Class: 12th

Subject: Biology

Unit 20: Chromosomes And DNA

Important MCQs:

1. Chromosomes were first observed by:

(a) Robert Hooke

(b) Walther Fleming ✅

(c) Gregor Mendel

(d) Watson and Crick

2. Walther Fleming discovered chromosomes in the dividing cells of:

(a) Frog

(b) Mouse

(c) Salamander larvae ✅

(d) Corner

3. Chromosomes appear inside the nucleus at the time of:

(a) Photosynthesis

(b) Cell division ✅

(c) Fertilization

(d) Respiration

4. The number of chromosomes in human cells is:

(a) 44

(b) 46 ✅

(c) 48

(d) 23

5. The number of pairs of chromosomes in humans is:

(a) 22

(b) 23 ✅

(c) 24

(d) 46

6. A mosquito has _____ chromosomes.

(a) 6 ✅

(b) 8

(c) 10

(d) 12

7. The particular array of chromosomes in an individual is called:

(a) Genome

(b) Genotype

(c) Karyotype ✅

(d) Chromatin

8. Chromosomes are classified into types based on the position of:

(a) Chromatids

(b) Centromere ✅

(c) Chromatin

(d) Genes

9. Depending on centromere location, chromosomes are called:

(a) Monocentric, Dicentric, Polycentric

(b) Telocentric, Acrocentric, Submetacentric, Metacentric ✅

(c) Short, Medium, Long

(d) Round, Oval, Linear

10. Chromosomes are mainly composed of:

(a) DNA and Lipid

(b) DNA and Protein ✅

(c) RNA and Carbohydrate

(d) RNA and Lipid

11. The proportion of DNA and protein in chromosomes is about:

(a) 30% DNA, 70% Protein

(b) 40% DNA, 60% Protein ✅

(c) 50% DNA, 50% Protein

(d) 60% DNA, 40% Protein

12. The complex formed when DNA coils around histone proteins is called:

(a) Chromatin

(b) Nucleosome ✅

(c) Ribosome

(d) Centrosome

13. Histone proteins are positively charged because they contain:

(a) Glucose and Fructose

(b) Arginine and Lysine ✅

(c) Adenine and Thymine

(d) Phosphate and Ribose

14. The highly condensed, inactive part of chromatin is called:

(a) Euchromatin

(b) Heterochromatin ✅

(c) Chromatid

(d) Kinetochore

15. The open and active part of chromatin during normal cell function is:

(a) Heterochromatin

(b) Euchromatin ✅

(c) Chromonema

(d) Chromatid

16. The chromosomal theory of inheritance was first proposed by:

(a) Karl Correns

(b) Walter Sutton ✅

(c) Thomas Hunt Morgan

(d) Gregor Mendel

17. Karl Correns suggested a central role for chromosomes in heredity in:

(a) 1890

(b) 1900 ✅

(c) 1910

(d) 1920

18. Walter Sutton formulated the chromosomal theory of inheritance in:

(a) 1900

(b) 1902 ✅

(c) 1910

(d) 1928

19. According to Sutton's theory, hereditary material must reside in the:

(a) Cytoplasm

(b) Nucleus ✅

(c) Cell membrane

(d) Mitochondria

20. Diploid individuals have:

(a) One copy of each gene

(b) Two copies of each gene ✅

(c) Three copies of each gene

(d) Variable copies of each gene

21. The chromosomal theory of inheritance was supported by which observation?

(a) Chromosomes segregate during meiosis ✅

(b) Genes are found in cytoplasm

(c) Gametes contain two sets of chromosomes

(d) Chromosomes remain constant during division

22. Thomas Hunt Morgan conducted his experiments on:

(a) Mouse

(b) Fruit fly (Drosophila melanogaster) ✅

(c) Pea plant

(d) Corn

23. In Morgan's experiment, the mutant male fly had:

(a) White eyes ✅

(b) Black body

(c) Curved wings

(d) Red eyes

24. In Morgan's F_2 generation, all white-eyed flies were:

(a) Females

(b) Males ✅

(c) Both males and females

(d) None of these

25. The gene for white eye color in Drosophila is located on the:

(a) Y chromosome

(b) X chromosome ✅

(c) Autosome

(d) Cytoplasm

26. A trait determined by a gene on the X chromosome is called:

(a) Recessive trait

(b) Sex-linked trait ✅

(c) Dominant trait

(d) Autosomal trait

27. The first evidence that DNA is hereditary material was given by:

(a) Thomas Hunt Morgan

(b) Frederick Griffith ✅

(c) Oswald Avery

(d) Alfred Hershey

28. In Griffith's experiment, transformation occurred when:

(a) Live R and dead S bacteria were injected together ✅

(b) Only live R bacteria were injected

(c) Only dead S bacteria were injected

(d) Both live S and R bacteria were dead

29. Avery, MacLeod, and McCarty proved that the transforming principle was:

(a) Protein

(b) DNA ✅

(c) RNA

(d) Lipid

30. Hershey and Chase used which radioactive isotope to label DNA?

(a) ^{35}S

(b) ^{32}P ✅

(c) ^{14}C

(d) ^{3}H

31. DNA was discovered by:

(a) James Watson

(b) Friedrich Miescher ✅

(c) Oswald Avery

(d) Rosalind Franklin

32. Friedrich Miescher discovered DNA in the year:

(a) 1859

(b) 1869 ✅

(c) 1900

(d) 1920

33. The substance first extracted by Miescher from nuclei was called:

(a) Chromatin

(b) Nuclein ✅

(c) Protein

(d) Ribosome

34. The three main components of DNA identified by P.A. Levene are:

(a) Sugar, phosphate, and base ✅

(b) Sugar, water, and oxygen

(c) Protein, RNA, and lipid

(d) Nitrogen, carbon, and hydrogen

35. The purine bases in DNA are:

(a) Adenine and Cytosine

(b) Adenine and Guanine ✅

(c) Thymine and Cytosine

(d) Guanine and Uracil

36. The pyrimidine bases in DNA are:

(a) Adenine and Guanine

(b) Thymine and Cytosine ✅

(c) Cytosine and Adenine

(d) Uracil and Adenine

37. The bond that links one nucleotide to another in DNA is called:

(a) Hydrogen bond

(b) Ionic bond

(c) Phosphodiester bond ✅

(d) Peptide bond

38. Erwin Chargaff discovered that:

(a) DNA is a double helix

(b) A = T and G = C ✅

(c) DNA replicates semi-conservatively

(d) RNA contains uracil

39. Rosalind Franklin's X-ray diffraction studies showed that DNA has a:

(a) Spherical shape

(b) Helical shape ✅

(c) Linear shape

(d) Zigzag shape

40. The DNA double helix model was proposed by:

(a) Franklin and Wilkins

(b) Watson and Crick ✅

(c) Avery and Chase

(d) Hershey and Stahl

41. In the DNA molecule, adenine pairs with thymine by:

(a) One hydrogen bond

(b) Two hydrogen bonds ✅

(c) Three hydrogen bonds

(d) Ionic bonds

42. Guanine pairs with cytosine through:

(a) Two hydrogen bonds

(b) Three hydrogen bonds ✅

(c) One hydrogen bond

(d) Peptide bonds

43. The Watson and Crick model of DNA replication is known as:

(a) Conservative

(b) Semi-conservative ✅

(c) Dispersive

(d) Random

44. The experiment that confirmed the semi-conservative replication of DNA was performed by:

(a) Avery and McCarty

(b) Hershey and Chase

(c) Meselson and Stahl ✅

(d) Watson and Crick

45. The enzyme that joins Okazaki fragments on the lagging strand is:

(a) DNA polymerase I

(b) Primase

(c) DNA ligase ✅

(d) Helicase

46. The concept that some diseases are inherited as Mendelian traits was proposed by:

(a) George Beadle and Edward Tatum

(b) Archibald Garrod ✅

(c) Frederick Sanger

(d) Vernon Ingram

47. Archibald Garrod studied inherited diseases like:

(a) Sickle cell anemia

(b) Alkaptonuria ✅

(c) Haemophilia

(d) Diabetes

48. The dark color of urine in alkaptonuria patients is due to the oxidation of:

(a) Melanin

(b) Homogentisic acid ✅

(c) Uric acid

(d) Amino acids

49. Garrod concluded that alkaptonuria was caused by a deficiency of a:

(a) Hormone

(b) Vitamin

(c) Enzyme ✅

(d) Protein

50. Garrod's work led to the idea that:

(a) Genes code for RNA

(b) Genes code for enzymes ✅

(c) Enzymes make genes

(d) Mutations are environmental

51. Beadle and Tatum carried out experiments on:

(a) Mice

(b) Neurospora fungus ✅

(c) Drosophila

(d) Bacteria

52. Beadle and Tatum induced mutations in Neurospora using:

(a) UV light

(b) X-rays ✅

(c) Chemicals

(d) Heat

53. Organisms that undergo changes in DNA due to radiation are called:

(a) Mutants ✅

(b) Variants

(c) Carriers

(d) Wild types

54. The medium containing only sugar, ammonia, salts, vitamins, and water is called:

(a) Complete medium

(b) Minimal medium ✅

(c) Nutrient agar

(d) Enzyme medium

55. The arginine-requiring mutants were called:

(a) Arg mutants ✅

(b) Auxotrophs

(c) DNA mutants

(d) RNA mutants

56. Beadle and Tatum proposed that each gene controls the synthesis of:

(a) A carbohydrate

(b) One enzyme ✅

(c) A lipid

(d) A vitamin

57. The "one gene-one enzyme" hypothesis was later modified to:

(a) One gene-one nucleus

(b) One gene-one protein

(c) One gene-one polypeptide ✅

(d) One gene-one RNA

58. The first protein whose complete amino acid sequence was determined was:

(a) Haemoglobin

(b) Insulin ✅

(c) Myosin

(d) Albumin

