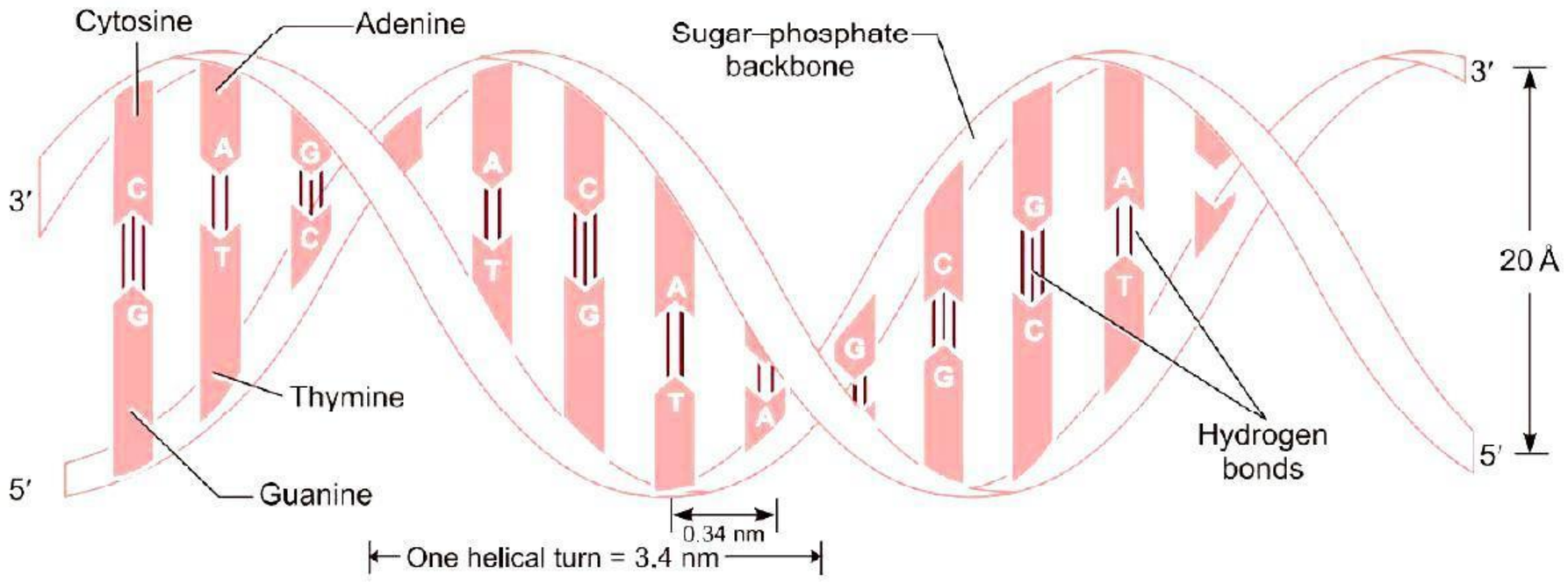
MOLECULAR BASIS OF INHERITANCE

BASIC CONCEPTS

1. A nitrogenous base is attached to the pentose sugar by an N-glycosidic linkage to form a nucleoside. When a phosphate group is attached to 5′–OH of a nucleoside through phosphodiester linkage, a nucleotide is formed.

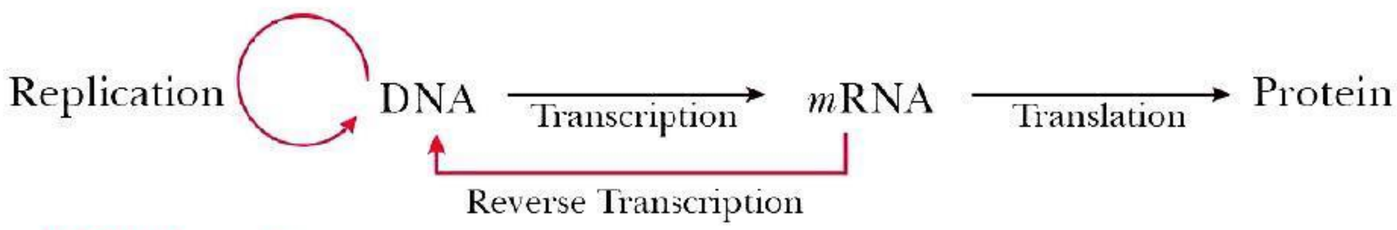
2. **Chargaff's rules:**
   (*i*) The amount of adenine is always equal to the amount of thymine and the amount of guanine is always equal to the amount of cytosine, *i.e.*, [A] = [T], [G] = [C]
   (*ii*) Adenine is joined to thymine with two hydrogen bonds and guanine is joined to cytosine by three hydrogen bonds.
   (*iii*) The ratio of adenine and guanine to that of thymine and cytosine is always equal to one, *i.e.*,

$$\frac{[A + G]}{[T + C]} = 1$$



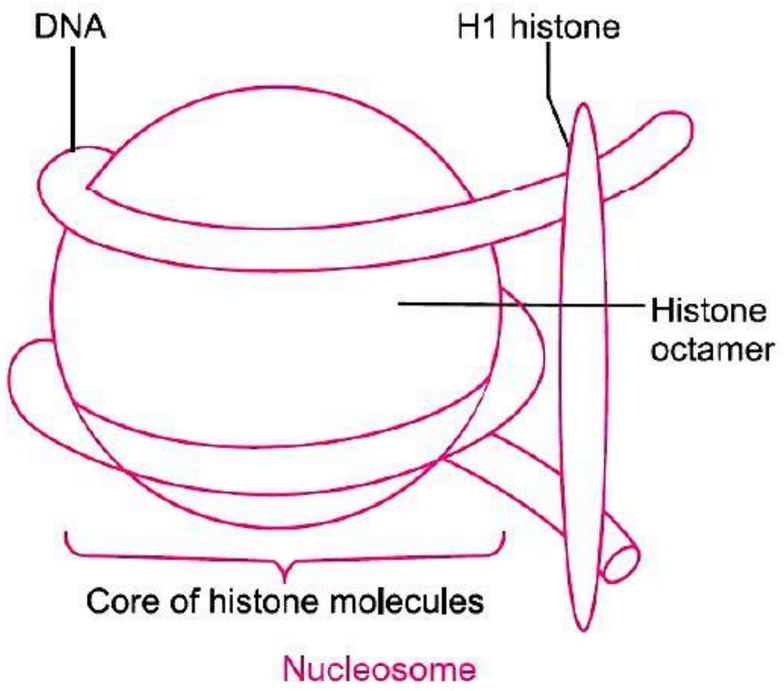
DNA double helix

3. **Francis Crick** proposed the central dogma of molecular biology which states that genetic information flows from DNA to *m*RNA (transcription) and then from *m*RNA to protein (translation) always unidirectionally (except bidirectionally in some viruses and the process is called reverse transcription).



4. **Packaging of DNA in eukaryotes**
   - The proteins associated with DNA are of two types—basic proteins (histones) and acidic non-histone chromosomal (NHC) proteins.
   - The negatively charged DNA molecule wraps around the positively charged histone proteins to form a structure called **nucleosome**.

- The nucleosome core is made up of four types of histone proteins—H_2A, H_2B, H_3 and H_4 occurring in pairs.
- 200 bp of DNA helix wrap around the nucleosome by 1¾ turns, plugged by H_1 histone protein.
- Repeating units of nucleosomes form the chromatin in nucleus, which is a thread-like structure.
- The chromatin is packed to form a **solenoid structure** of 30 nm diametre.
- Further supercoiling forms a looped structure called the **chromatin fibre**.



Nucleosome

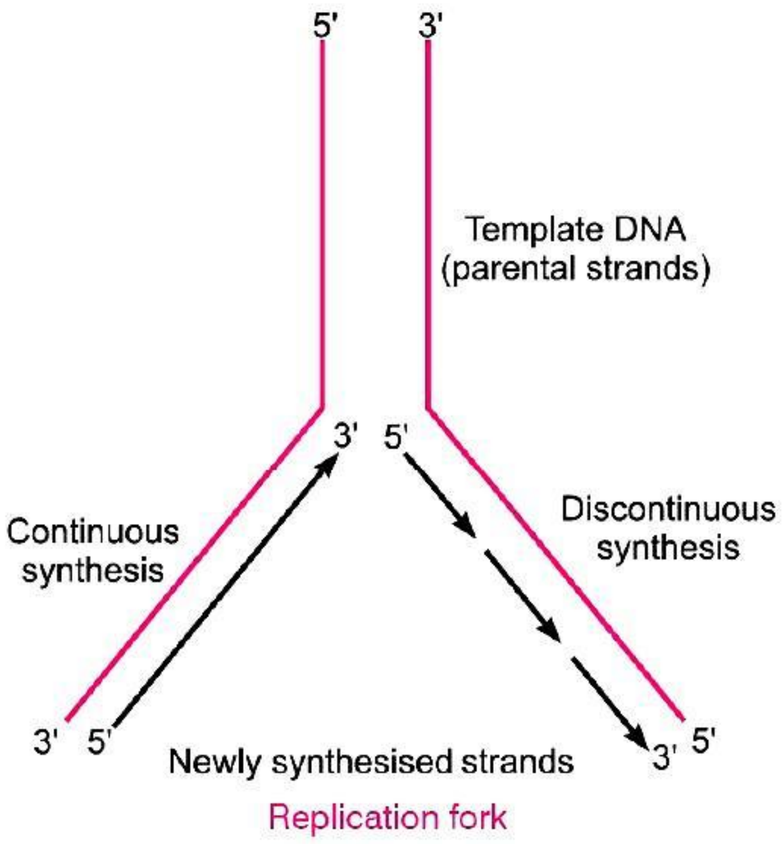
5. **Frederick Griffith** (1928) conducted experiments with *Streptococcus pneumoniae* (bacterium causing pneumonia).
   - He concluded that heat-killed S-type bacteria caused a transformation of the R-type bacteria into S-type bacteria but he was not able to understand the cause of this bacterial transformation.
   - He further stated that some 'transforming principle' transferred from heat killed S strain, enabled R strain to synthesize a smooth polysaccharide coat and become virulent. But biochemical nature of genetic material was not defined from his experiments.
6. **Oswald Avery, Colin MacLeod** and **Maclyn McCarty** repeated Griffith's experiment in an *in vitro* system in order to determine biochemical nature of transforming principle.
7. Both RNA and DNA can function as genetic material, but DNA being chemically less reactive and structurally being more stable is a better genetic material. DNA is more stable than RNA because of:
   (*i*) being double stranded
   (*ii*) two strands being complementary; even if separated by heating they come together
   (*iii*) DNA is less reactive than RNA as 2′–OH group is absent in every nucleotide (RNA has 2′–OH group). RNA being catalytic, is very reactive.
   (*iv*) Presence of thymine in place of uracil provides additional stability to DNA.
8. **Process of DNA replication:** DNA replication begins at a unique and fixed point called **origin of replication** or ***'ori'***.

