe – Glu – Leu – Val
Write the properties of genetic codes that can be and that cannot be correlated from the above given data. [Delhi 2013C, 2010C, 2009C]

Ans.UUUAUGUUCGAGUUAGUGUAA Phe – Met – Phe – Glu – Leu – Val According to the sequence given above

(i) Codon is triplet.

(ii) Genetic code is specific and unambiguous
For example, AUG – Codes for methionine (Met)
GAG – Codes for glutamine (Glu)
UUA – Codes for leucine (Leu)

(iii) Codon is degenerate, i.e. same amino acids are coded by more than one code.
For example, UUU and UUC both codes for phenylalanine (Phe).

(iv) Code is read without punctuation.

(v)UUA acts as a terminating code.
Thus, all properties of codon are satisfied from the above given data. Except the one that mostly AUG work as a initiating codon.

30.How are the structural genes activated in lac operon in coli?[All India 2012]

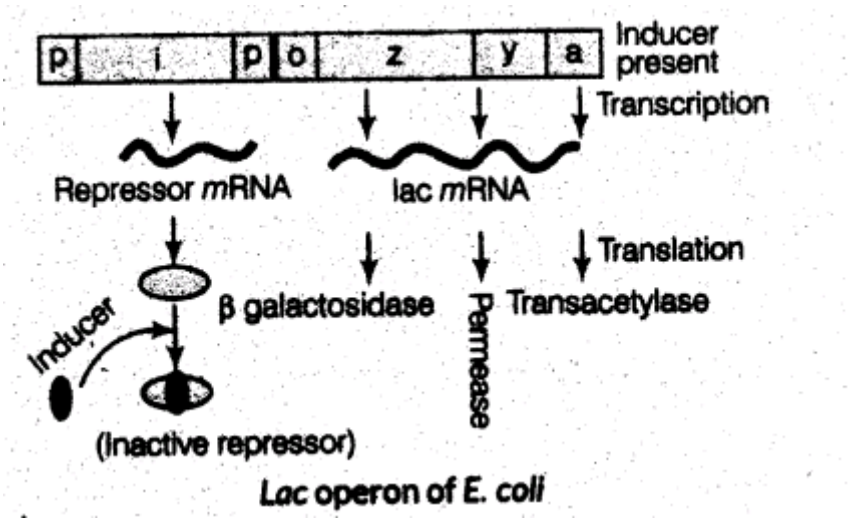
Ans.Lacoperon consists of

(i)an operator, which control all structural genes as a unit,

(ii)a regulatory gene (i gene)

(iii)three structural genes (z, y, a) which code for enzymes and

(iv)a promoter, where RNA polymerase binds for transcription.
The regulatory gene codes for a repressor protein and repressor has high affinity for the operator region and prevents RNA polymerase from transcribing the structural genes i.e. the lac operon is switched off or inactive



Lac operon of E. coli

lac operon in presence of inducer when inducer (lactose) is added it binds with repressor protein and inactivates it. This allow RNA polymerase access to promoter and transcription proceeds

31.State the conditions when genetic code is said to be
(i)Degenerate
(ii)Unambiguous and specific
(iii) Universal [Foreign 2012]
or
Unambiguous, universal and degenerate are some of the terms used for the genetic code. Explain the salient features of each of them [All India 2011]

Ans.(i)Genetic code is degenerate because some amino acids are coded by more than one codons.

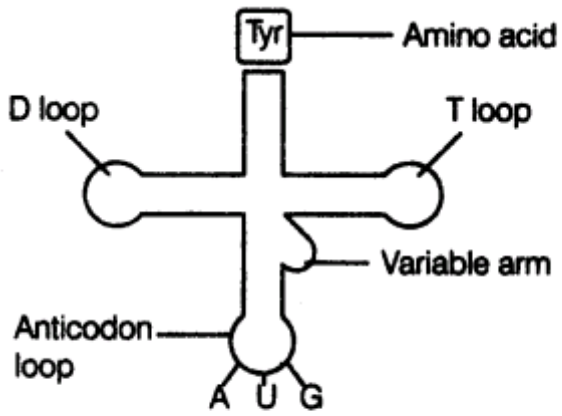
(ii) Genetic code is unambiguous as one codon codes for only a particular amino acid.