59. The complete amino acid sequence of insulin was described by:

(a) Vernon Ingram

(b) Frederick Sanger ✅

(c) Beadle and Tatum

(d) James Watson

60. Sickle cell anemia is caused by a defect in:

(a) Hemoglobin ✅

(b) Insulin

(c) DNA polymerase

(d) Albumin

61. Vernon Ingram discovered that in sickle cell anemia, glutamic acid is replaced by:

(a) Alanine

(b) Valine ✅

(c) Glycine

(d) Leucine

62. The change in a single nucleotide that leads to sickle cell disease is called a:

(a) Mutation ✅

(b) Transcription

(c) Translation

(d) Duplication

63. The sequence of nucleotides that determines the sequence of amino acids in a protein is called:

(a) Chromosome

(b) Gene ✅

(c) Codon

(d) Ribosome

64. The flow of genetic information from DNA → RNA → Protein is known as:

(a) Gene linkage

(b) Central dogma ✅

(c) Genetic drift

(d) Molecular inheritance

65. The process of making an mRNA copy from DNA is called:

(a) Translation

(b) Replication

(c) Transcription ✅

(d) Transformation

66. The RNA found in ribosomes is called:

(a) tRNA

(b) rRNA ✅

(c) mRNA

(d) snRNA

67. The main function of rRNA is to:

(a) Carry amino acids

(b) Provide site for protein synthesis ✅

(c) Carry genetic code

(d) Act as enzyme

68. Transfer RNA (tRNA) is responsible for:

(a) Carrying genetic code

(b) Carrying amino acids to ribosomes ✅

(c) Making ribosomes

(d) Copying DNA

69. Human cells contain about _____ kinds of tRNA molecules.

(a) 20

(b) 45 ✅

(c) 60

(d) 100

70. The RNA that carries information from DNA to ribosomes is called:

(a) tRNA

(b) mRNA ✅

(c) rRNA

(d) cRNA

71. The enzyme that catalyzes RNA synthesis from DNA template is:

(a) DNA polymerase

(b) RNA polymerase ✅

(c) Ligase

(d) Helicase

72. Only one strand of DNA is transcribed; it is called the:

(a) Coding strand

(b) Template strand ✅

(c) Sense strand

(d) Complementary strand

73. In prokaryotes, RNA polymerase synthesizes RNA in which direction?

(a) 3′ ⟶ 5′

(b) 5′ ⟶ 3′ ✅

(c) Both directions

(d) Randomly

74. In prokaryotes, how many types of RNA polymerases exist?

(a) One ✅

(b) Two

(c) Three

(d) Four

75. In eukaryotes, RNA polymerase II is responsible for synthesis of:

(a) rRNA

(b) tRNA

(c) mRNA ✅

(d) snRNA

76. The promoter region on DNA contains the sequence:

(a) TTGACA and TATAAT ✅

(b) GCGCGA and AAATTT

(c) AUG and UAA

(d) GGAACC and CCCGGG

77. In eukaryotes, promoter binding sites are found approximately at:

(a) −10 and −35

(b) −25 and −75 ✅

(c) −20 and −60

(d) −15 and −50

78. The subunit of RNA polymerase responsible for initiation is:

(a) Beta subunit

(b) Sigma factor ✅

(c) Alpha subunit

(d) Omega factor

79. The GC hairpin followed by U-rich sequence acts as:

(a) Promoter site

(b) Stop signal ✅

(c) Enhancer

(d) Intron site

80. In eukaryotes, mRNA receives a cap of:

(a) 7-methyl GTP ✅

(b) Poly C tail

(c) Poly G tail

(d) 3′ phosphate

81. The tail added to eukaryotic mRNA at the 3′ end is called:

(a) Poly C tail

(b) Poly A tail ✅

(c) Poly G tail

(d) GC tail

82. The function of the mRNA cap and tail is to:

(a) Aid in replication

(b) Protect mRNA from enzymes ✅

(c) Increase mutation

(d) Produce energy

83. The genetic code consists of _____ nucleotides per codon.

(a) Two

(b) Three ✅

(c) Four

(d) Five

84. The codon AUG codes for the amino acid:

(a) Glycine

(b) Methionine ✅

(c) Valine

(d) Arginine

85. The three stop codons in the genetic code are:

(a) UGA, UAA, UAG ✅

(b) AUG, GGA, UCA

(c) AAA, CCC, GGG

(d) UUU, UUA, UCU

86. In prokaryotes, translation begins when mRNA binds to:

(a) tRNA molecule

(b) rRNA molecule in ribosome ✅

(c) DNA strand

(d) Golgi body

87. The sequence of three nucleotides on tRNA that pairs with mRNA codon is called:

(a) Codon

(b) Anticodon ✅

(c) Template

(d) Operator

88. The enzyme that attaches specific amino acids to their tRNA molecules is:

(a) RNA polymerase

(b) Aminoacyl-tRNA synthetase ✅

(c) Peptidase

(d) Ligase

89. In prokaryotes, the first amino acid used to initiate polypeptide synthesis is:

(a) Methionine

(b) N-formyl methionine ✅

(c) Valine

(d) Glycine

90. The site on the ribosome where the growing peptide chain is held is called:

(a) A site

(b) P site ✅

(c) E site

(d) Active site

91. The ribosome moves along the mRNA in which direction?

(a) 3′ → 5′

(b) 5′ → 3′ ✅

(c) Both directions

(d) Randomly

92. Translation ends when the ribosome encounters a:

(a) Start codon

(b) Stop or nonsense codon ✅

(c) Anticodon

(d) Promoter

93. Mutations that involve loss or addition of a chromosome are called:

(a) Point mutations

(b) Chromosomal aberrations ✅

(c) Gene mutations

(d) Frameshifts

94. A mutation changing glutamic acid to valine in hemoglobin causes:

(a) Down's syndrome

(b) Sickle cell anemia ✅

(c) Klinefelter's syndrome

(d) Phenylketonuria

95. Phenylketonuria is caused by a defective enzyme called:

(a) Phenylalanine hydroxylase ✅

(b) Tyrosinase

(c) Hemoglobinase

(d) Catalase

Q4: Exercise Short Questions

1. What are the three major classes of RNA?

Answer:

The three major classes of RNA are:

👉 **rRNA (Ribosomal RNA):** Forms the structure of ribosomes and provides the site for protein synthesis.

👉 **tRNA (Transfer RNA):** Brings specific amino acids to the ribosome during protein synthesis.

👉 **mRNA (Messenger RNA):** Carries genetic information from DNA to ribosomes for protein formation.

2. What is the function of RNA polymerase in transcription?

Answer:

👉 RNA polymerase is the enzyme that synthesizes RNA using the DNA template strand.

👉 It binds to a specific region on DNA called the promoter and forms an RNA strand in the 5′ → 3′ direction by adding complementary RNA nucleotides.

3. How did Crick and his colleagues determine how many nucleotides are used to specify each amino acid?

Answer:

👉 Crick and his colleagues used mathematical reasoning and genetic experiments.

👉 They found that a triplet code of three nucleotides (codon) is required to specify one amino acid, because combinations of two nucleotides were not enough to code for 20 amino acids.

4. What is anticodon?

Answer:

👉 An anticodon is a sequence of three nucleotides on a tRNA molecule that is complementary to the codon on mRNA.

👉 It ensures that the correct amino acid is added to the growing polypeptide chain during translation.

Important Short Questions:

1. Who first observed chromosomes and when?

Answer:

Chromosomes were first observed by Walther Fleming in 1882 while studying the dividing cells of salamander larvae.

2. What are chromosomes?

Answer:

Chromosomes are thread-like structures that appear inside the nucleus during cell division and contain DNA and proteins carrying genetic information.

3. How many chromosomes are present in human cells?

Answer:

Human cells contain 46 chromosomes, arranged in 23 pairs.

4. Name two species with the lowest and highest number of chromosomes.

Answer:

👉 **Lowest**: Penicillium (1 pair)

👉 **Highest**: Some ferns (more than 500 pairs)

5. What are the main parts of a chromosome?

Answer:

A chromosome is made up of chromatids, a centromere (primary constriction), and sometimes a secondary constriction.

6. What is a karyotype?

Answer:

A karyotype is the complete set or arrangement of chromosomes in an individual, showing their size, shape, and number.

7. On what basis are chromosomes classified into different types?

Answer:

Chromosomes are classified based on the position of the centromere as telocentric, acrocentric, sub-metacentric, and metacentric.

8. What are chromosomes composed of?

Answer:

Chromosomes are composed of about 40% DNA and 60% protein, with a small amount of RNA also present.

9. What is a nucleosome?

Answer:

A nucleosome is a structural unit where DNA is coiled around a core of eight histone proteins, forming a “string of beads” appearance under an electron microscope.

10. Differentiate between heterochromatin and euchromatin.

Answer:

👉 **Heterochromatin:** Permanently condensed chromatin; DNA is inactive.

👉 **Euchromatin:** Loosely packed chromatin; DNA is active and expressed during cell functions.

11. Who gave the Chromosomal Theory of Inheritance and when?

Answer:

The Chromosomal Theory of Inheritance was given by Walter Sutton in 1902.

