

24 The Molecular Basis of Inheritance

I. Chapter Outline

- A. DNA Structure and Functions
 - 1. DNA Structure: Double Helix
 - 2. DNA Functions: At Least Three
- B. Protein Synthesis
 - 1. DNA Base Sequence: Is Coded
 - 2. Transcription: mRNA Base Sequence Has Codons
 - 3. Translation: From Codons to Polypeptide
 - 4. Protein Synthesis: Summary
- C. Control of Gene Expression
 - 1. Transcriptional Control in Prokaryotes
 - 2. Transcriptional Control in Eukaryotes
- D. Gene Mutations
 - 1. Adding, Deleting, Substituting Base
 - 2. Transposons: Jumping Genes
- E. Cancer: A Failure of Genetic Control
 - 1. What Causes Cancer
 - 2. Preventing Cancer

II. Chapter Review

- | Page | Questions | | | | | | | | | | | | | | | | | | |
|-----------|---|------------|------------|------------|-----------|--|--|--------|--|--|--------|--|--|----------|--|--|--------|--|--|
| 463 | 1. Where are the genes found in a cell? Name the two biomolecules found in chromosomes. | | | | | | | | | | | | | | | | | | |
| 464 | 2. What was the conclusion of the experiment in which radioactive proteins and DNA were labeled in viruses? | | | | | | | | | | | | | | | | | | |
| 464 | 3. List the 3 subunits of every nucleotide found in nucleic acid. What are the purine and pyrimidine bases? | | | | | | | | | | | | | | | | | | |
| 465 | 4. The 2 _____ of DNA twist about one another to form a _____ helix with the 2 strands held together by _____ bonds between the purine and pyrimidine bases. | | | | | | | | | | | | | | | | | | |
| 465 | 5. Which complementary bases pair together in DNA? How does the structure of unwound DNA compare to that of a ladder? | | | | | | | | | | | | | | | | | | |
| 465 | 6. Name the 2 scientists that first determined the structure of DNA. List Chargaff's rules that apply to DNA. | | | | | | | | | | | | | | | | | | |
| | 7. Complete the following table by comparing cellular DNA to cellular RNA: | | | | | | | | | | | | | | | | | | |
| | <table border="0"><thead><tr><th></th><th><u>DNA</u></th><th><u>RNA</u></th></tr></thead><tbody><tr><td>Function:</td><td></td><td></td></tr><tr><td>Sugar:</td><td></td><td></td></tr><tr><td>Bases:</td><td></td><td></td></tr><tr><td>Strands:</td><td></td><td></td></tr><tr><td>Helix:</td><td></td><td></td></tr></tbody></table> | | <u>DNA</u> | <u>RNA</u> | Function: | | | Sugar: | | | Bases: | | | Strands: | | | Helix: | | |
| | <u>DNA</u> | <u>RNA</u> | | | | | | | | | | | | | | | | | |
| Function: | | | | | | | | | | | | | | | | | | | |
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| Bases: | | | | | | | | | | | | | | | | | | | |
| Strands: | | | | | | | | | | | | | | | | | | | |
| Helix: | | | | | | | | | | | | | | | | | | | |
| 467 | 8. List the 3 basic functions that DNA, as a hereditary material, must be able to do. | | | | | | | | | | | | | | | | | | |
| 468 | 9. What is the function of helicase and DNA polymerase? List the steps required in DNA replication. | | | | | | | | | | | | | | | | | | |
| 468 | 10. Why is DNA replication said to be <i>semiconservative</i> ? Which enzyme "proofreads" the replicated DNA? | | | | | | | | | | | | | | | | | | |
| 469 | 11. What happens in the PKU pathway if the enzyme that converts phenylalanine to tyrosine is missing? | | | | | | | | | | | | | | | | | | |
| 470 | 12. What is meant by the one gene - one enzyme theory? | | | | | | | | | | | | | | | | | | |
| 470 | 13. Define the gene as currently understood today. | | | | | | | | | | | | | | | | | | |
| 471 | 14. State the central dogma of modern genetics. What is the difference between transcription and translation? | | | | | | | | | | | | | | | | | | |
| 471 | 15. Name the specific type of RNA that is used to produce the correct order of amino acids in a polypeptide. | | | | | | | | | | | | | | | | | | |
| 471 | 16. How many bases are used in the genetic code? Is the genetic code a doublet or triplet code? | | | | | | | | | | | | | | | | | | |
| 471 | 17. Define a codon. How are the 3 different types of codons used? | | | | | | | | | | | | | | | | | | |
| 471 | 18. Is the genetic code considered essentially universal? | | | | | | | | | | | | | | | | | | |
| 471 | 19. During transcription, a segment of _____ unwinds and complementary _____ nucleotides pair with the DNA nucleotides of one strand. What enzyme is used to join the RNA nucleotides together? | | | | | | | | | | | | | | | | | | |
| 471 | 20. Distinguish between introns and exons. What happens when mRNA is processed? Define ribozymes. | | | | | | | | | | | | | | | | | | |
| 471 | 21. What is the function of transfer RNA? What is found at each end of the tRNA molecule? | | | | | | | | | | | | | | | | | | |
| 471 | 22. What are the 2 types of molecules in each of the 2 subunits of a ribosome? Where is the rRNA produced? Where is the protein of the ribosomes produced? Where are the subunits assembled and then transferred? | | | | | | | | | | | | | | | | | | |