Initiation

- The complementary strands of DNA double helix are separated by enzyme, DNA helicase. This is called **unwinding** of double-stranded DNA.
- The separated strands tend to rewind, therefore these are stabilised by proteins called **single strand binding proteins (ssBPs)**, which bind to the separated strands.

Elongation

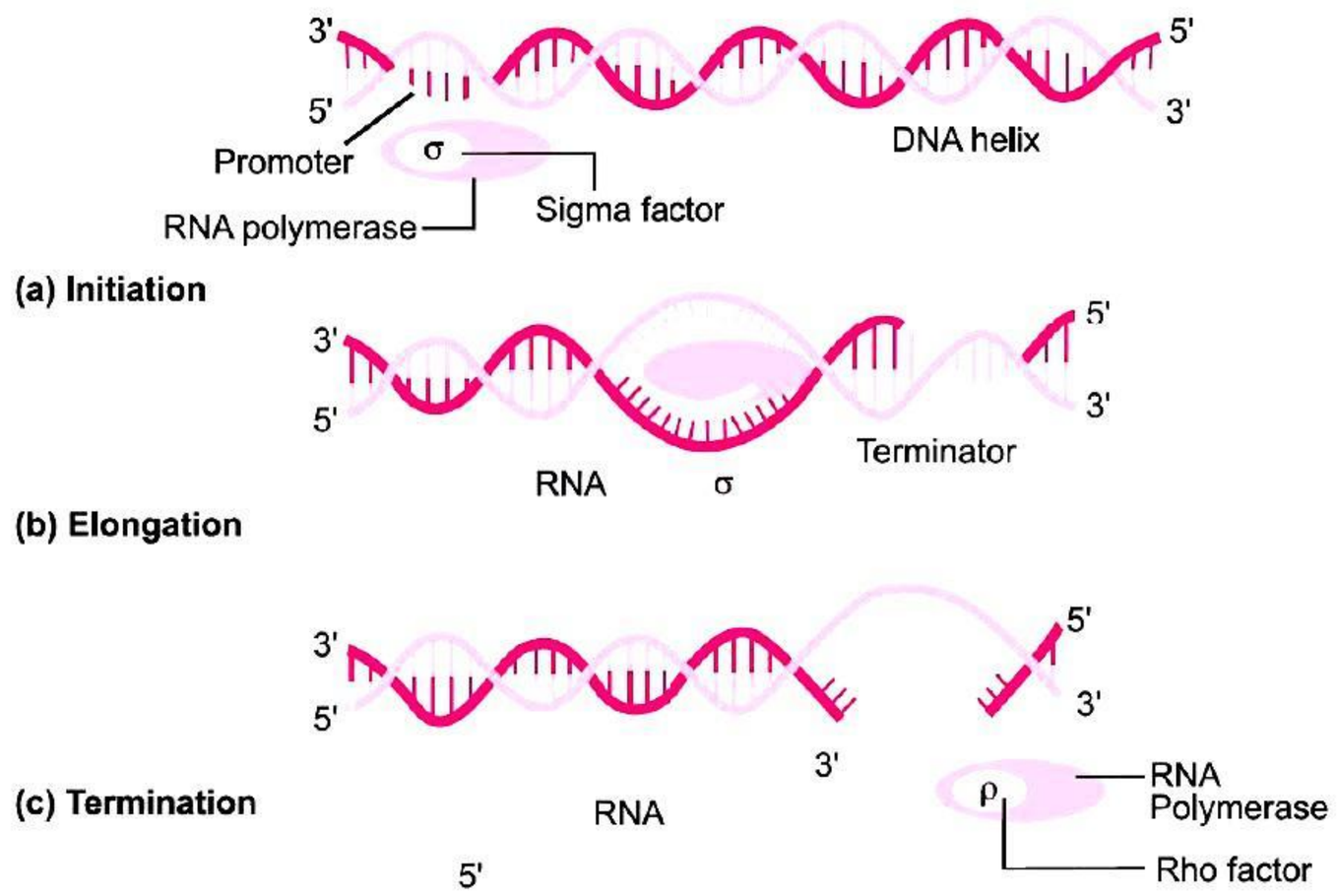
- An enzyme called **primase** initiates replication of the strand oriented in the 3′ (towards origin)→5′ (towards fork) direction. This generates 10–60 nucleotides long primer RNA (replicated in 5′→3′ direction).



Replication fork

- The free 3′–OH of this RNA primer provides the initiation point for DNA polymerase for sequential addition of deoxyribonucleotides.
- DNA polymerase progressively adds deoxyribonucleotides to the free 3′-end of the growing polynucleotide chain so that replication of the 3′→5′ strand of the DNA molecule is continuous (growth of the new strand in 5′→3′ direction).
- The replication of 3′→5′ strand is continuous and it is called **leading strand,** while the replication of second strand (5′→3′ strand) of the DNA molecules is discontinuous and it is known as the **lagging strand**.
- The replication of lagging strand generates small polynucleotide fragments called **'Okazaki fragments'** (after R. Okazaki, who first identified them).
- These Okazaki fragments are then joined together by enzyme called DNA **ligase.**

9. **Transcription in prokaryotes:** The transcription is completed in three steps: initiation, elongation and termination.
   - **Initiation:** σ (sigma) factor recognises the start signal and promotor region on DNA which then along with RNA polymerase binds to the promoter to initiate transcription. It uses nucleoside triphosphates as substrate and polymerises in a template-dependent fashion following the rule of complementarity.



Process of transcription in bacteria

   - **Elongation:** The RNA polymerase after initiation of RNA transcription loses the σ factor but continues the polymerisation of ribonucleotides to form RNA. It facilitates opening of helix and continues elongation with only a short stretch of RNA being bound to enzyme at a time.
   - **Termination:** Once the RNA polymerase reaches the termination region of DNA, the RNA polymerase is separated from DNA–RNA hybrid, as a result nascent RNA separates. This process is called termination which is facilitated by a termination factor ρ (**rho**).

10. **Transcription in eukaryotes:**
    - The structural genes are monocistronic in eukaryotes.
    - The process of transcription is similar to that in prokaryotes.
    - It takes place in the nucleus.

- In eukaryotes, three types of RNA polymerases are found in the nucleus:
  (*i*) **RNA polymerase I** transcribes *r*RNAs (28S, 18S, and 5.8S).
  (*ii*) **RNA polymerase II** transcribes the precursor of *m*RNA (called heterogeneous nuclear RNA or *hn*RNA).
  (*iii*) **RNA polymerase III** transcribes *t*RNA, 5S *r*RNA and *sn*RNAs (small nuclear RNAs).

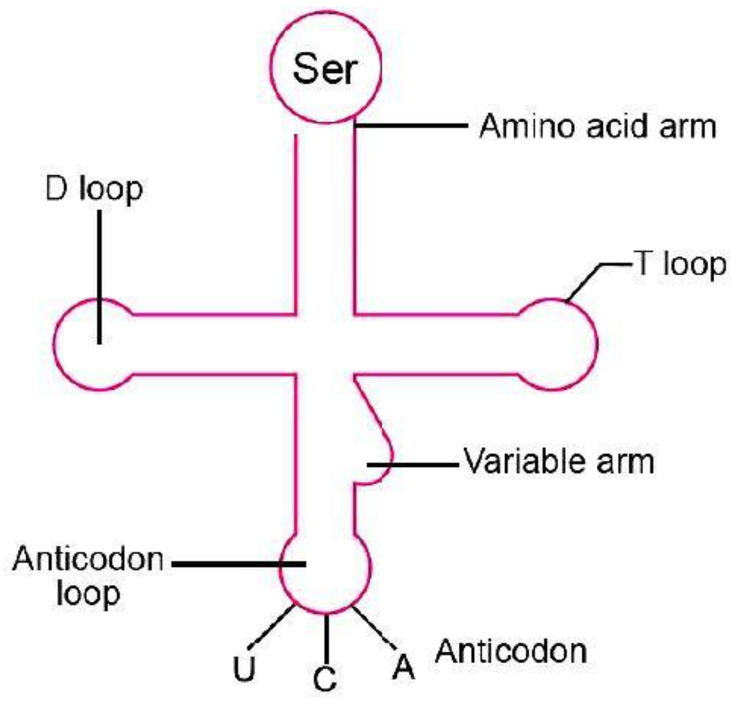
11. Post-transcriptional modifications

- The *hn*RNA undergoes splicing and two additional processes called **capping** and **tailing**.
- In capping, an unusual nucleotide, methyl guanosine triphosphate, is added to the 5′-end of *hn*RNA.
- In tailing, adenylate residues (about 200 300) are added at 3′ end in a template independent manner.
- Now the *hn*RNA undergoes a process where the introns are removed and exons are joined to form *m*RNA by the process called **splicing**.

12. Salient features of genetic code

(*i*) The codons are triplet. Out of 64 codons, 61 code for 20 amino acids and 3 codons (UAA, UGA, UAG) do not code for any amino acid hence, function as **stop** or **terminating codons**.
(*ii*) One codon codes for only one particular amino acid, hence the code is **unambiguous** and **specific**.
(*iii*) Some amino acids are coded by more than one codon, hence the code is **degenerate**.
(*iv*) The codon is read on *m*RNA in a contiguous fashion, *i.e.*, without punctuations and thus the code is **commaless**.
(*v*) The genetic code is nearly **universal**, *i.e.*, a particular codon codes for the same amino acid in all organisms from bacteria to human except in mitochondria and few protozoans.
(*vi*) AUG is a dual function codon, it codes for methionine (met) and it also acts as initiator codon.