12. Who first suggested that chromosomes play a role in heredity?

Answer:

Karl Correns first suggested it in 1900.

13. Which experiment provided clear evidence that genes are located on chromosomes?

Answer:

Thomas Hunt Morgan's fruit fly (Drosophila) experiment in 1910 provided this evidence.

14. What organism did Morgan use in his experiment?

Answer:

He used the fruit fly (Drosophila melanogaster).

15. What unusual observation did Morgan make in his experiment?

Answer:

He found that all white-eyed flies in the F_2 generation were males.

16. What is meant by a sex-linked trait?

Answer:

A sex-linked trait is a character controlled by a gene located on the X chromosome and absent on the Y chromosome.

17. What did Morgan's experiment prove?

Answer:

It proved that genes are present on chromosomes and follow Mendelian inheritance patterns.

18. What is the main idea of the Chromosomal Theory of Inheritance?

Answer:

It states that genes are located on chromosomes, and chromosomes segregate and assort independently during meiosis.

19. Who first demonstrated that DNA carries hereditary information?

Answer:

Frederick Griffith in 1928 demonstrated it through his transformation experiment.

20. What is transformation?

Answer:

Transformation is the transfer of genetic material from one cell to another, changing the genetic makeup of the recipient cell.

21. What were the S and R strains used by Griffith?

Answer:

- **S strain:** Smooth, virulent (causes disease)
- **R strain:** Rough, non-virulent (harmless)

22. What happened when Griffith injected mice with heat-killed S strain and live R strain?

Answer:

The mice died, and live virulent S bacteria were found in their blood, showing transformation had occurred.

23. Who identified DNA as the transforming principle?

Answer:

Oswald Avery, Colin MacLeod, and Maclyn McCarty in 1944 identified DNA as the transforming substance.

24. Which scientists proved that DNA is the hereditary material using bacteriophages?

Answer:

Alfred Hershey and Martha Chase in 1952 proved it through their bacteriophage experiment.

25. What conclusion was drawn from Hershey and Chase's experiment?

Answer:

They concluded that DNA, not protein, is the hereditary material that carries genetic information.

26. Who discovered DNA and when?

Answer:

Friedrich Miescher discovered DNA in 1869 while studying nuclei of human cells and fish sperm.

27. What name did Miescher give to DNA and why?

Answer:

He called it “nuclein” because it was found in the nucleus of cells.

28. Who determined the basic structure of nucleic acids and when?

Answer:

P.A. Levene determined the basic structure of nucleic acids in the 1920s.

29. What are the three main components of DNA?

Answer:

DNA contains:

1. Phosphate group
2. Pentose sugar (deoxyribose)
3. Nitrogen bases (A, T, G, C)

30. What are purines and pyrimidines? Give examples.

Answer:

- **Purines:** Double-ring bases — Adenine (A) and Guanine (G)
- **Pyrimidines:** Single-ring bases — Thymine (T) and Cytosine (C)

31. What is a nucleotide?

Answer:

A nucleotide is the basic unit of DNA or RNA, consisting of a sugar, phosphate group, and nitrogen base.

32. What is a phosphodiester bond?

Answer:

It is a covalent bond linking the phosphate group of one nucleotide to the sugar of another, forming the DNA backbone.

33. What is Chargaff's rule?

Answer:

Erwin Chargaff stated that A = T and G = C, and that purines (A+G) always equal pyrimidines (T+C) in DNA.

34. Who prepared the X-ray diffraction pattern of DNA?

Answer:

Rosalind Franklin, in Maurice Wilkins' laboratory, prepared the X-ray diffraction image of DNA.

35. What did the X-ray diffraction study reveal about DNA?

Answer:

It showed that DNA is a double helix with a diameter of 2 nm and a helical turn every 3.4 nm.

36. Who proposed the double helix model of DNA and when?

Answer:

James Watson and Francis Crick proposed the double helix model in 1953.

37. How are the two DNA strands arranged in the double helix?

Answer:

They are antiparallel, one running 3 ⟶ 5′ and the other 5′⟶3′, connected by hydrogen bonds between base pairs.

38. What is meant by semi-conservative replication?

Answer:

It means that each new DNA molecule consists of one old (parental) strand and one newly synthesized strand.

39. Who proved that DNA replication is semi-conservative and how?

Answer:

Meselson and Stahl (1958) proved it using E. coli bacteria grown in N^{15} and N^{14} isotopes, showing intermediate-density DNA after one replication.

40. What is the difference between the leading and lagging strands in DNA replication?

Answer:

- **Leading strand:** Synthesized continuously toward the replication fork.
- **Lagging strand:** Synthesized discontinuously as Okazaki fragments, later joined by DNA ligase.

41. What are the three main types of RNA?

Answer:

The three main types of RNA are:

1. Ribosomal RNA (rRNA)

2. Transfer RNA (tRNA)

3. Messenger RNA (mRNA)

42. What is the function of rRNA?

Answer:

rRNA provides the site for polypeptide assembly during protein synthesis (translation).

43. What is the main function of tRNA?

Answer:

tRNA transports amino acids to the ribosome and positions them correctly on the growing polypeptide chain.

44. What is the function of mRNA?

Answer:

mRNA carries genetic information from DNA to ribosomes, where it directs the sequence of amino acids in a protein.

45. What is transcription?

Answer:

Transcription is the process in which an RNA copy of a gene is synthesized from DNA using the enzyme RNA polymerase.

46. What is the template strand and coding strand?

Answer:

- **Template strand (antisense):** Used to synthesize RNA.
- **Coding strand (sense):** Has the same sequence as the RNA (except T is replaced by U).

47. In which direction does RNA synthesis occur?

Answer:

RNA synthesis always occurs in the 5'⟶ 3' direction.

48. How many types of RNA polymerases are found in prokaryotes and eukaryotes?

Answer:

Prokaryotes: One RNA polymerase for all RNAs.

Eukaryotes: Three types –

1. RNA polymerase I ⟶ rRNA

2. RNA polymerase II ⟶ mRNA

3. RNA polymerase III ⟶ tRNA

49. What is a promoter?

Answer:

A promoter is a specific sequence of DNA where RNA polymerase binds to start transcription.

50. What are -10 and -35 sequences in prokaryotes?

Answer:

They are promoter regions:

- **35 sequence:** TTGACA
- **10 sequence:** TATAAT

These help RNA polymerase attach to DNA.

51. What is the function of the sigma factor?

Answer:

The sigma factor helps RNA polymerase recognize the correct initiation site for transcription.

52. What is a transcription bubble?

Answer:

A transcription bubble is the unwound region of DNA where RNA synthesis is actively taking place.

53. What is the stop signal for transcription in prokaryotes?

Answer:

A GC-rich hairpin loop followed by a series of uracil (U) bases causes RNA polymerase to stop transcription.

54. What are the functions of cap and tail in eukaryotic mRNA?

Answer:

- Cap (7-methyl GTP) protects the mRNA at the 5′ end.
- Poly-A tail at the 3′ end increases stability and protects mRNA from enzymes.

55. What is the genetic code?

Answer:

The genetic code is a set of three nucleotides (codon) in DNA or RNA that specifies a particular amino acid.

56. What is translation?

Answer:

Translation is the process by which the information in mRNA is used to synthesize a polypeptide (protein) on the ribosome.

57. Where does translation occur in prokaryotes?

Answer:

In prokaryotes, translation occurs in the cytoplasm, where mRNA binds to rRNA in the ribosome.

58. What is the role of tRNA during translation?

Answer:

tRNA carries specific amino acids to the ribosome and matches its anticodon with the codon on mRNA.

59. What enzyme attaches amino acids to tRNA?

Answer:

The enzyme aminoacyl-tRNA synthetase attaches specific amino acids to their respective tRNAs.

60. What is the initiation complex in translation?

Answer:

The initiation complex includes:

- Small ribosomal subunit
- Initiator tRNA (carrying N-formyl methionine)
- mRNA molecule
- It marks the start of protein synthesis.

61. What are the three sites on the ribosome during translation?

Answer:

1. A site (Aminoacyl site) – where new tRNA binds.

2. P site (Peptidyl site) – where peptide bonds form.

3. E site (Exit site) – where empty tRNA leaves the ribosome.

62. What is translocation during translation?

Answer:

Translocation is the movement of the ribosome along the mRNA in the 5′⟶ 3′ direction, exposing the next codon for binding.

63. What are nonsense codons and what is their role?

Answer:

Nonsense codons (UAA, UAG, UGA) do not code for any amino acid; they signal termination of translation.

64. What are mutations?

Answer:

Mutations are changes in DNA sequence caused by errors in replication or damage from mutagens that can alter genetic information.

65. What are the two main types of mutations?

Answer:

1. Chromosomal aberrations – involve structural or numerical changes in chromosomes.

2. Point mutations – involve changes in one or few nucleotides in a gene sequence.

Q5: Extensive Questions:

🌟 Q1: How did Hershey and Chase determine which components of bacterial viruses contain the hereditary information?