(iii) Genetic code is universal as a codon codes for the same particular amino acid in all organisms from human to bacteria.

32.(i) Name the scientist who called tRNA an adapter molecule.
(ii)Draw a clover leaf structure of fRNA showing the following :
(a)Tyrosine attached to its amino acid site.
(b)Anticodon for this amino acid in its correct site (codon for tyrosine is UAC).
(iii)What does the actual structure of tRNA look like? [All India 2011]

Ans.(i)Francis Crick

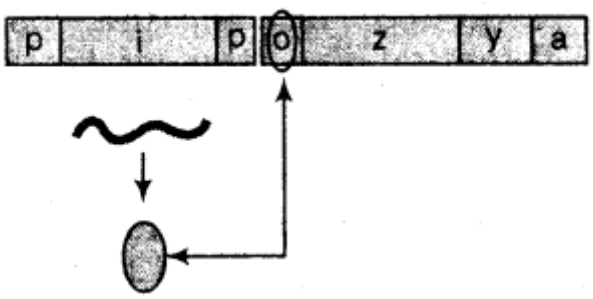
(ii) (a)Francis Crick proposed the presence of an adapter molecule which could read the code on one end and on the other end would bind to the specific amino acids.
(b) A clover leaf structure of tRNA



A tRNA functions as carrier of amino acids and participates in protein synthesis. **(2)**

(iii) tRNA looks like inverted L.

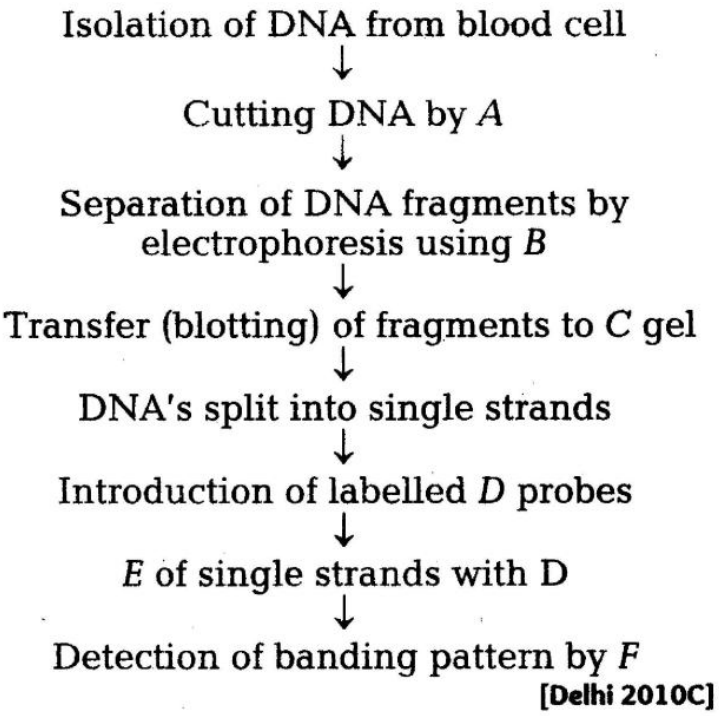
33.Given below is a scheme representation of a lac operon



(i)Identify i and p.
(ii) Name the inducer for this operon and explain its role. [Foreign 2011]

Ans.(i)i-Regulatory gene, p—Promoter gene.
(ii)Inducer is lactose. Its function? are : It enters the cell and binds to the repressor and inactivates it. As a result, repressor cannot bind to the operator. This allows RNA polymerase to have access to the promoter and transcription proceeds

34.The following is the flow chart highlighting the steps in DNA fingerprinting technique. Identify A, B, C, D, E and F.