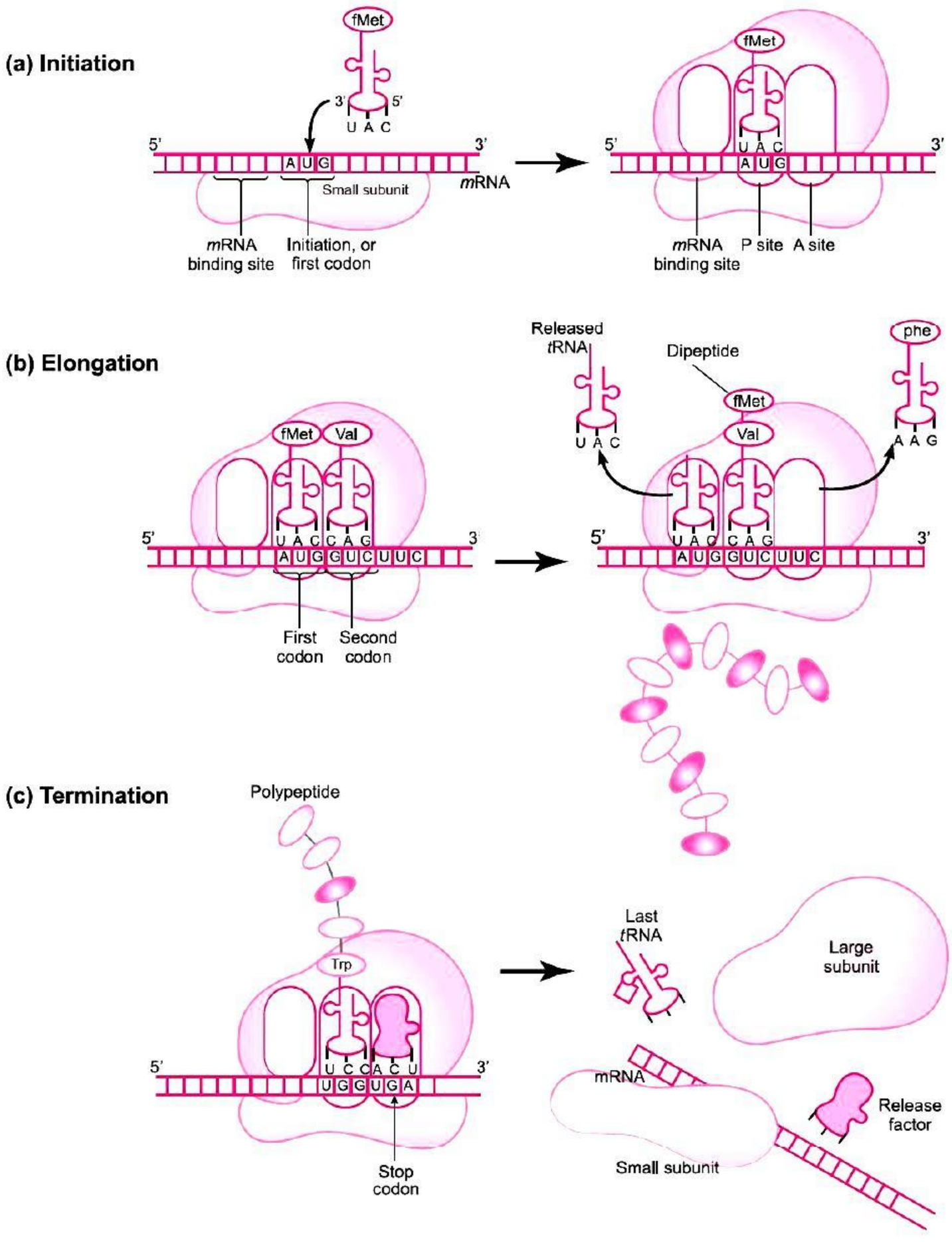
13. *t*RNA has five arms or loops:



*t*RNA—the adapter molecule

(*i*) **Anticodon loop,** which has bases complementary to the code.
(*ii*) **Amino acid acceptor end** to which amino acids bind.
(*iii*) **T loop,** which helps in binding to ribosome.
(*iv*) **D loop,** which helps in binding aminoacyl synthetase.
(*v*) **Variable arm**

14. Translation



Process of translation

(*i*) Initiation

- In prokaryotes, initiation requires the large and small ribosome subunits, the *m*RNA, initiation *t*RNA and three initiation factors (IFs).
- **Activation of amino acid:** Amino acids become activated by binding with aminoacyl *t*RNA synthetase enzyme in the presence of ATP.

$$\text{Amino acid (AA)} + \text{ATP} \xrightarrow[\text{synthetases}]{\text{Aminoacyl } t\text{RNA}} \text{AA–AMP–Enzyme complex} + P_i$$

- **Transfer of amino acid to *t*RNA:** The AA–AMP–Enzyme complex formed reacts with specific *t*RNA to form aminoacyl-*t*RNA complex.

$$\text{AA–AMP–Enzyme complex} + t\text{RNA} \longrightarrow \text{AA–}t\text{RNA} + \text{AMP} + \text{Enzyme}$$

- The cap region of *m*RNA binds to the smaller subunit of ribosome.
- The ribosome has two sites, A-site and P-site.
- The smaller subunit first binds to the initiator *m*RNA and then binds to the larger subunit so that initiation codon (AUG) lies on the P-site.
- The initiation *t*RNA, *i.e.*, methionyl *t*RNA then binds to the P-site.

(*ii*) Elongation of polypeptide chain

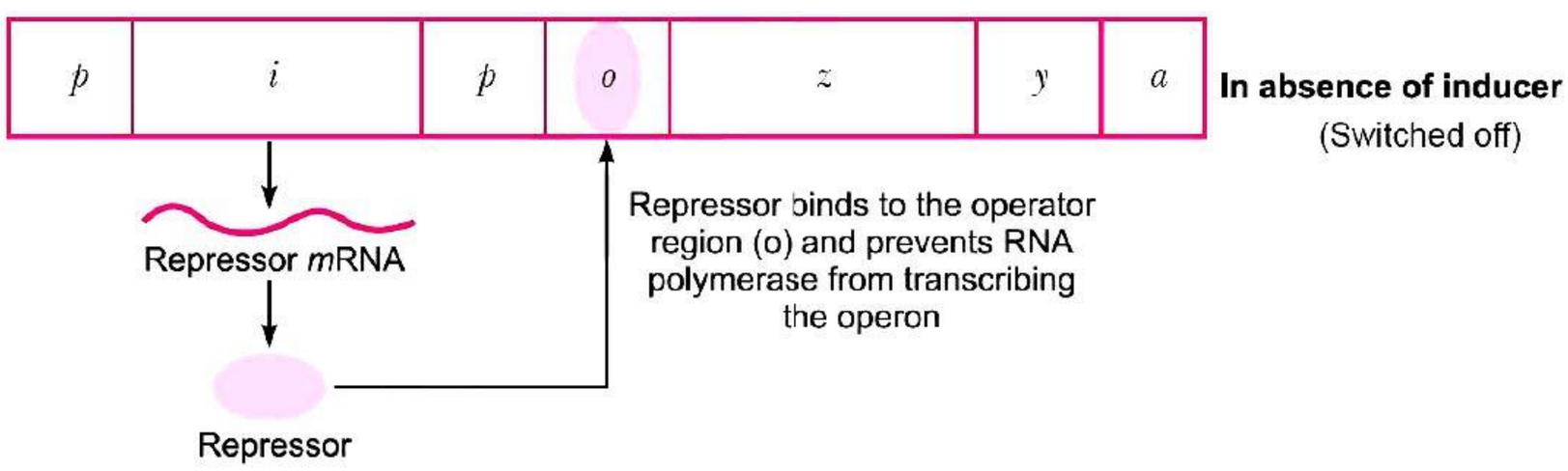
- Another charged aminoacyl *t*RNA complex binds to the A-site of the ribosome at the second codon.
- A peptide bond is formed between carboxyl group (—COOH) of amino acid at P-site and amino group (—NH) of amino acid at A-site by the enzyme **peptidyl transferase**.
- The ribosome slides over *m*RNA from codon to codon in the 5′→3′ direction called **translocation**.
- According to the sequence of codons, amino acids are attached to one another by peptide bonds and a polypeptide chain is formed.

(*iii*) Termination of polypeptide

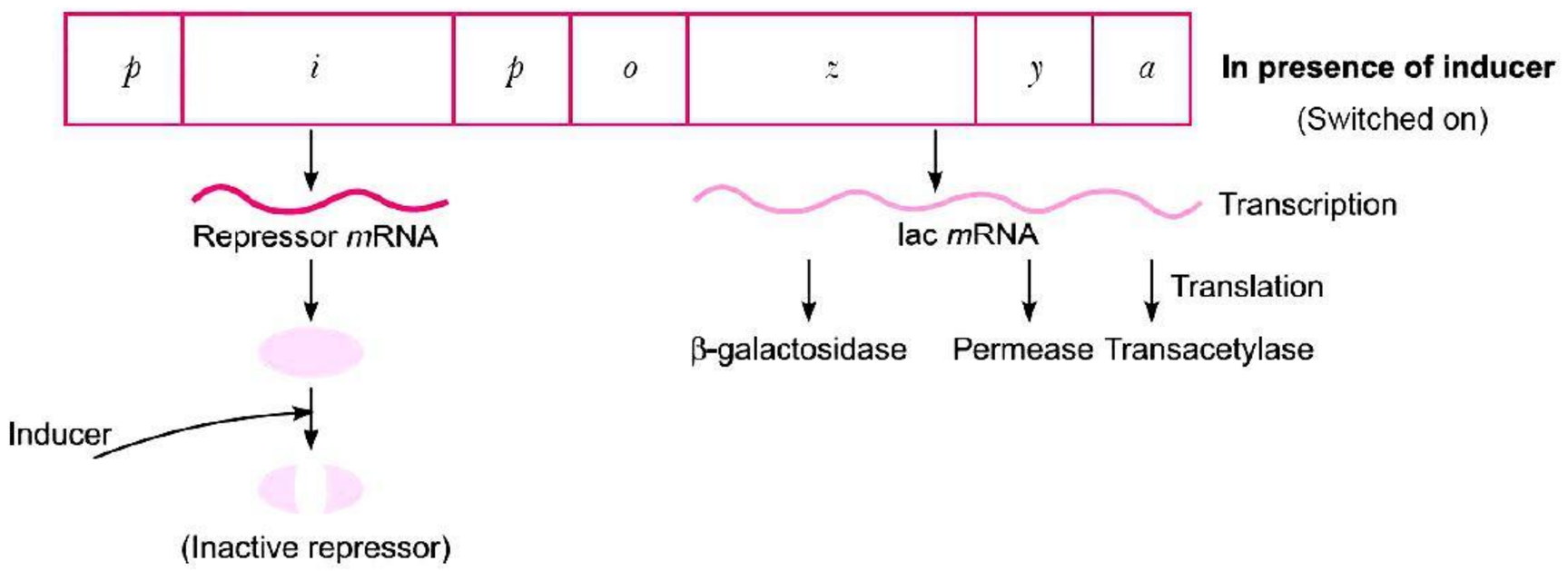
- When the A-site of ribosome reaches a termination codon, which does not code for any amino acid, no charged *t*RNA binds to the A-site.
- Dissociation of polypeptide from ribosome takes place, which is catalysed by a **'release factor'**.
- There are three **termination codons** namely UGA, UAG and UAA.

15. The lactose operon

- *lac* operon consists of **three structural genes** (*z*, *y*, *a*), operator (*o*), promoter (*p*) and a separate regulatory gene (*i*). Lactose is the inducer in *lac* operon.
- The three structural genes (*z*, *y*, *a*) transcribe a polycistronic *m*RNA.



The *lac* operon in absence of inducer



The *lac* operon in presence of inducer

- Gene *z* codes for β-galactosidase (β-gal) enzyme which breaks lactose into galactose and glucose.
- Gene *y* codes for permease, which increases the permeability of the cell to lactose (β-galactosides).
- Gene *a* codes for enzyme transacetylase, which catalyses the transacetylation of lactose in its active form.

16. When lactose is absent

(*i*) When lactose is absent, *i* gene regulates and produces repressor *m*RNA which translates into repressor protein.

(*ii*) The repressor protein binds to the operator region of the operon and as a result prevents RNA polymerase to bind to the operon.