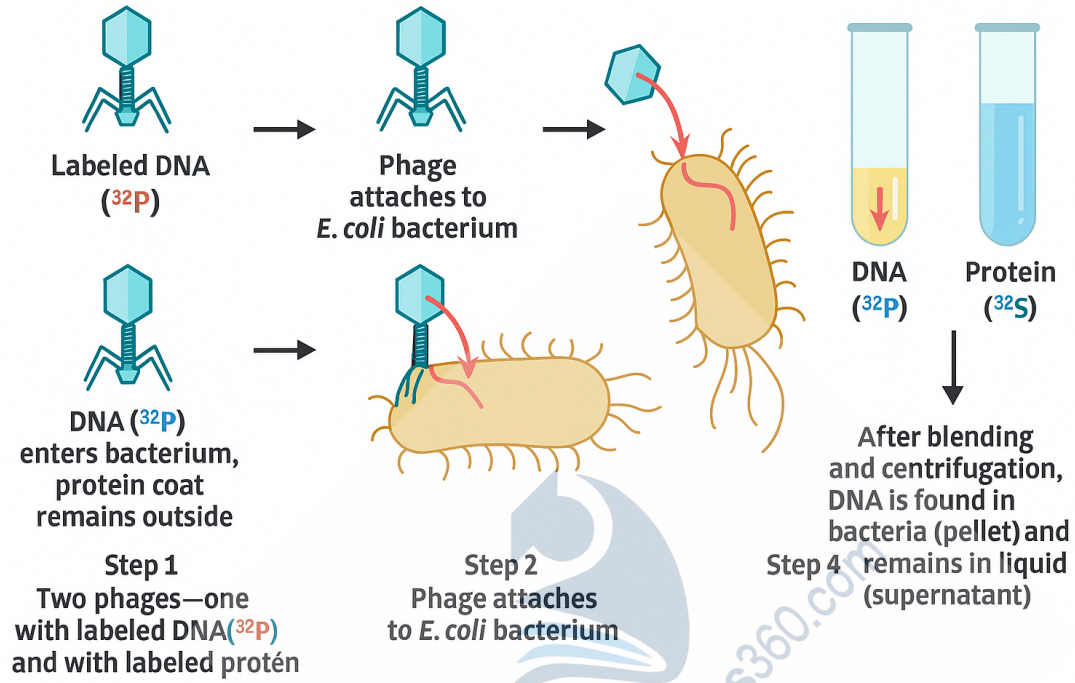
❖ **Introduction:**

During the early 1950s, scientists were unsure whether DNA or protein acted as the hereditary material. Both were major components of chromosomes. To solve this question, two American scientists, Alfred Hershey and Martha Chase, performed a famous experiment in 1952 using a bacteriophage (a virus that infects bacteria).

🔹 **Background of the Experiment:**

- A bacteriophage is composed of DNA enclosed within a protein coat. When a bacteriophage infects a bacterium, it attaches to the bacterial surface and injects its genetic material inside.

- Hershey and Chase wanted to find out which part of the virus — DNA or protein — enters the bacterial cell and carries hereditary information.



🔹 Experimental Design:

To identify the hereditary material, Hershey and Chase used radioactive isotopes as markers:

1. Phosphorus-32 (^{32}P) to label DNA, because DNA contains phosphorus but no sulfur.

2. Sulfur-35 (^{35}S) to label protein, because protein contains sulfur but no phosphorus.

Thus, they prepared two separate groups of bacteriophages:

- One with ^{32}P-labeled DNA
- One with ^{35}S-labeled protein coat

🔹 Steps of the Experiment:

1. Infection:

- Each type of labeled bacteriophage was allowed to infect the bacteria (E. coli). The viruses attached to the bacterial cells and injected their genetic material inside.

2. Blending:

- After infection, the mixture was placed in a blender and gently shaken to remove the viral protein coats from the surfaces of the bacterial cells.

3. Centrifugation:

- The mixture was then centrifuged. The heavier bacterial cells settled at the bottom (pellet), while the lighter viral coats remained in the liquid (supernatant).

🔹 Observations:

After centrifugation, Hershey and Chase found that:

- When the phages had ^{32}P-labeled DNA, the radioactivity was found inside the bacterial cells.
- When the phages had ^{35}S-labeled protein, the radioactivity remained outside the cells in the liquid.
- This showed that DNA entered the bacterial cells, while the protein did not.

🔹 **Significance:**

- This experiment provided final proof that DNA, not protein, is the genetic material.
- It supported the earlier findings of Avery, MacLeod, and McCarty (1944).
- It opened the way for further studies on the structure of DNA by Watson and Crick (1953).

🌟 **Q2: What is the three-dimensional shape of DNA? How does the three-dimensional shape of DNA fit with Chargaff's observations on the proportions of purines and pyrimidines in DNA?**

❖ **Introduction:**

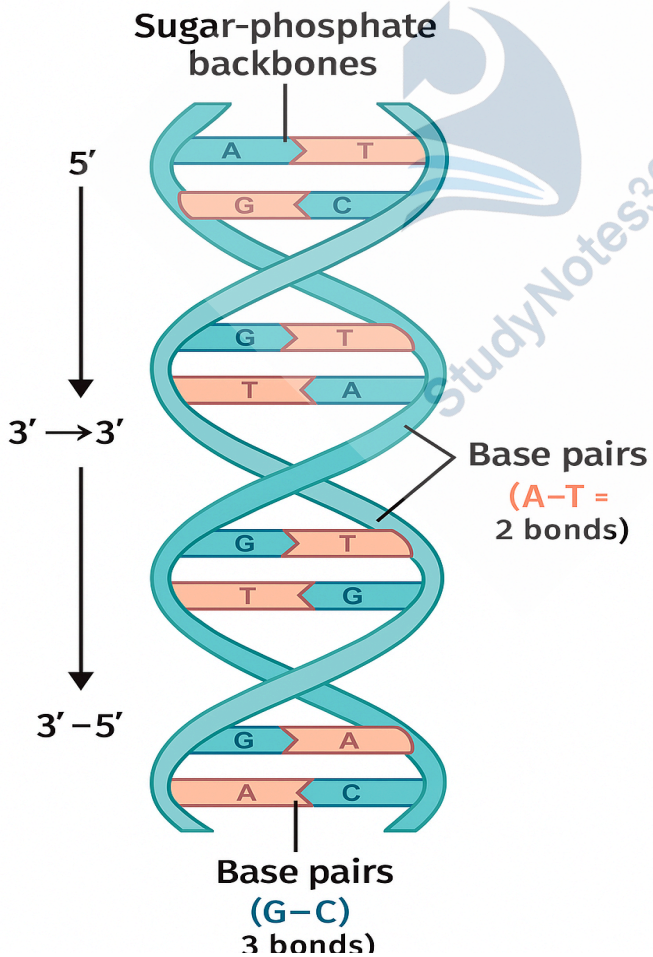
DNA (Deoxyribonucleic Acid) is the hereditary material in almost all organisms. It stores and transmits genetic information from one generation to another. The

three-dimensional structure of DNA was discovered by James Watson and Francis Crick in 1953.

🔹 Discovery of the Structure:

Watson and Crick proposed that DNA has a double helix structure, based on:

- X-ray diffraction studies by Rosalind Franklin and Maurice Wilkins, and Base composition studies by Erwin Chargaff.



🔹 Three-Dimensional Structure of DNA

1. Double Helix:

- DNA is composed of two long polynucleotide chains twisted around each other like a spiral staircase or twisted ladder.

2. Sugar-Phosphate Backbone:

- The sides of the ladder are made of alternating sugar (deoxyribose) and phosphate groups joined by phosphodiester bonds.

3. Nitrogenous Bases:

The rungs of the ladder are made of paired nitrogenous bases:

- **Purines:** Adenine (A) and Guanine (G)
- **Pyrimidines:** Thymine (T) and Cytosine (C)

4. Base Pairing Rule (Complementary Base Pairing):

- Adenine (A) pairs with Thymine (T) by two hydrogen bonds.
- Guanine (G) pairs with Cytosine (C) by three hydrogen bonds.

5. Antiparallel Strands:

- The two strands run in opposite directions — one in 5′ → 3′ and the other in 3′ → 5′ direction.

6. Helical Turn:

- One complete turn of the helix contains about 10 base pairs and measures 3.4 nanometers in length.

🔹 Relationship with Chargaff's Rule

Chargaff observed that:

- The amount of A = T and G = C in any DNA sample.
- The ratio of purines (A + G) to pyrimidibnes (T + C) is always 1:1.

👉 This fits with Watson and Crick's model because:

Each purine pairs with one pyrimidine (A with T, G with C), Maintaining a uniform width of the double helix and equal proportions of purines and pyrimidines.

🌟 Q3. How did Meselson and Stahl show that DNA replication is semi-conservative?

❖ Introduction:

- The process of DNA replication ensures that each daughter cell receives an exact copy of the genetic material.
- In 1958, Matthew Meselson and Franklin Stahl performed an experiment to determine how DNA replicates and showed that DNA replication is semi-conservative.