[Delhi 2010C]

Ans.A -Restriction endonuclease
B-Ethidium bromide
C-Agarose
D-VNTR E-A piece
F-Autoradiography

35.Explain the role of regulatory gene in a lac operon Why is regulation of lac operon called negative regulation? [All India 2010 c]

Ans.The lac operon consists of one regulatory gene and three structural gene (z, y and a)The i gene codes for the repressor of the lac
If repressor protein binds to operator region of operon, it prevents RNA polymerase from transcribing the operon. Whereas, in presence of lactose (inducer) the repressor become inactivated due to interaction with inducer.
This allow RNA polymerase access to promoter and transcription proceeds. Regulation of **lac** operon is negative, it can be visualised as regulation of enzymes synthesis by its substrate. Regulation of **lac** operon by repressor is referred to as negative regulation

36.A considerable amount of lactose is added to the growth medium of coli. How is the lac operon switched on in the bacteria? Mention the state of the operon when lactose is digested.[All India 2010 C]

Ans.In lac operon, when lactose is added, it enters the cell wall with the help of permease, a small amount of which is already present in cell. Lactose binds itself to active repressor and changes its structure. The repressor now fails to bind to the operator.
Then, RNA polymerase starts transcription of operon by binding to promoter site-P. All the three enzymes for lactose metabolism are synthesised. After sometime, when whole of lactose is consumed, there is no inducer present to bind to the repressor. Then the repressor becomes active again, attaches itself to the operator and finally switches off the operon.

37.(i) How many codons code for amino acids and how many do not?
(ii) Explain the following giving one example of each

- **Unambiguous and specific codon**
- **Degeneration codon**
- **Universal codon**
- **Initiator codon [All India 2010c]**

Ans.(i)Out of 64 codons 61 codons codes for amino acids and rest 3 codons do not code for any amino acids. These function as stop codons.

(ii) (a) Unambiguous and specific—codon codes for only one amino acid, so it is unambiguous and specific, e.g. GGA.

(b) Some amino acids are coded by more than one codon so, the code is degenerate, e.g. UUV

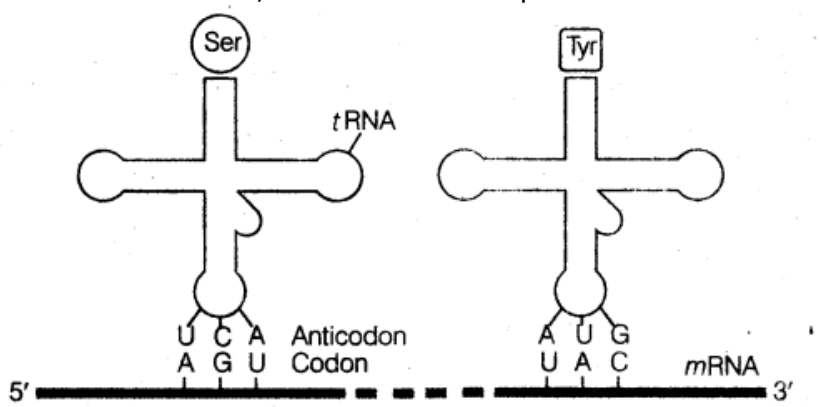
(c)Codon is nearly universal. Some exceptions to ^ ,the rule are mitochondrial codon ahd in some protozoans, e.g.,UUV

(d)Initiator codon. AUG has dual function. It codes for methionine and also acts as initiator.

38.(i) Why is fRNA called an adapter? (ii) Draw and label a secondary structure of fRNA. How does the actual structure of fRNA look like? [All India 2010 C; 2008]

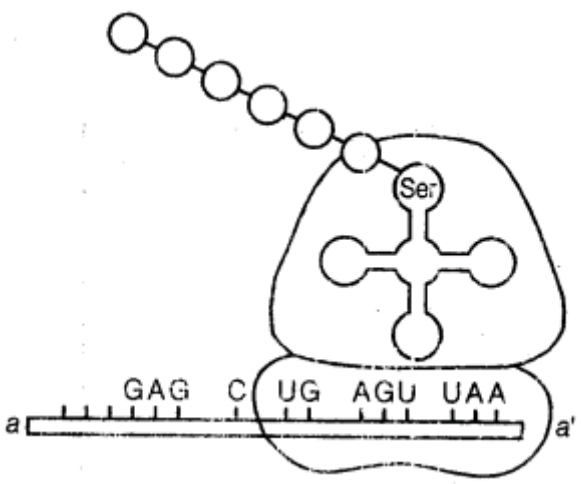
Ans.(i)tRNA binds to a specific amino acid and it also reads the codon of the amino acid bound to it through it anticodon. So, it is called an adapter molecule.