(*iii*) The operon is switched off.

17. When lactose is present

(*i*) Lactose acts as an inducer which binds to the repressor and forms an inactive repressor.

(*ii*) The repressor fails to bind to the operator region.

(*iii*) The RNA polymerase binds to the operator and transcribes *lac m*RNA.

(*iv*) *lac m*RNA is polycistronic, *i.e.*, produces all three enzymes, β-galactosidase, permease and transacetylase.

(*v*) The *lac* operon is switched on.

MULTIPLE CHOICE QUESTIONS

Choose and write the correct option in the following questions.

1. Amino acid sequence in protein synthesis is decided by the sequence of

(*a*) *r*RNA (*b*) *t*RNA

(*c*) *m*RNA (*d*) *c*DNA

2. Antiparallel strands of a DNA molecule means that

(*a*) one strand turns clockwise

(*b*) one strand turns anti-clockwise

(*c*) the phosphate groups of two DNA strands, at their ends, share the same position

(*d*) the phosphate groups at the start of two DNA strands are in opposite positions (pole)

3. Polysome is formed by

(*a*) a ribosome with several subunits

(*b*) ribosomes attached to each other in a linear arrangement

(*c*) several ribosomes attached to a single *m*RNA

(*d*) many ribosomes attached to a strand of endoplasmic reticulum

4. In the DNA molecule

(*a*) the proportion of adenine in relation to thymine varies with the organism

(*b*) there are two strands which run antiparallel—one in $5' \rightarrow 3'$ direction and other in $3' \rightarrow 5'$

(*c*) the total amount of purine nucleotides and pyrimidine nucleotides is not always equal

(*d*) there are two strands which run parallel in the $5' \rightarrow 3'$ direction

5. What is not true for genetic code?

(*a*) It is nearly universal.

(*b*) It is degenerate.

(*c*) It is unambiguous.

(*d*) A codon in *m*RNA is read in a non-contiguous fashion.

6. Removal of introns and joining the exons in a defined order in a transcription unit is called

(*a*) tailing
(*b*) transformation
(*c*) capping
(*d*) splicing

7. The net electric charge on DNA and histones is *[NCERT Exemplar]*

(*a*) both positive
(*b*) both negative
(*c*) negative and positive, respectively
(*d*) zero

8. Gene controls

(*a*) protein synthesis but not heredity
(*b*) protein synthesis and heredity
(*c*) heredity but not protein synthesis
(*d*) biochemical reaction of some enzymes

9. The promoter site and the terminator site for transcription are located at *[NCERT Exemplar]*

(*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

10. Which of the following statements is the most appropriate for sickle cell anaemia? *[NCERT Exemplar]*

(*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

11. With regard to mature *m*RNA in eukaryotes *[NCERT Exemplar]*

(*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

12. The human chromosome with the highest and least number of genes in them are respectively *[NCERT Exemplar]*

(*a*) chromosome 21 and Y
(*b*) chromosome 1 and X
(*c*) chromosome 1 and Y
(*d*) chromosome X and Y

13. Who amongst the following scientists had no contribution in the development of the double helix model for the structure of DNA? *[NCERT Exemplar]*

(*a*) Rosalind Franklin
(*b*) Maurice Wilkins
(*c*) Erwin Chargaff
(*d*) Meselson and Stahl

14. 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? *[NCERT Exemplar]*

(*a*) Replace purine with pyrimidines
(*b*) Remove/replace 3′ OH group in deoxyribose
(*c*) Remove/replace 2′ OH group with some other group in deoxyribose
(*d*) Both (*b*) and (*c*)

15. Discontinuous synthesis of DNA occurs in one strand, because [*NCERT Exemplar*]

(*a*) DNA molecule being synthesised is very long

(*b*) DNA dependent DNA polymerase catalyses polymerisation only in one direction (5′ → 3′)

(*c*) it is a more efficient process

(*d*) DNA ligase joins the short stretches of DNA

16. Which of the following steps in transcription is catalysed by RNA polymerase? [*NCERT Exemplar*]

(*a*) Initiation (*b*) Elongation

(*c*) Termination (*d*) All of the above

17. Control of gene expression in prokaryotes take place at the level of [*NCERT Exemplar*]

(*a*) DNA-replication (*b*) transcription

(*c*) translation (*d*) none of the above

18. Which of the following statements is correct about the role of regulatory proteins in transcription in prokaryotes? [*NCERT Exemplar*]

(*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.

19. Which was the last human chromosome to be completely sequenced? [*NCERT Exemplar*]

(*a*) Chromosome 1 (*b*) Chromosome 11

(*c*) Chromosome 21 (*d*) Chromosome X

20. Which of the following are the functions of RNA? [*NCERT Exemplar*]

(*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

21. 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 [*NCERT Exemplar*]

(*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

22. In some viruses, DNA is synthesised by using RNA as template. Such a DNA is called [*NCERT Exemplar*]

(*a*) A-DNA (*b*) B-DNA

(*c*) *c*DNA (*d*) *r*DNA

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

(*a*) 1 : 1 :0 (*b*) 1 : 4 : 0

(*c*) 0 : 1 : 3 (*d*) 0 : 1 : 7

24. 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 [*NCERT Exemplar*]

(*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′

25. In *E.coli*, the *lac* operon gets switched on when [*NCERT Exemplar*]

(*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

26. A sample of DNA has 30% adenine . What is the quantity of cytosine present?

(*a*) 30% (*b*) 20%

(*c*) 50% (*d*) 15%

27. The process of addition of methyl guanosine triphosphate at the 5′ end of *hn*RNA is

(*a*) capping (*b*) tailing

(*c*) termination (*d*) splicing

28. Base pairing rule of DNA was proposed by

(*a*) Griffith (*b*) Erwin Chargaff

(*c*) Baltimore (*d*) Francis Crick

29. Purpose of deoxyribonucleoside triphosphate is

(*a*) it acts as substrate (*b*) it provides energy for polymerisation reaction

(*c*) both (*a*) and (*b*) (*d*) it joins the two fragments of DNA

30. The region where replication originates is

(*a*) replication point (*b*) nexus

(c) origin of replication (*d*) cistron

31. Gene *'i'* which is present in the *lac* operon of *E.coli* codes for

(*a*) repressor (*b*) permease

(*c*) transacetylase (*d*) inducer

32. Which of the following cellular factory is responsible for the protein synthesis ?

(*a*) Peroxisome (*b*) Ribosome

(*c*) Mitochondria (*d*) Lysosomes

33. At which phase the replication of DNA takes place in eukaryotes ?

(*a*) S-phase (*b*) G_2 phase

(*c*) M-phase (*d*) Cytokinesis phase

34. The dark staining region in a chromosome is called

(*a*) euchromatin (*b*) heterochromatin

(*c*) plectonemic (*d*) paranemic

35. Heterochromatic region in comparison to the euchromatic regions are

(*a*) late replicating (*b*) more loosely coiled

(*c*) store house of genetic information (*d*) confined to sex chromosomes only

36. Histone proteins are rich in

(*a*) lysine (*b*) tyrosine

(*c*) arginine (*d*) both (*a*) and (*c*)

37. The strongest evidence that DNA is the genetic material comes from

(*a*) the fact that chromosomes are made of DNA

(*b*) studies on the transformation of bacterial cells

(*c*) the knowledge that DNA is present in the nucleus

(*d*) the finding that DNA is not present in the cytoplasm

38. Genes are made up of

(*a*) DNA (*b*) RNA

(*c*) DNA and RNA (*d*) proteins

39. The usual method of DNA replication is

(*a*) conservative (*b*) dispersive

(*c*) non-conservative (*d*) semi-conservative

40. Semi-conservative mode of replication of chromosome was demonstrated by

(*a*) Meselson and Stahl (*b*) Taylor and Stahl

(*c*) Taylor only (*d*) Meselson only

41. The experimental system used in studies of the discovery of replication of DNA has been

(*a*) *Drosophila melanogaster* (*b*) *Pneumococcus*

(*c*) *Escherichia coli* (*d*) *Neurospora crassa*

42. DNA polymerase is required for the synthesis of

(*a*) DNA from DNA (*b*) DNA from RNA

(*c*) DNA from nucleotides (*d*) DNA from nucleosides

43. The bits of DNA segments formed are joined with each other by an enzyme

(*a*) polymerase (*b*) ligase

(*c*) lipase (*d*) kinase

44. The post-transcriptional process involves

(*a*) splicing (*b*) tailing

(*c*) capping (*d*) all of the above

45. Replication of DNA in eukaryotes commences from

(*a*) one end of the chromatid extending to the other end

(*b*) both ends of the chromatid simultaneously

(*c*) the centromere to either of the ends of chromatids

(*d*) several sites along the DNA of the chromatid simultaneously

46. The modern concept of gene is that it is

(*a*) a segment of DNA capable of crossing over

(*b*) a functional unit of DNA

(*c*) a segment of DNA

(*d*) a segment of chromosome

47. Genetic code determines

(*a*) structural pattern of an organism

(*b*) sequence of amino acid in protein chain

(*c*) variation in offsprings

(*d*) constancy of morphological trait

48. Dr. Hargobind Khorana has been awarded Nobel Prize for research on

(*a*) oral contraceptives (*b*) genetic code

(*c*) hormones (*d*) immunology

49. Genetic code was deciphered through chemical synthesis of trinucleotides by

(*a*) Watson and Crick (*b*) Beadle and Tatum

(*c*) Briggs and King (*d*) M.W. Nirenberg

50. Choose the incorrect statement.

(*a*) *lac* operon shows the control of gene expression at the transcription level in *E.coli*.

(*b*) The enzyme DNA polymerase catalyses the polymerisation of nucleotides in the 5′ → 3′ direction for the lagging strand.

(*c*) The promoter site and the terminator site for transcription are located at 5′(upstream) end and 3′(downstream) end, respectively of the transcription unit.

(*d*) The DNA site where DNA-dependent RNA-polymerase binds for transcription is called regulator.