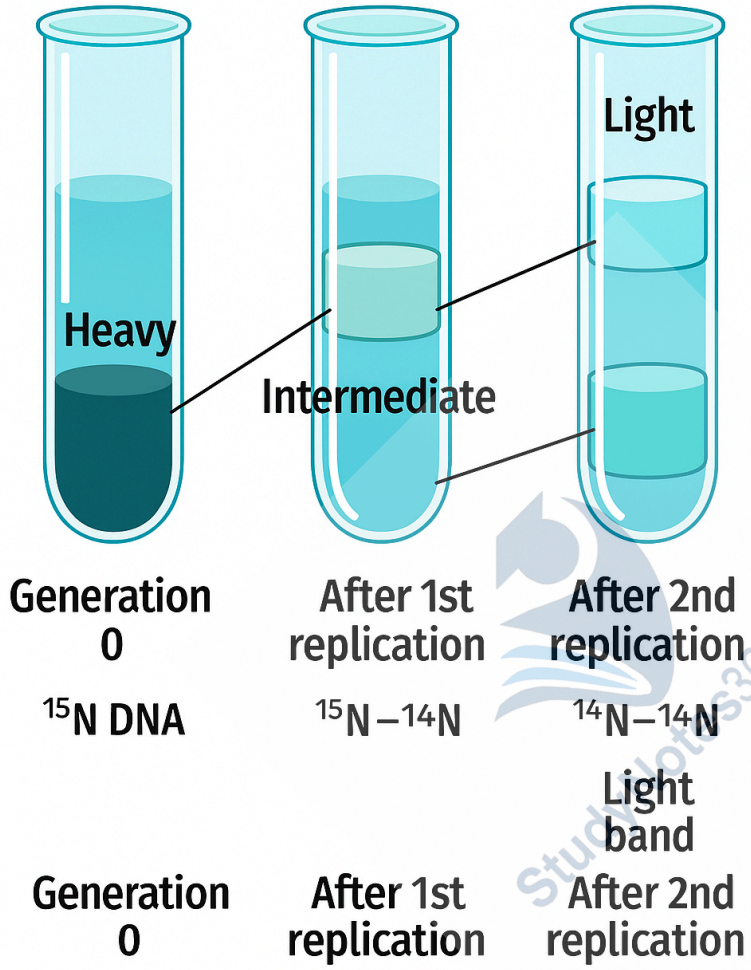
🔹 Theories of DNA Replication

Before their experiment, three hypotheses existed:

1. Conservative model: Parent DNA remains intact; a completely new copy is made.

2. Semi-conservative model: Each new DNA molecule has one old (parental) and one new strand.

3. Dispersive model: Both strands of new DNA are a mixture of old and new segments.



🔹 Experimental Design

1. Bacteria Used:

- E. coli bacteria were grown in a medium containing heavy nitrogen isotope (^{15}N) for several generations.

- → Their DNA became fully labeled with ^{15}N (heavy DNA).

2. Transfer to Light Nitrogen Medium (^{14}N):

- The bacteria were then transferred to a medium containing ^{14}N (light nitrogen).
- → As the cells divided, they produced new DNA strands using ^{14}N.

3. Centrifugation in Cesium Chloride (CsCl):

- After each generation, DNA was extracted and centrifuged in a density gradient of CsCl to separate heavy and light DNA.

🔹 Observations

Generation 0 (before transfer):

- DNA contained only ^{15}N — appeared as a single heavy band.

After 1st replication (in ^{14}N medium):

- DNA showed a single intermediate band — indicating one heavy and one light strand (hybrid DNA).

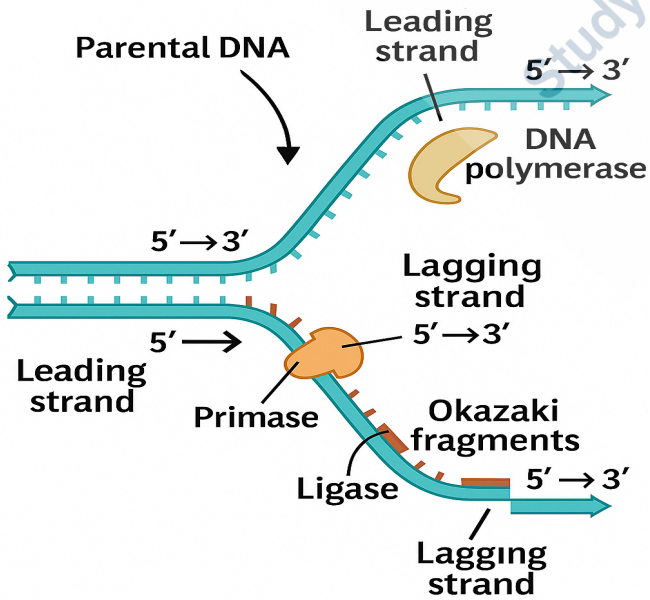
After 2nd replication:

- DNA showed two bands — one light and one intermediate, showing that one strand from the parent was conserved.

🌟 Q4. What is the basis for the requirement that the leading and lagging strands be replicated by different mechanisms?

❖ Introduction:

- DNA replication is the process through which the DNA molecule copies itself before cell division.
- This process is semi-conservative, meaning each new DNA molecule contains one old and one new strand.
- **However**, both strands of DNA cannot be replicated in the same way because of their antiparallel nature.



⚡ Antiparallel Nature of DNA

DNA consists of two strands that run in opposite directions:

- One strand runs from 5′ → 3′.
- The other runs from 3′ → 5′.

DNA polymerase, the main enzyme that synthesizes new DNA, can only add nucleotides in the 5′ → 3′ direction.

Because of this limitation, one strand can be synthesized continuously, while the other must be made in fragments.

🔹 Leading and Lagging Strands

1. Leading Strand:

- Synthesized continuously in the same direction as the replication fork movement.
- DNA polymerase follows the fork and adds nucleotides smoothly.

2. Lagging Strand:

- Synthesized discontinuously in the opposite direction of the fork movement.

- DNA polymerase makes short segments of DNA called Okazaki fragments, each later joined by the enzyme DNA ligase.

🔍 Basis of Different Mechanisms

The requirement for different mechanisms arises because:

- DNA polymerase cannot work in the 3′ → 5′ direction.
- Since the two strands of DNA are antiparallel, replication can move smoothly on one strand but must occur in short bursts on the other.
- Thus, the leading strand is made continuously, and the lagging strand is made discontinuously.

🌟 Q5. What hypothesis did Beadle and Tatum test in their experiments on Neurospora?

❖ Introduction:

- In 1941, American geneticists George Beadle and Edward Tatum performed a famous experiment on the bread mold Neurospora crassa.
- Their work demonstrated the direct connection between genes and enzymes, forming a major foundation for molecular genetics.

🧠 The Hypothesis

They proposed the "One Gene–One Enzyme Hypothesis."

👉 According to this hypothesis:

> “Each gene controls the production of a single specific enzyme that, in turn, affects a single step in a metabolic pathway.”

🔬 Beadle and Tatum’s Experiment

1. Organism Used:

- The mold Neurospora crassa, which can grow on minimal medium containing only sugar, salts, and biotin.

2. Inducing Mutations:

- Spores of Neurospora were exposed to X-rays to produce mutations.

3. Observation:

- Some mutants could no longer grow on minimal medium, but they grew when specific amino acids or vitamins were added.

4. Conclusion:

- Each mutant had lost the ability to make a particular enzyme required to produce a specific amino acid or vitamin.
- Therefore, each gene is responsible for the formation of one enzyme in a metabolic pathway.

🧩 Example:

- A mutant that could not produce the enzyme needed to make arginine could grow only when arginine was supplied in the medium.

⟶ This showed that the mutation occurred in the gene controlling that enzyme.

🧩 Important Long Questions:

🌟 Q1. Define chromosomes and describe their types based on centromere position.

❖ Definition of Chromosomes:

- Chromosomes are thread-like structures present in the nucleus of eukaryotic cells that become visible during cell division.

- They carry genetic information in the form of genes, which control all the characteristics and functions of an organism.

👉 Discovery:

- Chromosomes were first discovered by Walther Flemming in 1882 while studying dividing cells of salamander larvae.

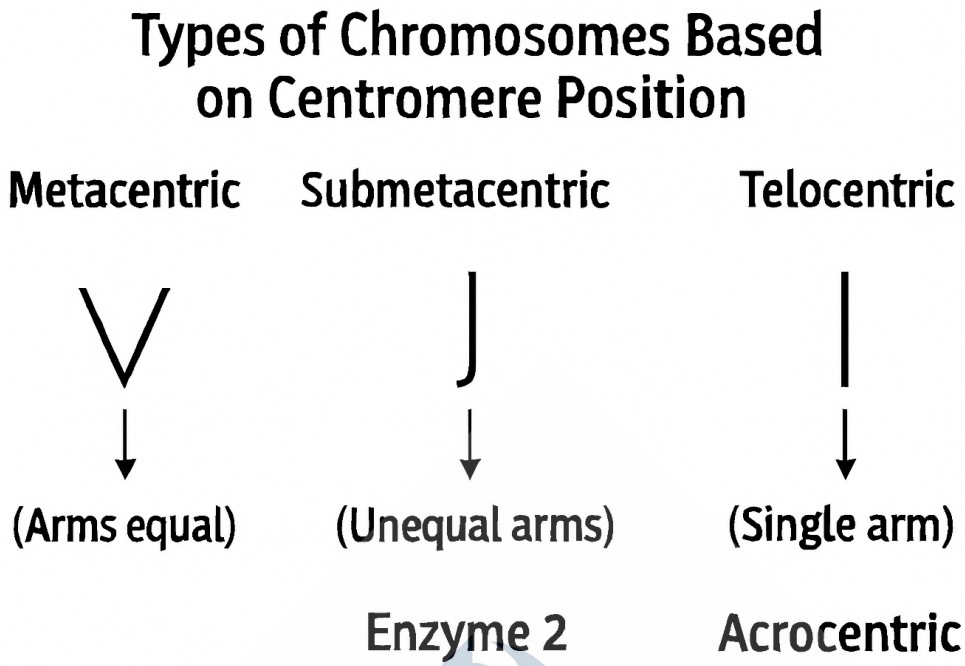
🧠 Structure of a Chromosome:

Each typical chromosome consists of the following parts:

- **Chromatids:** Two identical arms joined together at the centromere.
- **Centromere (Primary constriction):** The point of attachment between chromatids.
- **Secondary constriction:** Sometimes found in specific chromosomes.
- **Satellite:** A small portion separated by secondary constriction.