(ii) In actual structure, thetRNA is a compact molecule and looks like inverted **L**



Secondary structure of t RNA

39.(i) Identity the polarity from a to d,in the diagram below and mention how many more amino acids are expected to be added to this polypeptide chain.



(ii)Mention the DNA sequence coding for serine and the anticodon of fRNA for the some amino acid.
(iii)Why are some untranslated sequence of bases seen in mRNA coding for a polypeptide? Where exactly are they present on mRNA?[Foreign 2009]

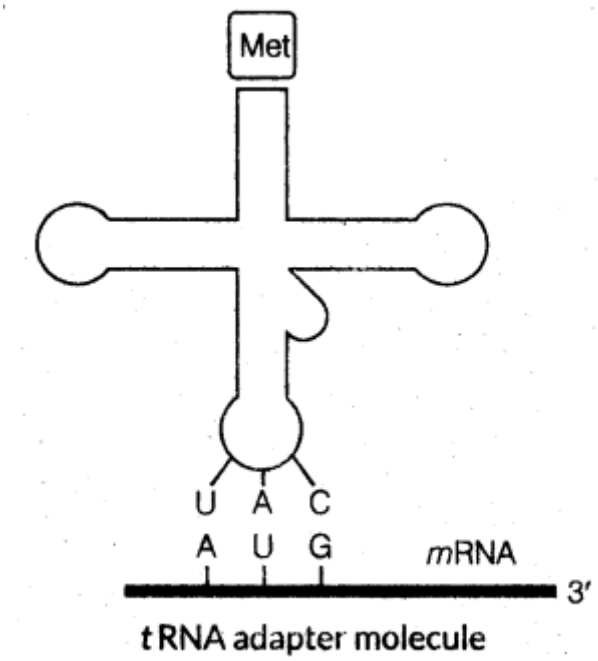
Ans.(i)a to a! is 5′———– > 3′ . No more amino acid will be added.

(ii) TCA, Anticodon is UCA.

(iii) The untranslated regions are required for efficient translation process. They are present before the initiation codon at the 5 – end and after the stop/termination codon, at the 3 – end.

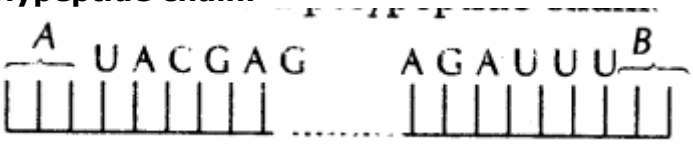
40.One of the codons on mRNA is AUG. Draw the structure of fRNA adapter molecule for this codon. Explain the uniqueness of this fRNA. [Delhi 2008]

Ans.



Uniqueness of this tRNA is that, it is referred to as initiator tRNA because it is specific for initiation.

41.Study the mRNA segment given below which is complete to be translated into a polypeptide chain.



(i)Write the codons A and
(ii)What do they code for?
(iii)How is peptide bond formed between two amino acids in the ribosome? [All India 2008]

Ans.(i)A- -AUG, B— UAA/UAG/UGA

(ii) AUG codes for methionine. UAA/UAG/ UGA does not code for any amino acid but, brings about termination of polypeptide synthesis.

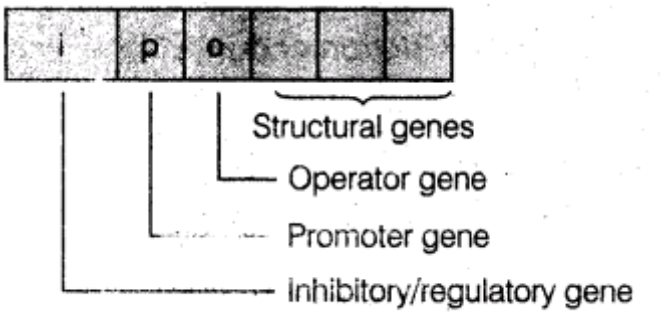
(iii) In the large subunit of ribosome, there are **two** sites where subsequent amino acids bind to and come close enough for the formation of peptide bond. It is catalysed by the peptidyl transferase.The ribosome also acts as a catalyst for peptide bond formation.