51. When did human genome project start?

(*a*) 1989 (*b*) 1990

(*c*) 1988 (*d*) None of the above

52. What is the length of DNA having 75 base pairs?

(*a*) 255 Å (*b*) 112.5 Å

(*c*) 750 Å (*d*) 421 Å

53. Khorana synthesised a RNA molecule with repeating sequence of UG nitrogen bases (UGUGUGUGUGUG). It produced a tetrapeptide with alternating sequence of cysteine and valine. It proves that codon for cysteine and valine is

(*a*) UGG and GUU (*b*) UUG and GGU

(*c*) UGU and GUG (*d*) GUG and UGU

54. The genetic information is carried by long chain molecules of

(*a*) enzymes (*b*) amino acids

(*c*) nucleotides (*d*) chromosomes

55. In order to enable a chemical to serve as a genetic code, it is essential that chemical should be

(*a*) able to duplicate itself (*b*) able to form itself into long spiral molecules

(*c*) a compound of pyrimidines and purines (*d*) easily changed

56. The process by which DNA of the nucleus passes genetic information to *m*RNA is called

(*a*) tanscription (*b*) transportation

(*c*) translocation (*d*) translation

57. The *m*RNA is formed

(*a*) in the nucleus

(*b*) by free ribosomes

(*c*) from the ribosomes on endoplasmic reticulum

(*d*) from DNA in nucleus

58. Which is the correct sequence of code transfer involved in the formation of polypeptide?

(*a*) DNA, *t*RNA, RNA and *m*RNA (*b*) RNA,DNA, *m*RNA, *t*RNA

(*c*) *m*RNA, *t*RNA, DNA, amino acids (*d*) DNA, *m*RNA, *t*RNA, amino acids

59. In protein synthesis, the codon used as a start signal is

(*a*) AUG (*b*) UGA

(*c*) GUA (*d*) UAG

60. Termination of chain growth in protein synthesis is brought about by

(*a*) UUG, UGC, UCA (*b*) UGC, GCG, ACC

(*c*) UAA, UAG, UGA (*d*) UUG,UAG, UCG

61. The process by which proteins are synthesised in a cell is called

(*a*) translation (*b*) transcription

(*c*) translocation (*d*) transduction

62. Initiation of polypetide chain in protein synthesis is induced by

(*a*) methionine (*b*) glycine

(*c*) leucine (*d*) lysine

63. In an operon, the RNA polymerase binds to

(*a*) regulator (*b*) promotor gene

(*c*) operator gene (*d*) constitutive gene

64. Which of the following is employed in recombinant DNA technology?

(*a*) Plastids (*b*) Plasmids

(*c*) Ribosomes (*d*) Histones

65. Which one of the following unit is unrelated to DNA or gene?

(*a*) Plastids (*b*) Plasmids

(*c*) Mutations (*d*) Hybrid vigour

66. The operon model of gene regulation and organization in prokaryotes was proposed by

(*a*) Jacob and Monod (*b*) Beadle and Tatum

(*c*) Meselson and Stahl (*d*) Wilkins and Franklin

67. Successive nucleotides are covalently linked through

(*a*) glyosidic bonds (*b*) phosphodiester bonds

(*c*) hydrogen bonds (*d*) nitrogen bonds

68. *t*RNA takes part in

(*a*) transfer of genetic code to cytoplasm

(*b*) transfer of amino acids to ribosome

(*c*) collection of RNA in ribosome

(*d*) copy the genetic code from DNA in nucleus

69. Enzyme catalysing synthesis of RNA over DNA template is

(a) DNA polymerase (*b*) reverse transcriptase

(c) RNA polymerase (*d*) endonuclease

70. Genetic code translates the language of

(*a*) RNA into that of protein (*b*) amino acids to that of RNA

(*c*) RNA into that of DNA (*d*) protein into that of DNA

71. In a DNA molecule cytosine is 28%. Percentage of adenine would be

(*a*) 64% (*b*) 22%

(*c*) 18% (*d*) 36%

72. *m*RNA is a polymer of

(*a*) deoxyribonucleotides (*b*) ribonucleotides

(*c*) deoxyribonucleosides (*d*) ribonucleosides

73. Which step of translation does not consume high energy phosphate bond ?

(*a*) translocation (*b*) peptidyl transferase reaction

(*c*) amino acid activation (*d*) aminoacyl *t*RNA binding to A-site

74. Pyrimidine base present in RNA in place of thymine of DNA is

(*a*) uracil (*b*) adenine

(*c*) cytosine (*d*) guanine

75. Nucleotide base present in DNA and not in RNA is

(*a*) cytosine (*b*) uracil

(*c*) thymine (*d*) guanine

76. The Watson and Crick's model of DNA is duplex with

(*a*) 10 base pairs and 34 Å distance for every turn

(*b*) 10 base pairs and 3.4 Å distance for each turn of spiral

(*c*) 20 base pairs and 34 Å for each turn

(*d*) none of the above

77. DNA sequence of ATTCGATG is transcribed as

(*a*) AUUCGAUG (*b*) CAUCGAAU

(*c*) GUAGCUUA (*d*) UAAGCUAC

78. The codon for anti-codon 3′-UUUA - 5′ is

(*a*) 5′ UAAA 3′ (*b*) 5′ AAAU - 3′

(*c*) 3′ UAAG - 5′ (*d*) 3′ AAAU -5′

79. Hydrogen bonds between cytosine and guanine are

(*a*) 1 (*b*) 2

(*c*) 3 (*d*) 4

80. Double hydrogen bonds occur in DNA between

(*a*) adenine and thymine (*b*) uracil and thymine

(*c*) adenine and guanine (*d*) thymine and cytosine

81. Watson and Crick are known for their discovery that DNA is

(*a*) single stranded (*b*) double stranded

(*c*) having deoxyribose only (*d*) template for *r*RNA synthesis

82. Find out the correct answers out of the following discoveries.

1. **Griffith - transformation**
2. **Gamow - triplet code**
3. **Meischer - nucleic acid**

(*a*) 1, 2 and 3 are correct (*b*) 1 and 2 are correct, 3 is incorrect

(*c*) 1 is correct, 2 and 3 are incorrect (*d*) 1 and 3 are correct, 2 is incorrect

83. Which of the following is correct for protein synthesis ?

(*a*) Code transfer on *m*RNA (*b*) Code transfer on *t*RNA

(*c*) Coding is done by DNA strands (*d*) DNA coding takes place in antiparallel fashion

84. Cytosine base inserted in the beginning of DNA codons ATGATGATG will produce

(*a*) C ATG ATG ATG (*b*) CAT GAT GAT G

(*c*) CA TGA TGA TG (*d*) none of these

85. DNA strand with nitrogen base sequence ATTGCC will have which of the following sequence in *m*RNA?

(*a*) ATCGCC (*b*) UAACGG

(*c*) ATTGCA (*d*) UGGACC

86. DNA template sequence of ATGATAGC is transcribed over *m*RNA as

(*a*) GUCTUTCG (*b*) TACAUCG

(*c*) GAUTATUG (*d*) UACTATCG

87. Which of the following is not involved in protein synthesis ?

(*a*) Initiation (*b*) Transcription

(*c*) Elongation (*d*) Termination

88. Because most of the amino acids are represented by more than one codon, the genetic code is

(*a*) overlapping (*b*) wobbling

(*c*) degenerate (*d*) generate

89. Nucleotide arrangement in DNA can be seen by

(*a*) ultracentrifuge (*b*) electron microscope

(*c*) X-ray crystallography (*d*) light microscope

90. Site of *t*RNA that binds to *m*RNA molecules is

(*a*) codon (*b*) 5′ end

(*c*) 3′ end (*d*) anticodon

91. In the genetic dictionary, there are 64 codons as

(*a*) 64 amino acids are to be coded

(*b*) 64 types of *t*RNA are present

(*c*) there are 44 nonsense codons and 20 sense codons

(*d*) genetic code is triplet

92. Which of the following is the largest gene in man?

(*a*) Dystrophin (*b*) Dystonin

(*c*) Dystromin (*d*) Dystropine

93. The experimental materials used by Griffith to prove that DNA is the genetic material were

(*a*) *E.coli* and *Streptococcus pneumonia* (*b*) mice, *Staphylococcus pneumonia* and *E.coli*

(*c*) mice and *Streptococcus pneumonia* (*d*) none of these

94. Genetic code is said to be degenerate because

(*a*) codons degenerate very quickly

(*b*) one amino acid is coded by more than one codon

(*c*) one codon codes for more than one amino acid

(*d*) none of the above

95. The two strands of DNA are held together by

(*a*) peptide bonds (*b*) hydrogen bonds

(*c*) S-S bonds (*d*) phosphodiester bonds

96. Nucleotides present in one turn of DNA helix is

(*a*) 8 (*b*) 9

(*c*) 4 (*d*) 10

97. A DNA molecule in which both strands have radioactive thymidine is allowed to duplicate in non-radioactive thymidine. What will be the exact number of DNA molecules that contain some radioactive thymidine after 5 duplications?

(*a*) One (*b*) Two

(*c*) Four (*d*) Eight

98. A bacterium *E.coli* with completely radioactive DNA was allowed to replicate in a non-radioactive medium for two generations. What percentage of the bacteria should contain radioactive DNA?

(*a*) 100%
(*b*) 25%
(*c*) 50%
(*d*) 12.5%

99. Discontinuous segments are

(*a*) DNA segments capable of free replication
(*b*) DNA segments formed during replication
(*c*) nucleotide segments formed during transcription
(*d*) segments of genes which undergo mutation and recombination

100. DNA replication is

(*a*) continuous and conservative
(*b*) discontinuous and semi-conservative
(*c*) semi-discontinuous and semi-conservative
(*d*) conservative and semi-discontinuous

101. A functional unit of gene which specifies the synthesis of one polypeptide is known as

(*a*) muton
(*b*) recon
(*c*) intron
(*d*) cistron

102. DNA is the major source of genetic information which is transmitted by transcription into RNA molecules. These RNA molecules are responsible to get this genetic information translated into proteins and thus central dogma of molecular biology is

(*a*) RNA $\rightarrow$ DNA $\rightarrow$ Protein
(*b*) DNA $\rightarrow$ RNA $\rightarrow$ Proteins
(*c*) RNA $\rightarrow$ Proteins
(*d*) RNA $\rightarrow$ Proteins $\rightarrow$ DNA

103. A DNA strand is directly involved in the synthesis of all the following except

(*a*) *t*RNA molecule
(*b*) *m*RNA molecule
(*c*) another DNA strand
(*d*) protein synthesis

104. Consider the following:

1. **Codes for amino acid methionine**
2. **Initiation codon**
3. **Stop codon**
4. **Sense codon**

Which of the above are true with respect to AUG?

(*a*) 1, 2 and 3 are correct
(*b*) 2, 3 and 4 are correct
(*c*) 1, 2 and 4 are correct
(*d*) Only 1 is correct

105. RNA polymerase which is on the promoter, moves to the structural genes to transcribe them. However, it happens when

(*a*) there is no repressor on the operator
(*b*) there is repressor on the operator
(*c*) inducer binds to structural genes
(*d*) RNA polymerase shifts first to regulator gene

106. Choose the incorrect statement.

(*a*) During splicing in eukaryotes, the exons are joined to form the RNA.

(*b*) Sigma factor functions as the initiation factor in the transcription of prokaryotes.

(*c*) VNTR belongs to a class of satellite DNA, called micro-satellite.

(*d*) Frederich Meischer discovered DNA and named it called nuclein.

107. The central dogma deviates in some viruses as:

(*a*) They show the flow of information in reverse direction *i.e.*, from RNA to DNA.

(*b*) They do not contain DNA.

(*c*) They do not show translation of proteins from RNA.

(*d*) They contain single stranded DNA.