⚙️ Basis of Classification:

- Chromosomes are classified into four main types based on the position of the centromere.
- The centromere divides the chromosome into arms of different lengths and affects its shape during anaphase of cell division.



- **Types of Chromosomes:**

1 Metacentric Chromosome

- **Centromere Position**: In the middle of the chromosome.
- **Arms:** Both arms are equal in length.

Shape During Anaphase: **V-shaped.**

Example: Found in some human chromosomes.

2 Submetacentric Chromosome

- **Centromere Position:** Slightly away from the center.
- **Arms:** One arm is shorter and the other is longer.

Shape During Anaphase: J-shaped.

Example: Common type in humans.

3️⃣ Acrocentric Chromosome

- **Centromere Position**: Near one end of the chromosome.
- **Arms:** One very short arm and one very long arm.

Shape During Anaphase: L-shaped.

Example: Found in humans (chromosomes 13, 14, 15).

4️⃣ Telocentric Chromosome

- **Centromere Position:** At the tip (end) of the chromosome.
- **Arms:** Only one arm is present.

Shape During Anaphase: I-shaped.

Example: Found in some animals, not in humans.

🧩 Shapes of Chromosomes During Anaphase:

Type	Shape
Metacentric	V-shape
Submetacentric	J-shape
Acrocentric	L-shape
Telocentric	I-shape

🌟 Q2. Explain the composition and structure of chromosomes.

❖ Introduction:

- Chromosomes are mainly composed of DNA, proteins, and a small amount of RNA.
- They are the hereditary units that carry genetic information from one generation to the next.
- Their unique structure allows efficient packaging of DNA inside the small space of the nucleus.

⚛️ Chemical Composition of Chromosomes:

1️⃣ Deoxyribonucleic Acid (DNA) — 40%

- The main hereditary material of the chromosome.
- Exists as a long, double-stranded molecule of nucleotides.
- Each human chromosome contains about 140 million nucleotides (1.4×10^8).

- **If stretched,** the DNA from one chromosome would be about 5 cm long, yet it fits inside the nucleus due to coiling.
- DNA carries the genetic code that determines all inherited traits.

2️⃣ Proteins — 60%

- Mainly histone proteins and some non-histone proteins.
- Histones help in coiling and packaging of DNA.
- They are positively charged (rich in lysine and arginine) and attract the negatively charged phosphate groups of DNA.
- This tight binding forms stable structural units inside the chromosome.

3️⃣ Ribonucleic Acid (RNA) — Small Amount

- Found in association with chromosomes.
- RNA is produced during transcription, since chromosomes are the sites of RNA synthesis.

🧬 Structural Organization of Chromosomes:

1️⃣ DNA Fiber:

- Each chromosome contains one long, continuous DNA molecule.
- This DNA fiber is coiled and folded many times to fit inside the nucleus.

2️⃣ Nucleosome:

- When observed under an electron microscope, DNA appears as a string of beads.
- Each "bead" is a nucleosome, formed when DNA wraps around eight histone proteins.
- Each nucleosome occurs after every 200 nucleotides.

3️⃣ Supercoiling:

- The string of nucleosomes coils further into supercoils, forming chromatin fibers.
- These fibers condense during cell division, forming visible chromosomes.

🧠 Types of Chromatin:

(a) Heterochromatin:

- Highly condensed part of chromatin.
- DNA remains inactive (not expressed).
- Permanently condensed even when the cell is not dividing.

(b) Euchromatin:

- Loosely packed and active part of chromatin.
- Genes are expressed here.

- Becomes condensed only during cell division.

🌟 Q3: Differentiate between Heterochromatin and Euchromatin.

❖ Answer:

Chromatin exists in two main forms — heterochromatin and euchromatin, which differ in structure, function, and gene activity.

🔹 1. Heterochromatin

- It is the densely packed and highly coiled form of chromatin.
- Appears darkly stained under the microscope.
- It remains permanently condensed, even when the cell is not dividing.
- The DNA in heterochromatin is genetically inactive (genes are not expressed).
- Found mostly near centromeres and telomeres of chromosomes.
- Plays a structural and stabilizing role for chromosomes.
- Prevents unwanted recombination and maintains chromosome integrity.

🔹 2. Euchromatin

- It is the loosely packed and lightly coiled form of chromatin.

- Appears lightly stained under the microscope.
- Condenses only during cell division and stays relaxed in interphase.
- The DNA in euchromatin is genetically active and involved in gene expression.
- Found in the central (arm) regions of chromosomes.
- Provides access to RNA polymerase for transcription of genes.
- Plays an important role in protein synthesis and genetic regulation.

✳️ **Summary:**

👉 Euchromatin is active and functional, while heterochromatin is inactive and structural, but both are essential for maintaining proper chromosome function and gene regulation.

🌟 **Q4: Explain the One-Gene-One-Enzyme Hypothesis**

❖ **Answer:**

The One-Gene-One-Enzyme Hypothesis was proposed by George Beadle and Edward Tatum in 1941 through their experiments on Neurospora crassa (red bread mold).

🔹 **1. Experiment**

- Beadle and Tatum exposed Neurospora to X-rays to create mutations.

- Normal strains grew on a minimal medium (sugar, salts, and biotin).
- Mutated strains failed to grow on the same medium.
- When specific amino acids (like arginine or tryptophan) were added, growth resumed.

🔹 2. Observation

- Each mutant lacked the ability to make a specific enzyme needed to synthesize one amino acid.
- This showed a direct link between a gene and an enzyme involved in metabolism.

🔹 3. Conclusion

They proposed that:

> "Each gene controls the synthesis of one specific enzyme responsible for one step in a metabolic pathway."

This became known as the One-Gene-One-Enzyme Hypothesis.

🔹 4. Later Modificationl

Later studies showed that:

- Not all proteins are enzymes.

- Many enzymes are made of multiple polypeptides, each coded by a separate gene.

Therefore, the concept was modified into the One-Gene-One-Polypeptide Hypothesis.

🌟 Q5: Describe the Chromosomal Theory of Inheritance.

❖ Introduction:

- The Chromosomal Theory of Inheritance explains that genes are located on chromosomes, and these chromosomes act as carriers of hereditary information from one generation to the next.
- This theory established a strong connection between Mendel's principles of inheritance and the behavior of chromosomes during meiosis.

👨‍🔬 Contribution of Karl Correns and Walter Sutton (1900–1902)

- In 1900, Karl Correns, while rediscovering Mendel's work, suggested that chromosomes play a central role in heredity.
- **In 1902,** the American scientist Walter Sutton observed that chromosomes occur in pairs in diploid cells and separate during meiosis just like Mendelian factors (genes).
- Sutton proposed that genes are carried on chromosomes, and chromosome behavior during meiosis could explain

Mendel's laws of segregation and independent assortment.

⚙️ Role of Meiosis in Inheritance:

- During meiosis, homologous chromosomes pair and then separate into different gametes.
- This separation ensures that each gamete receives only one chromosome from each pair — similar to how each gamete receives one allele for each gene.
- During fertilization, male and female gametes unite, restoring the diploid chromosome number in the offspring.

Hence, meiosis explains why offspring inherit traits from both parents and how variation arises due to independent assortment.

🧩 Relationship Between Genes and Chromosomes

- Genes are segments of DNA located at specific positions (loci) on chromosomes.
- Each chromosome carries many genes, which determine different traits.
- Since chromosomes are passed from parents to offspring, genes are also transmitted, ensuring hereditary continuity.

📖 Supporting Evidences

1. Gamete Formation:

- Egg and sperm each contribute one set of chromosomes to the zygote.

Thus, hereditary material must be carried in chromosomes present in gamete nuclei.

2. Segregation During Meiosis:

- Homologous chromosomes separate during meiosis, mirroring Mendel's Law of Segregation.

3. Independent Assortment:

- The random orientation of chromosome pairs on the metaphase plate explains Mendel's Law of Independent Assortment.

4. Equal Contribution of Parents:

- Both parents contribute one set of chromosomes to the offspring, maintaining equal genetic contribution.

🌟 Q6: Describe the Importance of Morgan's Discovery in the History of Genetics

❖ Introduction:

- In 1910, American geneticist Thomas Hunt Morgan performed experiments on the fruit fly (Drosophila melanogaster) that revolutionized the field of genetics.
- His discoveries confirmed the Chromosomal Theory of Inheritance and introduced new concepts such as sex-linked inheritance, genetic linkage, and gene mapping.

🔹 1. Confirmation of the Chromosomal Theory of Inheritance:

- **Walter Sutton** had earlier proposed that genes are located on chromosomes, but there was no direct evidence.
- **Morgan's** experiments provided the first clear proof by showing that specific traits (like eye color in fruit flies) were linked to specific chromosomes.
- This established that chromosomes are the physical carriers of genes, confirming Sutton's theory.

👁️ 2. Discovery of Sex-Linked Inheritance:

- Morgan discovered a mutant male fruit fly with white eyes instead of the normal red.
- When he crossed it with a red-eyed female, all F_1 offspring had red eyes, but in F_2 generation, white-eyed flies were only males.

- He concluded that the gene for eye color was located on the X chromosome, and since males have only one X, the recessive trait appeared in them.
- This was the first demonstration of sex-linked inheritance in animals.

3. Foundation for Modern Genetics:

- Morgan's research connected Mendelian principles with chromosome behavior, giving rise to classical genetics.
- His findings explained how genes are arranged linearly on chromosomes and how they are inherited together or separated by crossing over.
- Thus, his work became the foundation for understanding genetic structure and inheritance.