42.(i)State the arrangement of different genes that in bacteria is referred to as operon.
(ii)Draw a schematic labelled illustration of lac operon in a switched on state.
(iii)Describe the role of lactose in the lac operon. [All India 2008; Delhi 2008C]

Ans.(i)The different genes in an operon are:

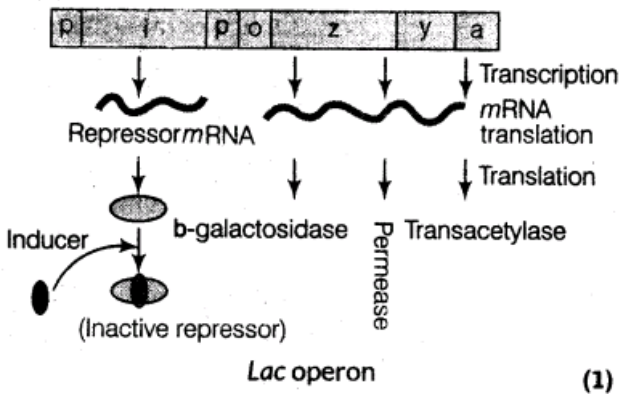
- Structural genes
- Operator gene
- Promoter gene
- Inhibitor/regulatory gene.

An operator gene lies adjacent to the structural gene.
Promoter gene lies on its other side.
On the other side of promoter gene, lies regulatory/inhibitory gene



(1)

(ii)



Lac operon **(1)**

(iii)Role of lactose in lac operon

- It is the substrate for the enzyme (3-galactosidase.
- It functions as the inducer and regulates the switching on and off of the operon.
- When lactose is present, it combines with the repressor protein, which otherwise has high affinity for the operator.
- It inactivates the repressor from binding to the operator and hence, transcription continues, i.e. the operon is switched on

43.Describe how the lac operon operates, both in the presence and the absence of an inducer in coli.
[All India 2014]

Ans.Lac operon is made up of one regulatory gene and three structural genes (z, y, a).
Its function in the presence and the absence of inducer is as under:
(i) When inducer (lactose) is absent i-gene regulates and produces repressor mRNA in the absence of lactose, which translate repressor. The repressor protein binds to the operator region of operon and as a result prevents RNA polymerase to bind to the operon. The operon is switched off in this situation. (ii) When inducer (lactose) is the present Lactose acts as an inducer and binds to the repressor. Thus, forming an inactive repressor.
The repressor fails to bind the operator region. The RNA polymerase binds to the operator and transcripts lac mRNA Lac mRNA is known to be polycistronic which produces all three enzymes, i.e. p-galactosidase, permease and **trans** acetylase. Operon is switched on in this situation.

44.Explain the process of translation. [All India 2014 C]

Ans.Translation is the process of polymerisation of amino acids to form a polypeptide.

The different phases of translation are:
(i) Activation of amino acids
(ii) Initiation of polypeptide synthesis
(iii) Elongation of polypeptide chain
(iv) Termination of polypeptide

45.(i) What is a genetic code?
(ii) Explain the following Degenerate code, Unambiguous code. Universal code, Initiator code.
[All India 2014C]

Ans. The relationship between the sequence of nucleotides on mRNA and sequence of amino acids in the polypeptide is called genetic code,

(i)Out of 64 codons 61 codons codes for amino acids and rest 3 codons do not code for any amino acids. These function as stop codons.

(ii) (a) Unambiguous and specific—codon codes for only one amino acid, so it is unambiguous and specific, e.g. GGA.

(b) Some amino acids are coded by more than one codon so, the code is degenerate, e.g. UUV

(c)Codon is nearly universal. Some exceptions to ^ ,the rule are mitochondrial codon ahd in some protozoans, e.g.,UUV

(d)Initiator codon. AUG has dual function. It codes for methionine and also acts as initiator.