108. The four nitrogen base sequence which form the code words for DNA language are

(*a*) UTAC (*b*) ACTU

(*c*) AGCU (*d*) ATCG

109. Where does tailing of *hn*RNA takes place ?

(*a*) 5′ end (*b*) 3′ end

(*c*) Both (*a*) and (*b*) (*d*) Along the length of *hn*RNA

110. The presence of which of the following bonds makes the DNA strands antiparallel?

(*a*) H-bonds (*b*) Peptide bonds

(*c*) Disulphide bonds (*d*) Phosphodiester bonds

111. The type of RNA specifically responsible for directing the proper sequence of amino acids in protein synthesis is

(*a*) ribosomal RNA (*b*) messenger RNA

(*c*) chromosomal RNA (*d*) transfer RNA

112. According to Chargaff's rules

(*a*) A+C=G+T (*b*) A+T=G+C

(*c*) A+T=T+C (*d*) A+G=C+U

113. The transforming principle was confirmed experimentally by

(*a*) Oswald Avery (*b*) Collin MacLeod

(*c*) Maclyn McCarty (*d*) All of them together

114. The location of terminator in the transcription unit is

(*a*) towards 5′ end of template strand (*b*) towards 3′ end of template strand

(*c*) towards 5′ end of coding strand (*d*) towards 3′ end of coding strand

115. Match the terms in column I with those in column II.

Column I	Column II
A. RNA polymerase I	1. A set of three bases on *t*RNA that is complementary to the bases.
B. Anticodon	2. A unit of DNA that codes for a polypeptide.
C. Cistron	3. Transcribes rRNAs

(*a*) A-2, B-3, C-1 (*b*) A-1, B-2, C-3

(*c*) A-3, B-2, C-1 (*d*) A-3, B-1, C-2

116. Which gene produces permease in *lac* operon?

(*a*) Z-gene (*b*) A- gene

(*c*) Y-gene (*d*) P-gene

117. There are _____naturally occuring amino acids.

(*a*) 21 (*b*) 64

(*c*) 20 (*d*) 48

118. RNA polymerase III transcribes

(*a*) *t*RNA (*b*) 5 *sr*RNA

(*c*) *sn*RNA (*d*) all of these

119. Choose the correct statements.

1. **Polycistronic *m*RNA is generally found in eukaryotes.**
2. **The RNA polymerase II transcribes precursor of *m*RNA, the heterogeneous nuclear RNA.**
3. **The process of translation of *m*RNA begins, when the *m*RNA encounters the large subunit of ribosome.**
4. **Termination/stop codons do not have any *t*RNAs.**

(*a*) 1 and 2 (*b*) 2 and 3

(*c*) 2 and 4 (*d*) 1, 2 and 4

120. Choose the odd one out.

(*a*) Promoter (*b*) Inducer

(*c*) Terminator (*d*) Operator

121. Regulation of *lac* operon by repressor is

(*a*) negative regulation (*b*) positive regulation

(*c*) neutral regulation (*d*) none of these

122. Which molecule acts as an adaptor during translation?

(*a*) *m*RNA (*b*) *r*RNA

(*c*) *t*RNA (*d*) *hn*RNA

123. DNA- dependent DNA polymerase catalyse in which direction?

(*a*) $5' \rightarrow 3'$ (*b*) $3' \rightarrow 5'$

(*c*) Either (*a*) or (*b*) (*d*) None of these

124. An octamer of four histones complex with DNA is called

(*a*) centrosome (*b*) mesosome

(*c*) nucleosome (*d*) endosome

125. Which one of the following is a purine ?

(*a*) Cytosine (*b*) Uracil

(*c*) Thymine (*d*) Adenine

126. A bacterium containing 100% N^{15} nitrogen bases is allowed to replicate in a medium containing N^{14} bases. After one round of duplication, the result would be :

(*a*) All individuals would be identical to parents.

(*b*) All individuals would be radioactive but the percentage of radioactivity in DNA would be 50%.

(*c*) Only 50% individuals would be radioactive.

(*d*) All individuals would be similar to parents but different among themselves.

127. Which of the following is needed during DNA replication?

(*a*) DNA polymerase and DNA ligase

(*b*) RNA polymerase and translocase

(*c*) DNA polymerase only

(*d*) DNA ligase only

128. Gene controls

(*a*) protein synthesis but not heredity
(*b*) protein synthesis and heredity
(*c*) heredity but not protein synthesis
(*d*) biochemical reaction of some enzymes

129. Enzyme necessary for transcription is

(*a*) DNA polymerase
(*b*) RNA polymerase
(*c*) endonuclease
(*d*) RNase

130. In *E. coli*, according to the operon theory, an operator gene combines with

(*a*) inducer gene to "switch on" structural gene transcription
(*b*) regulator gene to "switch on" structural gene transcription
(*c*) regulator protein to "switch off" structural gene transcription
(*d*) regulator protein to "switch on" structural gene transcription

131. During tailing which molecule is added at the 3′ and of *hn*RNA?

(*a*) Polyadenylate residue
(*b*) Methyl guanosine triphosphate
(*c*) Methyl guanosine diphosphate
(*d*) Adenosine monophosphate

132. Eukaryotes differ from prokaryotes in mechanism of DNA replication due to

(*a*) different enzymes for opening of strands
(*b*) DNA primers instead of RNA primers
(*c*) unidirectional rather than bidirectional
(*d*) discontinuous rather than semi-discontinuous

Answers

1. (*c*)	**2.** (*d*)	**3.** (*c*)	**4.** (*b*)	**5.** (*d*)	**6.** (*d*)	**7.** (*c*)	**8.** (*b*)
9. (*b*)	**10.** (*d*)	**11.** (*b*)	**12.** (*c*)	**13.** (*d*)	**14.** (*b*)	**15.** (*b*)	**16.** (*b*)
17. (*b*)	**18.** (*d*)	**19.** (*a*)	**20.** (*d*)	**21.** (*b*)	**22.** (*c*)	**23.** (*d*)	**24.** (*a*)
25. (*a*)	**26.** (*b*)	**27.** (*a*)	**28.** (*b*)	**29.** (*c*)	**30.** (*c*)	**31.** (*a*)	**32.** (*b*)
33. (*a*)	**34.** (*b*)	**35.** (*a*)	**36.** (*d*)	**37.** (*b*)	**38.** (*a*)	**39.** (*d*)	**40.** (*a*)
41. (*c*)	**42.** (*a*)	**43.** (*b*)	**44.** (*d*)	**45.** (*d*)	**46.** (*b*)	**47.** (*b*)	**48.** (*b*)
49. (*d*)	**50.** (*a*)	**51.** (*b*)	**52.** (*a*)	**53.** (*c*)	**54.** (*c*)	**55.** (*a*)	**56.** (*a*)
57. (*a*)	**58.** (*d*)	**59.** (*a*)	**60.** (*c*)	**61.** (*a*)	**62.** (*a*)	**63.** (*b*)	**64.** (*b*)
65. (*a*)	**66.** (*a*)	**67.** (*b*)	**68.** (*b*)	**69.** (*c*)	**70.** (*a*)	**71.** (*b*)	**72.** (*b*)
73. (*b*)	**74.** (*a*)	**75.** (*c*)	**76.** (*b*)	**77.** (*d*)	**78.** (*b*)	**79.** (*c*)	**80.** (*a*)
81. (*b*)	**82.** (*a*)	**83.** (*a*)	**84.** (*b*)	**85.** (*b*)	**86.** (*d*)	**87.** (*b*)	**88.** (*c*)
89. (*c*)	**90.** (*d*)	**91.** (*d*)	**92.** (*a*)	**93.** (*c*)	**94.** (*b*)	**95.** (*b*)	**96.** (*d*)
97. (*b*)	**98.** (*c*)	**99.** (*b*)	**100.** (*b*)	**101.** (*d*)	**102.** (*b*)	**103.** (*d*)	**104.** (*c*)
105. (*a*)	**106.** (*c*)	**107.** (*a*)	**108.** (*d*)	**109.** (*b*)	**110.** (*d*)	**111.** (*b*)	**112.** (*b*)
113. (*d*)	**114.** (*d*)	**115.** (*d*)	**116.** (*c*)	**117.** (*c*)	**118.** (*d*)	**119.** (*c*)	**120.** (*b*)
121. (*a*)	**122.** (*c*)	**123.** (*a*)	**124.** (*c*)	**125.** (*d*)	**126.** (*b*)	**127.** (*a*)	**128.** (*b*)
129. (*b*)	**130.** (*c*)	**131.** (*a*)	**132.** (*d*)				

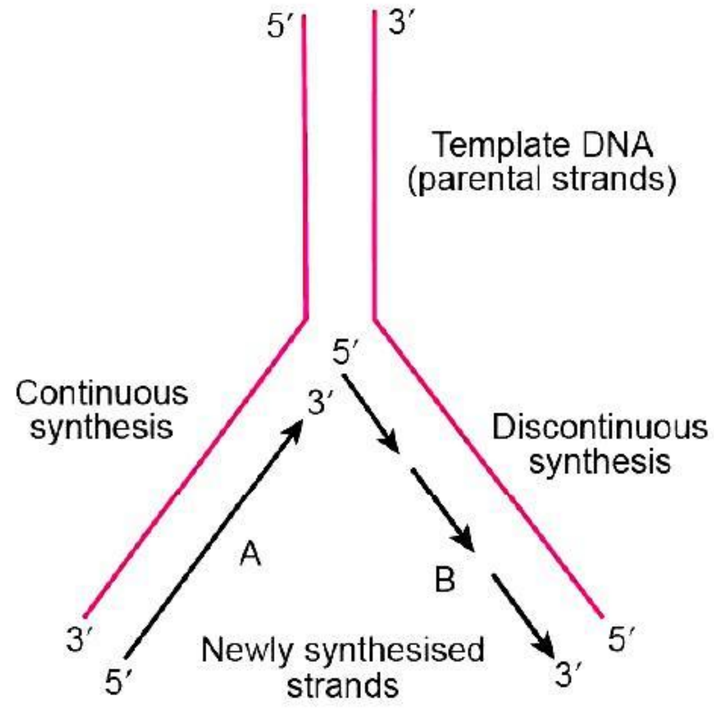
CASE-BASED QUESTIONS

Attempt any 4 sub-parts from each question. Each question carries 1 mark.

1. Read the following and answer the questions given below:

DNA REPLICATION

The process of DNA replication takes place in direction 3′ → 5′ of the template. The enzyme DNA polymerase performs polymerization in 5′ → 3′ direction. The enzyme helicase opens up the DNA helix to develop a replication fork. In prokaryotes, the replication fork runs in both directions from the point of 'origin' to complete DNA replication.



(*i*) The DNA strand labelled by 'A' is

(*a*) leading strand

(*b*) continuous strand

(*c*) both (*a*) and (*b*)

(*d*) discontinuous strand

(*ii*) The fragments represented by 'B' are

(*a*) Morgan fragments

(*b*) Okazaki fragments

(*c*) Ochoa fragments

(*d*) discontinuous fragments

(*iii*) The enzyme which is required to join the fragments represented by 'B' is

(*a*) Ochoa enzyme (*b*) Kornberg Enzyme

(*c*) *Taq* polymerase (*d*) ligase

(*iv*) Replication fork is developed by the activity of enzyme

(*a*) topoisomerase (*b*) DNA polymerase

(*c*) helicase (*d*) primase

(*v*) How many origins are present in prokaryotic DNA?