🧩 4. Concept of Genetic Linkage and Mapping:

- Morgan and his students, especially Alfred Sturtevant, discovered that some genes are linked because they are located close together on the same chromosome.
- They developed the concept of genetic maps, showing the relative position of genes based on recombination frequency.
- This led to the development of chromosomal mapping, a key tool in genetics even today.

🏅 5. Nobel Recognition and Scientific Impact:

- In 1933, Thomas Hunt Morgan received the Nobel Prize in Physiology or Medicine for his discoveries on the role of chromosomes in heredity.
- His pioneering work transformed genetics from a theoretical idea into an experimental science.
- It inspired future discoveries in molecular biology, DNA structure, and gene technology.

🌟 **Q7: Describe the discovery and chemical composition of DNA.**

❖ **Introduction:**

DNA (Deoxyribonucleic Acid) is the fundamental molecule of life that carries genetic information in all living organisms. It determines heredity, controls cell functions, and transmits genetic traits from parents to offspring.

🔹 **Discovery of DNA**

1. Friedrich Miescher (1869) — A German chemist first discovered DNA.

2. He extracted a white, sticky substance from the nuclei of human white blood cells and fish sperm.

3. Miescher named this substance “nuclein” because it was found inside the nucleus of cells.

4. Later, since it showed acidic properties, it was renamed "nucleic acid."

5. This discovery laid the foundation for future research on genetic material.

🔹 Contribution of P.A. Levene

1. In the 1920s, biochemist P.A. Levene studied the chemical structure of nucleic acids.

2. He found that DNA is composed of three main components:

1. Phosphate group (PO_4)
2. Five-carbon sugar (deoxyribose in DNA)
3. Nitrogen-containing bases

3. He concluded that DNA and RNA are made up of repeating units called nucleotides.

🔹 Structure of a Nucleotide

1. Each nucleotide consists of:

- A nitrogen base attached to the 1' carbon of the sugar.
- A phosphate group attached to the 5' carbon of the sugar.
- A free hydroxyl (-OH) group on the 3' carbon.

2. These features allow nucleotides to join together and form long DNA chains.

🔹 Formation of Phosphodiester Bonds

1. Nucleotides link through a dehydration reaction between the phosphate group (5' end) of one nucleotide and the hydroxyl group (3' end) of another.

2. This reaction forms a phosphodiester bond, creating a strong sugar-phosphate backbone.

3. The chain thus has a 5' phosphate end and a 3' hydroxyl end, allowing it to grow in length.

🔹 Types of Nitrogen Bases

DNA contains four nitrogen bases of two types:

1. Purines (Double-ringed):

- Adenine (A)
- Guanine (G)

2. Pyrimidines (Single-ringed):

- Thymine (T)
- Cytosine (C)

Note: In RNA, Uracil (U) replaces Thymine.

🔹 Importance of Nucleotide Arrangement

1. The sequence of nucleotides in DNA determines the genetic code.

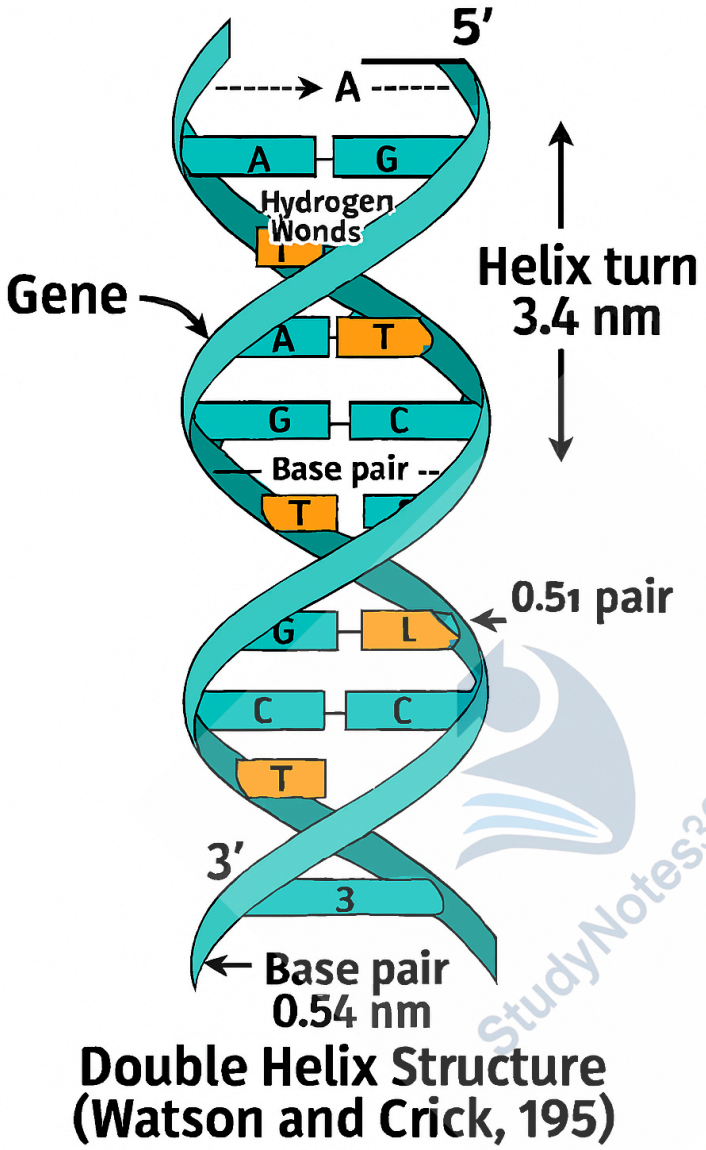
2. This sequence carries instructions for protein synthesis and controls all cellular activities.

3. Even a slight change in the nucleotide order can cause genetic mutations and alter traits.

🌟 Q8: Explain the Watson and Crick Model of DNA

❖ Introduction:

- In 1953, James Watson and Francis Crick, working at the University of Cambridge, proposed the Double Helix Model of DNA.
- This model explained the three-dimensional structure of DNA and how it can store and replicate genetic information accurately.



Double Helix Structure
(Watson and Crick, 195)

✦ 1. Double Helical Structure

- DNA is composed of two long strands of nucleotides twisted around each other to form a double helix, similar to a twisted ladder.
- Each strand has a sugar-phosphate backbone on the outside and nitrogenous bases on the inside.

🔄 2. Antiparallel Orientation

The two strands run in opposite directions:

- One strand runs 5′ to 3′
- The other runs 3′ to 5′

This opposite arrangement is called antiparallel and is crucial for replication and base pairing.

3. Base Pairing Rules

- Adenine (A) always pairs with Thymine (T) by two hydrogen bonds.
- Guanine (G) always pairs with Cytosine (C) by three hydrogen bonds.
- These specific pairings maintain stability and ensure accurate genetic copying.

📏 4. Constant Diameter

- Purine (A or G) always pairs with Pyrimidine (T or C).
- This combination keeps the DNA helix diameter constant at 2 nanometers (nm).

📐 5. Distance and Helical Turn

- The distance between two successive base pairs is 0.34 nm.
- One complete turn of the helix contains about 10 base pairs and measures 3.4 nm in length.

🧲 6. Stability of the Molecule

- The hydrogen bonds between complementary bases provide internal stability.
- Hydrophobic interactions between stacked base pairs add extra strength to the structure.

🔁 7. Complementary Nature

- The two DNA strands are complementary, meaning the sequence of one strand determines the sequence of the other.
- This complementarity is the basis of DNA replication, allowing genetic information to be copied precisely.

🧪 8. Importance of the Model

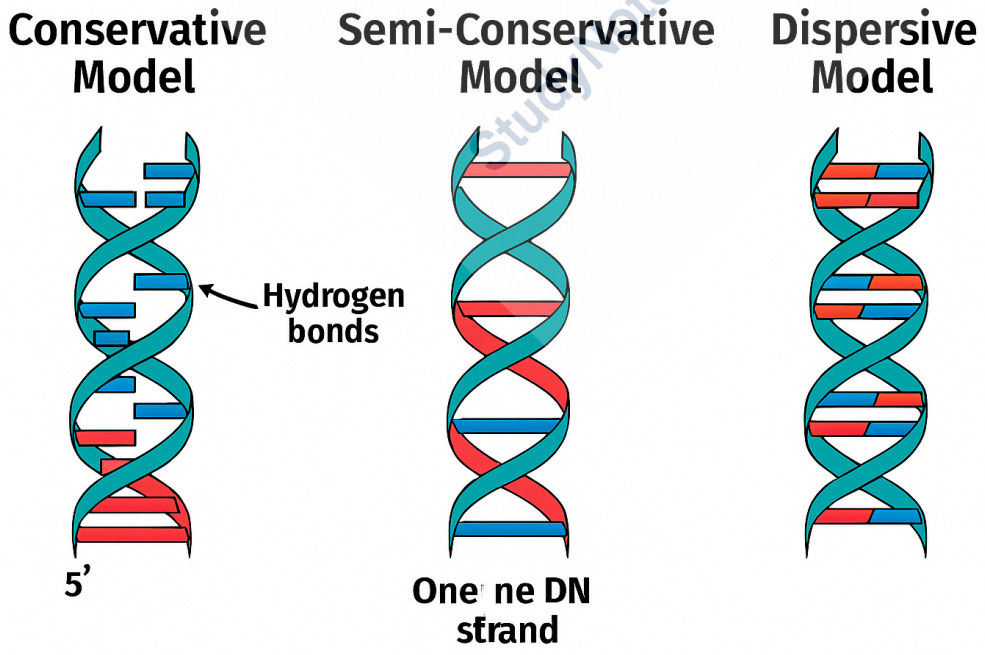
The Watson and Crick model provided a clear explanation of:

- How genetic information is stored
- How DNA replicates semi-conservatively
- How mutations can occur due to changes in base sequence

🌟 Q9: Compare Different Models of DNA Replication (Conservative, Semi-Conservative, and Dispersive)

❖ Introduction:

- DNA replication is the process by which genetic information is copied before cell division, ensuring that each daughter cell receives an identical copy of DNA.
- Scientists proposed three models to explain how DNA replicates: Conservative, Semi-Conservative, and Dispersive.
- **Later**, the experiments of Meselson and Stahl (1958) provided evidence that DNA replication is semi-conservative in nature.