5 Marks Questions

46.(i)Write the specific features of the genetic code AUG.
(ii) Genetic codes can be universal and degenerate. Write about them, giving one example of each.
(iii) Explain aminoacylation of the tRNA. [All India 2013]

Ans.(i)Genetic code AUG is an initiation codon that works as a start signal and also codes for methionine.

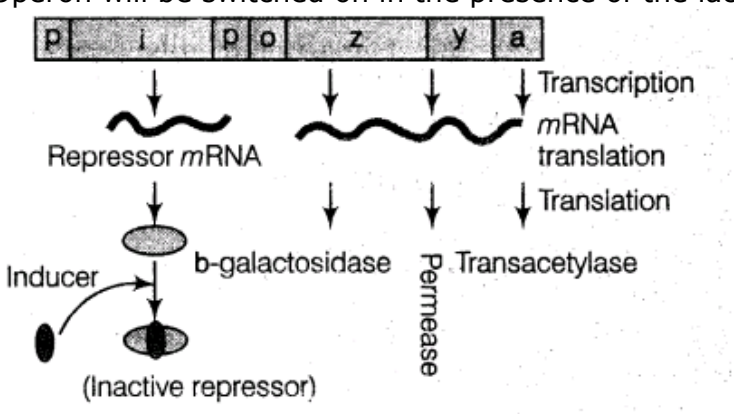
(ii) (a) Genetic codes are universal, i.e. a codon specifies the same amino acid from a virus, to a tree or human being.

(b) The degeneracy of genetic code can be proved by the fact that there are 64 triplet codons, and only 20 amino acids, the incorporation of some amino acids must be influenced by more than one codon with the exception of tryptophan (UGG) and methionine (AUG) that are specified by single codons, while all other amino acids are specified by two to six codons

(iii)Aminoacylation of the fRNA Refer to answer 10

47.Given below is the schematic representation of lac operon of E. coli. Explain the functioning of this operon when lactose is provided in the growth medium of the bacteria. [Delhi 2013 c]

Ans. Lactose in the lac operon regulates the switching the operon, on and off. If lactose is present in the medium, it acts as an inducer here and the substrate for the enzyme ^-galactosidase.
It binds to the repressor and forms an inactive repressor which fails to bind to the operator region of the Operon.
The RNA polymerase thus, binds to the operator and transcribes lac mRNA. lac mRNA produces all three enzymes (|J-galactosidase, permease and transacetylase) known as polycistronic. Therefore, Operon will be switched on in the presence of the lactose.



Lac operon of *E. coli* (5)

48.Study the schematic representation of the genes involved in the lac operon given below and answer the questions that follow

(i)Identify and name the regulatory gene in this operon. Explain its role in 'switching off' the operon.
(ii)Why is lacoperon's regulation referred to as negative regulation?
(iii)Name the inducer molecule and the products of the genes z and y of the operon. Write the function of these gene products. [Foreign 2010]

Ans.(i)i gene-regulatory gene. It codes for the repressor protein of the operon,, which is synthesised constitutively.The repressor has the affinity for the operator gene. It binds to the operator and prevents the RNA polymerase from transcribing the structural genes. (2)

(ii) When repressor binds to the operator, the operon is switched off and transcription is stopped. So, it is called negative regulation.

(iii) Lactose is an inducer molecule.Gene 'z' codes for |3-galactosidase which is responsible for the hydrolysis of lactose into galactose and glucose.
'y' gene codes for permease. It increases the permeability of the cell to lactose.

49.DNA polymorphism is the basis of DNA fingerprinting technique. Explain.
(ii) Mention the causes of DNA polymorphism. [Foreign 2010]

Ans.(i)DNA polymorphism It Is the occurrence of inheritable mutations at a frequency greater than 0.01 in a population.

(a)Such variations often occur in non-coding sequences. They keep on accumulating generation after generation.

(b)Types of polymorphism range from single nucleotide change to very large scale changes.

(c)Single nucleotide polymorphism is used to diagnose disease related sequences of DNA on the chromosome.

(d)Variable number of tandem repeats show a high degree of polymorphism.