(*a*) One (*b*) Two

(*c*) Several (*d*) No origin present

Answers

1. (*i*) (*c*) The replication of 3′→5′ strand is continuous and it is called leading strand(A).

(*ii*) (*b*) The replication of lagging strand generates small polynucleotide fragments called 'Okazaki fragments'(B).

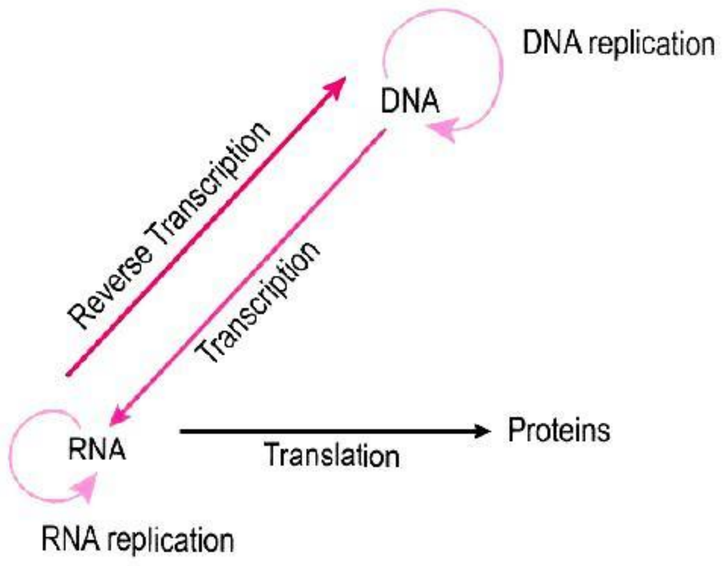
(*iii*) (*d*) These Okazaki fragments are then joined together by enzyme called DNA ligase.

(*iv*) (*c*) The enzyme helicase unwinds the DNA strand to form the replication fork.

(*v*) (*a*) There is only one origin in prokaryotic DNA and it is characterized by arrays of repeated sequences.

2. Read the following and answer the questions given below:

CENTRAL DOGMA OF LIFE



The diagram represents flow of genetic information in the living world (including viruses). It is termed as "Central Dogma of molecular Biology". The concept of Central Dogma got modified after the discovery of viral genetics.

(*i*) The concept of Central Dogma was proposed by

(*a*) Watson and Crick (*b*) F.H.C. Crick

(*c*) T.H. Morgan (*d*) Bateson and Punett

(*ii*) The process of RNA replication refers to

(*a*) synthesis of RNA on RNA template

(*b*) synthesis of RNA on DNA template

(*c*) synthesis of RNA without any template

(*d*) all of these

(*iii*) In which of the following virus, reverse transcription occurs?

(*a*) HIV (*b*) CMV

(*c*) TMV (*d*) Polio virus

(*iv*) Transcription results into the synthesis of

(*a*) *m*RNA (*b*) *t*RNA

(*c*) *r*RNA (*d*) all of these

(*v*) RNA replication is the characteristic feature of

(*a*) all plant viruses (*b*) all animal viruses

(*c*) most of the plant viruses (*d*) most of the animal viruses

Answers

2. (*i*) (*b*) Francis Crick or F.H.C Crick proposed the central dogma of molecular biology which states that genetic information flows from DNA to RNA (transcription) and then from RNA to protein (translation) always unidirectionally (except bidirectionally in some viruses and the process is called reverse transcription).

(*ii*) (*a*) The process of RNA replication refers to the synthesis of RNA on RNA template.

(*iii*) (*a*) Reverse transcription occurs in human immunodeficiency virus (HIV).

(*iv*) (*d*) The process of copying genetic information from one strand of the DNA into RNA(*m*RNA, *t*RNA, *r*RNA) is termed as transcription.

(*v*) (*c*) RNA replications is the characteristic feature of most of the plant viruses.

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

THE OPERON MODEL

In prokaryotes, control of the rate of transcriptional initiation is the predominant site for the control of gene expression. In a transcription unit, the activity of RNA polymerase with accessory proteins, which affects its ability to recognise start sites. These regulatory proteins can act both positively (activators) and negatively (repressors). The accessibility of promoter regions of prokaryotic DNA is in many cases regulated by the interaction of proteins with sequences termed operators. The operator region is adjacent to the promoter region in most operons and in most cases the sequence of operator binds a repressor proteins. Each operon has its specific operator and specific repressor, as in case of '*lac* operon' there is presence of *lac* operator which interacts specifically with *lac* repressor only.

(*i*) Chief control of gene expression is at

(*a*) transcriptional level

(*b*) translational level

(*c*) the site of transcription to the site of translation

(*d*) all of these

(*ii*) Which of the following statements is correct?

(*a*) Operator-repressor means functional repressor.

(*b*) Repressor binds to promoter.

(*c*) Regulatory proteins are only repressors.

(*d*) Repressor bound to operator means non-functional operon.

(*iii*) Presence of functional repressor in any operon means

(*a*) the operon is normally non functional

(*b*) the operon is repressible operon

(*c*) the operon requires a co-repressor to start activity

(*d*) function of operon is required in excess

(*iv*) *lac* operon is regulated by

(*a*) interaction of protein with operator

(*b*) interaction of *lac*-repressor with lac-operator

(*c*) interaction of *lac*-repressor with regulators

(*d*) both (*a*) and (*b*)

(*v*) Assertion : *lac*-operon is an inducible operon.

Reason : Regulator of *lac*-operon produces functional repressor.

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

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

(*c*) Assertion is true but reason is false.

(*d*) Both assertion and reason are false.

Answers

3. (*i*) (*a*) Transcriptional level

(*ii*) (*d*) Repressor bound to operator means non-functional operon.

(*iii*) (*a*) The operon is normally non-functional.

(*iv*) (*d*) Both (*a*) and (*b*)

(*v*) (*a*) Both assertion and reason are true, and the reason is correct explanation of assertion.

ASSERTION-REASON QUESTIONS

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

1. Assertion : The *t*RNA molecules possess anticodons.
Reason : *t*RNA reads the message in form of codons.

2. Assertion : Histones are basic proteins of major importance in packaging of eukaryotic DNA.
Reason : Histones are of five major types: H_1, H_2A, H_2B, H_3 and H_4.

3. Assertion : *m*RNA attaches to ribosome through its 5′ end.
Reason : The *m*RNA has bases of lagging sequence.

4. Assertion : Replication and transcription occur in the nucleus but translation occurs in the cytoplasm.
Reason : *m*RNA is transferred from the nucleus into the cytoplasm where ribosomes and amino acids are available for protein synthesis.

5. Assertion : In Griffith's experiment, the mixture of heat-killed virulent R bacteria and live non-virulent S bacteria, lead to the death of mice.
Reason : The transforming principle got transferred from S strain to heat-killed R strain and made it virulent.

6. Assertion : DNA is considered to be a better genetic material than RNA for most organisms.
Reason : 2′–OH group present in DNA makes it less reactive.

7. Assertion : DNA replication is semi-conservative in nature.
Reason : In each cycle of replication the complementary strands of parental double helix is conserved.

8. Assertion : *lac* operon is a repressible operon.
Reason : The product of repressor binds to the operator and prevents expression of the said gene.

9. Assertion : The human genome comprise of a large amount of repetitive sequences.
Reason : The repetitive sequences in the genome do not have direct coding functions.

10. Assertion : Eukaryotic *m*RNA requires post-transcriptional modifications to form functional *m*RNA.
Reason : Eukaryotic transcripts possess extra non-functional gene segments called introns.

Answers

1. (*b*) **2.** (*b*) **3.** (*c*) **4.** (*a*) **5.** (*a*) **6.** (*a*) **7.** (*a*) **8.** (*d*)
9. (*b*) **10.** (*a*)

HINTS/EXPLANATIONS OF SELECTED MCQs

26. (*b*) If 30 percent of DNA is adenine, then by Chargaff's rule 30 percent will be thymine. The remaining 40 percent of the DNA is cytosine and guanine. Since the ratio of cytosine to guanine must be equal, then each accounts for 20 percent of the bases.

27. (*a*) The premature *m*RNA undergoes post-translation modifications to get converted to the mature *m*RNA. There are three processes which are involved in this modification, splicing, capping and tailing. The capping process refers to the addition of the 7-methylated guanosine cap at the 5′ end of the premature *m*RNA.

29. (*c*) Deoxyribonucleoside triphosphates serve dual purposes. They serve as substrates *i.e.*, nucleotides during replication and also provide energy for polymerisation reaction by cleavage of high energy terminal phosphates bond.

30. (*c*) Origin of replication is a sequence from where replication starts and any piece of foreign DNA is linked to this sequence. The replication occurs inside the host cells. This new sequence is also responsible for controlling copy number of linked DNA.

33. (*a*) S-phase (synthesis phase) is the phase of the cell cycle in which DNA is replicated, occurring between G_1 phase and G_2 phase.

34. (*b*) The DNA in the nucleus exists in two forms that reflect the level of activity of the cell : heterochromatin and euchromatin. Heterochromatin appears as small, darkly staining, irregular particles scattered throughout the nucleus or accumulated adjacent to the nuclear envelope.

35. (*a*) Euchromatin, which has an open structure and is frequently transcribed, tends to replicate in early S-phase. Heterochromatin, which is more condensed and rarely transcribed, usually replicates in late S-phase.

37. (*b*) The strongest and the first experimental evidence that DNA is the genetic material came from transforming principle experiment. The transformation was discovered by Frederick Griffith in 1928 in bacteria *Diplococcus pneumoniae*.

39. (*d*) DNA replication is a semi-conservative process, because when a new double-stranded DNA molecule is formed, a new strand will be formed from the original template.

41. (*c*) *Escherichia coli* is used for the studies related to the discovery of replication of DNA because it is a single-celled organism and grows and reproduces rapidly which leads to the enormous amount of sample DNA that can be used for the study and experiments. *E. coli* can survive in variable growth conditions. This naturally occurring strains of *E.coli* are harmless.

42. (*a*) The DNA polymerases are enzymes that create DNA molecules by assembling nucleotides, the building blocks of DNA.

44. (*d*) The pre-*m*RNA molecule undergoes three main modifications. These modifications are 5′ capping, 3′ polyadenylation, and RNA splicing, which occur in the cell nucleus before the RNA is translated.

45. (*d*) Replication of DNA in eukaryotes commences from multiple origin of replication sites.

47. (*b*) Genetic code determines sequence of amino acids in protein chain. The genetic code expresses in a way that 64 codons constitute it, as it occurs in triplets. According to the genetic code, three bases must be employed to encode the 20 standard amino acids used by living cells to build proteins.

50. (*a*) *lac* operon shows the control of gene expression at the transcription level in *E.coli*.