🔹 1. Conservative Model

- According to this model, the parental double helix remains intact after replication.
- A completely new DNA molecule is synthesized.

So, one DNA molecule is entirely old, and the other is entirely new.

After replication:

⟶ One old (original) DNA molecule

⟶ One new (completely synthesized) DNA molecule

🗒️ Limitation:

No experimental evidence supported this model.

🔹 2. Semi-Conservative Model

- Proposed by Watson and Crick (1953) and confirmed by Meselson and Stahl (1958).
- In this model, each daughter DNA molecule contains one old (parental) strand and one newly synthesized strand.

- The two strands of the parent DNA separate, and each serves as a template for the formation of a new complementary strand.
- This ensures accurate transmission of genetic information from one generation to the next.

🗒️ Evidence:

Meselson and Stahl grew E. coli in heavy nitrogen (^{15}N) and then transferred them to light nitrogen (^{14}N). After replication, DNA showed intermediate density, confirming the semi-conservative model.

🔹 3. Dispersive Model

- According to this model, the parental DNA is broken into small fragments.
- The newly synthesized DNA is formed in short sections that are intermixed with the original DNA fragments.

As a result, each daughter DNA strand is a mixture of old and new segments.

🗒️ Limitation:

Experimental results from Meselson and Stahl clearly refuted this model.

🔹 4. Evidence Supporting Semi-Conservative Model

Meselson and Stahl Experiment (1958):

- Used E. coli grown in ^{15}N medium and then shifted to ^{14}N medium.
- After first replication → hybrid (intermediate) DNA observed.
- After second replication → one hybrid and one light DNA band formed.

This confirmed that each daughter DNA had one old and one new strand.

🔹 5. Biological Significance of Semi-Conservative Replication

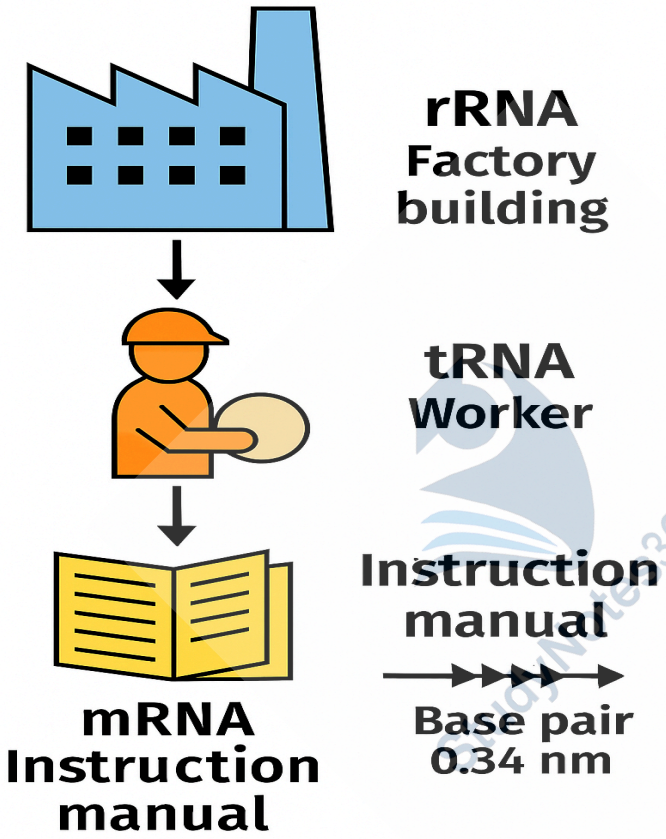
- Ensures accurate copying of genetic information.
- Maintains genetic stability between generations.
- Reduces chances of mutations and errors.
- Forms the basis of heredity and evolution.

🌟 Q10: Describe the three major types of RNA and their functions.

❖ Introduction:

- RNA (Ribonucleic Acid) is a nucleic acid essential for protein synthesis in cells.

- It acts as a messenger, transporter, and structural component in the process of translating genetic information from DNA into proteins.
- RNA is single-stranded and is synthesized from DNA during transcription.



1. Ribosomal RNA (rRNA)

- rRNA is the major component of ribosomes, the cellular structures where proteins are assembled.
- It provides a structural and functional site for translation.

- During protein synthesis, rRNA ensures that amino acids are linked in the correct order by forming peptide bonds.
- rRNA combines with proteins to form the small and large subunits of ribosomes.

2. Transfer RNA (tRNA)

- tRNA acts as an adapter molecule during translation.
- Its main function is to carry specific amino acids from the cytoplasm to the ribosome.
- Each tRNA has a complementary anticodon that pairs with a codon on the mRNA, ensuring the correct amino acid is added to the growing polypeptide chain.
- **In humans,** there are about 45 different kinds of tRNA, each specific for one or more amino acids.

3. Messenger RNA (mRNA)

- mRNA is a long strand of RNA transcribed from the DNA of a gene.
- Its primary role is to carry the genetic code from the DNA in the nucleus (in eukaryotes) to the ribosomes in the cytoplasm.
- mRNA directs the sequence of amino acids in a protein according to the codons present in its sequence.
- In eukaryotes, mRNA undergoes capping and tailing to increase stability before translation.

✦ **Summary:**

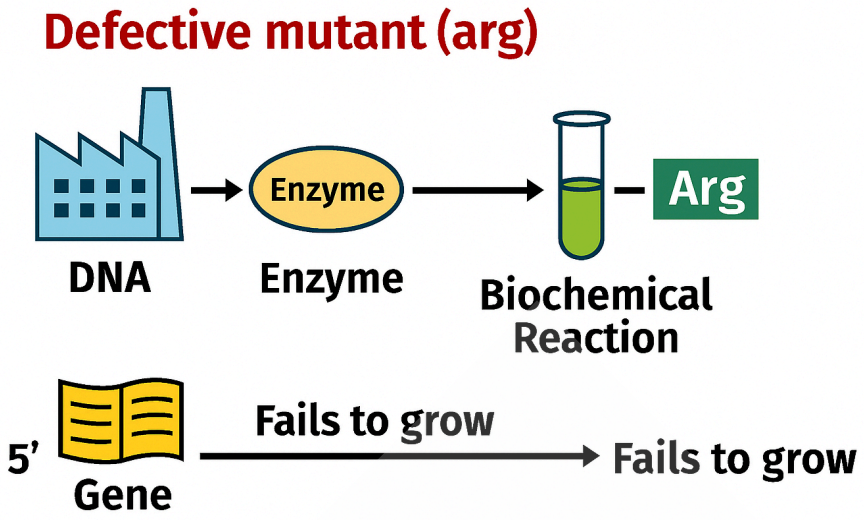
Together, the three types of RNA ensure accurate protein synthesis:

- rRNA ⟶ Forms the ribosome and catalyzes peptide bond formation
- tRNA ⟶ Brings the correct amino acids to the ribosome
- mRNA ⟶ Provides the template with the genetic code for the protein

🌟 Q11: What is a Gene? Explain the one-gene-one-enzyme hypothesis.

❖ **Introduction:**

- A gene is a segment of DNA that carries the instructions to make a specific functional product, usually a protein.
- Early evidence for the concept of genes came from studying inherited disorders in families.



1. Archibald Garrod's Contribution (1902)

- Observed that certain diseases, like alkaptonuria, were more prevalent in some families.
- Concluded that these were Mendelian traits caused by recessive alleles.
- Noticed that alkaptonuria patients lacked an enzyme to break down homogentisic acid, leading to black urine upon oxidation.
- Proposed that inherited traits result from enzyme deficiencies, hinting that genes control chemical reactions in cells.

2. Beadle and Tatum's Experiments (1941)

Studied the fungus Neurospora to investigate the relationship between genes and enzymes.

- **Mutagenesis:** Exposed spores to X-rays to induce mutations in DNA, producing mutants.
- **Minimal medium test:** Mutants were placed on minimal media; those unable to grow were deficient in producing certain compounds.
- **Supplementation:** Adding specific chemicals (like arginine) allowed growth, pinpointing the specific metabolic block caused by a gene mutation.

3. One-Gene-One-Enzyme Hypothesis

- **Observation:** Each mutation affected a single enzyme in a metabolic pathway.

Conclusion: Each gene specifies the structure of one enzyme, establishing a direct link between genes and enzyme production.

Modern refinement: Many enzymes have multiple polypeptide subunits, each encoded by a separate gene → thus the term one gene-one-polypeptide hypothesis.

4. Importance of the Hypothesis

- Shows that DNA controls the chemical reactions in the cell by coding for enzymes.
- Explains how genes determine the structure and function of an organism through proteins.
- Provides the foundation for understanding genetic diseases, metabolic pathways, and molecular biology.

Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

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Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.