(ii) DNA polymorphism occurs due to mutations

50.Name and describe the technique that will help in solving a case of paternity dispute over the custody of a child by two different families.[All India 2010]
or
Two blood samples A and B picked up from the crime scene were handed over to the forensic department for genetic fingerprinting. Describe how the technique of genetic fingerprinting is carried out. How it will be confirmed whether the samples belonged to the same individual or to two different inividuals? [Delhi 2009]
or
Explain the steps of DNA fingerprinting that will help in processing of the two blood samples 'A' and 'B' picked up from the crime scene. [Foreign 2009]

Ans. The technique which help in solving a case of paternity dispute over the custody of child by two families is called DNA fingerprinting.
Procedure of DNA fingerprinting.

(i) VNTR form the basis of DNA fingerprinting: The repeats of it show high degree of polymorphism.

(ii) After hybridisation with the radiolabelled VNTR probe and autoradiography, bands of various sizes are formed.

(iii) Bands form a characteristic pattern, which varies from person to person.

(iv) The patterns developed by sample A and B, can confirm that whether they belong to one person or two different persons.

Miscellaneous Questions

3 Marks Questions

1.(i) Name the enzyme responsible for transcription of tRNA and the amino acid, the initiator tRNA gets linked with.
(ii) Explain the role of initiator tRNA in initiation of protein synthesis. [Delhi 2012]

Ans.(i) RNA polymerase transcribes tRNA and the amino acid, the initiator tRNA gets linked with methionine.

(ii) The initiator tRNA binds to the amino acids methionine, at its amino acid acceptor site.
It has anticodon loop, which has anticodon for methionine, i.e. UAC, it recognises the start codon (AUG) at P site and binds to it according to complementarity of bases.

2.Given below is a part of the template strand of a structural gene.
TACCATTAGGAT
(i)Write its transcribed mRNA strand with its polarity.
(ii)Explain the mechanism involved in initiation of transcription of this strand.[Delhi 2008]

Ans.(i)5'-AUGGUAAUCCUA-3'.

(ii) Initiation of transcriptionTranscription is carried out by the enzyme DNA-dependent RNA polymerase, that catalyses the polymerisation of nucleotides in the 5'->3' direction only.Strand of DNA with 3'-» 5' polarity acts as the template.RNA polymerase binds to the promoter site, a particular sequence of DNA and starts the process.

3.Describe the role of RNA polymerases in transcription in bacteria and in eukaryotes. [Foreign 2010]

Ans. In bacteria, there is a single DNA-dependent RNA polymerase which catalyses the formation of mRNA, tRNA and rRNA.
In eukaryotes, there are three types of RNA polymerases, which show division of labour.
In the nucleus, there are three types of RNA polymerases

(i) RNA polymerase I transcribes rRNAs, (28S, 18S and 5.8S)

(ii) RNA polymerase II transcribes the precursor of mRNA called hnRNA.

(iii)RNA polymerase III transcribes tRNA, 5 SrRNA and SnRNAs.

4.(i) Name the enzyme responsible for the transcription of tRNA and the amino acid, the tRNA gets linked with.
(ii) Explain the role of initiator tRNA in intiation of protein synthesis. [Delhi 2012]

Ans.(i)RNA polymerase III is responsible for transcription of tRNA and methionine is the amino acid that gets linked with the initiator tRNA.

(ii) Initiator tRNA carries amino acid methionine at its amino acid binding site and has anticodon UCA at its anticodon binding site. Initiator tRNA binds with the codon AUG present on the mRNA and in this way the initiator tRNA plays a role in initiation of protein synthesis.

5 Marks Questions

5.Where do transcription and translation occur in bacteria and eukaryotes respectively? Explain the complexities in transcription and translation in eukaryotes that are not seen in bacteria. [Foreign 2010]

Ans. In bacteria, both processes occur in cytoplasm as there is no nucleus.
In eukaryotes, transcription occurs in nucleus, while translation occurs in the cytoplasm.
Complexities in eukaryotic transcription

Complexities in translation in eukaryotes are

- The mRNA formed in nucleus has to be transported to the cytoplasm.
- Transcription and translation cannot be coupled in eukaryotes.