51. (*b*) The Human Genome Project was a 13-year-long, publicly funded project initiated in 1990 with the objective of determining the DNA sequence of the entire euchromatic human genome within 15 years.

52. (*a*) Distance between two consecutive base pairs in DNA strand is 3.4 Å. Thus, length of a DNA strand with 75 base pairs = 3.4 × 75 = 255 Å.

53. (*c*) *m*RNA molecules have the sequence of nucleotides. The three nucleotides together on *m*RNA is known as codon which codes for particular amino acids. The RNA has the sequence of UGU GUG UGU GUG that codes for tetrapeptides which contain only cysteine and valine. Thus, the codons UGU and GUG codes for cysteine and valine respectively.

54. (*c*) Genetic information is carried by the long chain molecules which are made up of nucleotides. The link between successive generation is provided by nucleic acids. Nucleic acids, which include DNA and RNA, are made from monomers known as nucleotides.

58. (*d*) Replication of DNA copies the genetic information present in it which is transcribed into RNA by transcription. The codons of *m*RNA are translated into an amino acid sequence of polypeptides by the process of translation. Transfer RNAs (*t*RNAs) read the *m*RNA codons and transfer the appropriate amino acid to a growing polypeptide chain on ribosomes. Ribosomal RNAs (*r*RNAs) are component of ribosomes. The sequence of codon transfer is DNA-*m*RNA-*t*RNA-*r*RNA-amino acid.

62. (*a*) The start codon is the first codon of a messenger RNA (*m*RNA) transcript translated by a ribosome. The start codon always codes for methionine in eukaryotes and a modified Met (fMet) in prokaryotes. The most common start codon is AUG.

64. (*b*) A plasmid is a small, extracellular DNA molecule that is physically separated from a chromosomal DNA and can replicate independently. It is used in recombinant DNA technology. Recombinant DNA (rDNA) molecules are DNA molecules formed by laboratory methods of genetic recombination to bring together genetic material from multiple sources, creating sequences that would not otherwise be found in biological organisms.

65. (*a*) Plastids are double-membrane organelles which are found in the cells of plants and algae. Plastids are responsible for manufacturing and storing of food. These often contain pigments that are used in photosynthesis and different types of pigments that can change the colour of the cell.

68. (*b*) Transfer RNA (tRNA) is a small type of stable RNA that carries an amino acid to the corresponding site of protein synthesis in the ribosome. It is the base pairing between the tRNA and mRNA that allows for the correct amino acid to be inserted in the polypeptide chain being synthesized.

71. (*b*) According to Chargaff's rule, the amount of adenine is always equal to that of thymine and the amount of guanine is always equal to that of cytosine *i.e.*, A = T and G = C. If dsDNA has 28% of cytosine, then according to the law, it would have 28% of guanine. The remaining 44% represents both A + T molecule. Since adenine and guanine are always present in equal numbers, the percentage of adenine molecule is 22%.

72. (*b*) A ribonucleotide is a nucleotide containing ribose as its pentose component. It is considered a molecular precursor of nucleic acids. Nucleotides are the basic building blocks of DNA and RNA. The monomer itself from ribonucleotides forms the basic building blocks for RNA.

73. (*b*) This reaction is catalysed by enzyme peptidyl transferase which is an RNA-enzyme.

78. (*b*) Uracil (U) always pairs with adenine (A). Further, the *m*RNA codon is read in 5′ to 3′ direction. Alignment of the *m*RNA and *t*RNA is antiparallel, which means that 5′ end of *m*RNA pairs with 3′ end of *t*RNA. This makes options (*a*) and (*d*) incorrect. The first base of the codon in *m*RNA (read in the 5′ to 3′ direction) pairs with the third base of the anticodon, thus the anticodon 3′-UUUA-5′ would pair with 5′-AAAU-3′ codon.

79. (*c*) Purines always bond with pyrimidines via hydrogen bonds following the Chargaff rule in *ds*DNA, more specifically each bond follows Watson-Crick base pairing rules. Therefore, adenine specifically bonds to thymine forming two hydrogen bonds, whereas guanine forms three hydrogen bonds with cytosine.

82. (*a*) In the mid-1950s, the physicist George Gamow extended line of thinking to deduce the genetic code. He proposed that a group of 3 successive nucleotides in a gene might code for one amino acid in a polypeptide.

Griffith's experiment, reported in 1928 by Frederick Griffith, was the first experiment suggesting that bacteria are capable of transferring genetic information through a process known as transformation

Johannes Friedrich Miescher (13 August 1844 – 26 August 1895) was a Swiss physician and biologist. He was the first scientist to isolate nucleic acid.

83. (*a*) Expressing a gene means manufacturing its corresponding protein, and this multi -layered process has two major steps. In the first step, the information in DNA is transferred to a messenger RNA (*m*RNA) molecule by way of a process called transcription. During transcription, the DNA of a gene serves as a template for complementary base-pairing, and an enzyme called RNA polymerase II catalyses the formation of a pre-*m*RNA molecule, which is then processed to form mature *m*RNA. The resulting *m*RNA is a single-stranded copy of the gene, which next must be translated into a protein molecule.

89. (*c*) Rosalind Franklin used X-ray diffraction to determine the structure of DNA molecules. These diffraction patterns indicates that DNA is a double helix. In addition, the radius, pitch, pitch angle and the number of phosphate molecules per pitch of the DNA helix could be determined.

92. (*a*) 3DMD (Duchenne muscular dystrophy) is the largest known human gene which provides instructions for the formation of a protein called dystrophin. Dystrophin is a rod-shaped cytoplasmic protein located primarily in skeletal muscles and cardiac muscles. The DMD gene, encoding the dystrophin protein, covers 2.3 megabases (0.08% of the human genome).

97. (*b*) Because of semi-conservative method of DNA replication only two molecules of DNA will have some radioactive thymidine.

98. (*c*) DNA replication is semi-conservative which means that when a new double-stranded DNA molecule is formed, one strand will be from the original template molecule and another strand will be newly synthesised.

When *Escherichia coli* with completely radioactive DNA is allowed to replicate in non-radioactive medium, with each generation one strand will remain as such radioactive while new one synthesised will be non-radioactive.

After the first generation, both the bacteria formed will have 50% non-radioactive and 50% radioactive DNA. In the second generation, these strands with mixed composition separate and again replicate in the same manner. The non-radioactive strand replicates and synthesises new non-radioactive strands. While radioactive strands replicate to form new bacterial cells with the mixed composition of DNA. Now, among 4 bacterial cells, 2 have mixed composition of DNA (both radioactive and non-radioactive strands) while 2 cells have purely non-radioactive DNA.

99. (*b*) Discontinuous replication produces a series of short DNA fragments (Okazaki fragments) complementary to the template strand.

100. (*b*) Replication is semi-conservative because the new daughter DNA synthesized is composed of one parent DNA and one newly synthesized complementary strand of parent molecule.

Discontinuous because during replication there are two complementary strands synthesized that run anti-parallel. The DNA polymerase can only add nucleotides to a 3′ end. This results in one strand synthesized continuously, called leading strand and the other synthesized discontinuously, called lagging strand.

101. (*d*) Cistron is a segment of DNA that is equivalent to a gene and that specifies a single functional unit (such as a protein or enzyme).

103. (*d*) In molecular biology and genetics, translation is the process in which ribosomes in the cytoplasm or endoplasmic reticulum synthesize proteins after the process of transcription of DNA to RNA in the cell's nucleus. The entire process is called gene expression.

104. (*c*) There are 3 STOP codons in the genetic code - UAG, UAA, and UGA. These codons signal the end of the polypeptide chain during translation. These codons are also known as nonsense codons or termination codons as they do not code for an amino acid.

106. (*c*) VNTR or the Variable Number of Tandem Repeats are the repeated DNA sequences at a defined locus. The tandem repeat sequences of DNA are also termed as "satellite DNA". These are of three main types: satellite, minisatellite and microsatellite.

110. (*d*) The sugar and phosphate make up the backbone, while the nitrogen bases are found in the centre and hold the two strands together. Due to the base pairing via hydrogen bonds, the DNA strands are complementary to each other, run in opposite directions and are called antiparallel strands.

112. (*b*) The rules of base pairing (or nucleotide pairing) are:

A with T: the purine adenine (A) always pairs with the pyrimidine thymine (T).

C with G: the pyrimidine cytosine (C) always pairs with the purine guanine (G).

This is consistent with there not being enough space (20 Å) for two purines to fit within the helix and too much space for two pyrimidines to get close enough to each other to form hydrogen bonds between them.

113. (*d*) Oswald Avery, Colin MacLeod, and Maclyn McCarty showed that DNA (not proteins) can transform the properties of cells, clarifying the chemical nature of genes. Avery, MacLeod and McCarty identified DNA as the "transforming principle" while studying *Streptococcus pneumoniae*, bacteria that can cause pneumonia.

114. (*d*) Terminator region is present downstream of structural gene at the 3′ end of coding strand which is actually 5′ end of the template strand.

116. (*c*) The *lac* operon consists of three structural genes: *lac*Z, which codes for β-galactosidase, which acts to cleave lactose into galactose and glucose; *lac*Y, which codes for *lac* permease, which is a transmembrane protein necessary for lactose uptake; and *lac*A, which codes for a transacetylase that transfers an acetyl group from coenzyme A (CoA) to the hydroxyl group of galactosides.

118. (*d*) In eukaryote cells, RNA polymerase III (also called Pol III) transcribes DNA to synthesize ribosomal 5S *r*RNA, *t*RNA and other small RNAs.

120. (*b*) All the given terms except inducer are related to an operon.

123. (*a*) Since DNA polymerase requires a free 3′ OH group for initiation of synthesis, it can synthesize in only one direction by extending the 3′ end of the pre-existing nucleotide chain. Hence, DNA polymerase moves along the template strand in 3′→ 5′ direction, and the daughter strand is formed in a 5′→ 3′ direction.

124. (*c*) The nucleosome is the fundamental sub-unit of chromatin. Each nucleosome is composed of a little less than two turns of DNA wrapped around a set of eight proteins called histones, which are known as a histone octamer.

125. (*d*) A purine is an aromatic heterocycle composed of carbon and nitrogen. Purines include adenine and guanine, which participate in DNA and RNA formation. Purines are also constituents of other important biomolecules, such as ATP, GTP, cyclic AMP, NADH, and coenzyme A.

129. (*b*) A RNA polymerase (RNAP), or ribonucleic acid polymerase, is a multi-subunit enzyme that catalyses the process of transcription where an RNA polymer is synthesized from a DNA template. The sequence of the RNA polymer is complementary to that of the template DNA and is synthesized in a 5′→ 3′ orientation.

132. (*d*) Site of DNA replication in prokaryotes is cytoplasm as compared to eukaryotes, where DNA replication site is nucleus. There is single origin of replication in prokaryotes whereas numerous in eukaryotes. The Okazaki fragments are large (1000-2000 nucleotides long) in prokaryotic DNA while these are short (100-200 nucleotides long) in eukaryotes.