- 472 23. What 3 processes are required for translation? The codon that stands for the amino acid _____ will _____ in the initiation of protein synthesis.
24. How many tRNA molecules will attach to a ribosome at one time?
- 473 25. Define a polysome. What is the advantage of forming polysomes?
- 475 26. The _____ of each tRNA is complementary to a particular codon in _____.
27. During translation, the order of mRNA codons determines the order in which _____ and their attached amino acids come to a ribosome to determine the sequence of amino acids in a polypeptide.
28. List the 4 levels at which gene expression can occur.
- 476 29. List and define the 4 elements of an operon used for transcriptional control in prokaryotes.
30. What is the difference between a structural gene and a regulator gene?
31. In the *lac* operon, are the structural genes active or inactive? Why is it called an inducible operon?
32. Describe the evidence that indicates that eukaryotic genes are ordinarily inactive and must be turned on.
33. What is the function of transcription factors?
- 478 34. Define gene mutations. Are they always deleterious?
35. Distinguish between gene mutations involving substitutions, additions, and deletions. What type occurs in sickle cell hemoglobin?
36. What are transposons? Where are they found?
- 480 37. What do cancer cells exhibit? Do they demonstrate contact inhibition? What term is used to describe the process by which cancer spreads to other parts of the body?
38. What is the difference between a benign tumor and a malignant tumor?
39. Distinguish between initiators and promoters of cancer. What is the difference between oncogenes and proto-oncogenes?
- 481 40. How do oncogenes work? What is the function of tumor suppressor genes?
- 482 41. List 4 ways to help prevent cancer.

III. Objective Chapter Test

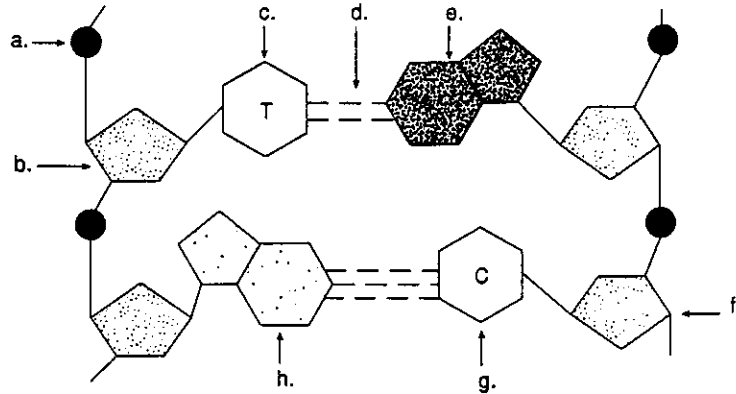
Completion and Short Answer Questions

1. All nucleotides are made up of three parts: a base, a sugar, and a _____.
2. In DNA the base adenine, symbolized by A, is always paired with a base symbolized by the letter _____.
3. DNA is a _____ stranded helix with the nucleotides found on the _____.
4. In RNA the base thymine, symbolized by a T, is replaced by a base symbolized by a _____.
5. DNA replication is called _____ because each new double helix is made up of an old strand and a new strand.
6. A mutation is a change in the sequence of _____ within a DNA molecule.
7. The central dogma of modern biochemical genetics states that _____ precedes translation.
8. During transcription, DNA serves as a _____ for mRNA formation.
9. A _____ consists of three adjacent bases that code for one amino acid.
10. Each tRNA has a(n) _____ at one end and a specific _____ at the other end.
11. A person with PKU has a defective _____ so that phenylalanine cannot be converted to tyrosine.
12. A person with sickle-cell anemia has inherited a DNA molecule that does not _____ properly for one amino acid in hemoglobin.
13. The nucleus of a cell contains coded information.
 - a. The name of the nucleic acid that contains this code is _____.
 - b. The nucleolus has a concentration of a nucleic acid called _____.

14. RNA is a polynucleotide. How is its structure different from that of DNA?

- a. _____
 b. _____
 c. _____

15. The diagram shown below is a portion of a DNA molecule that is untwisted. Label each of the following parts.

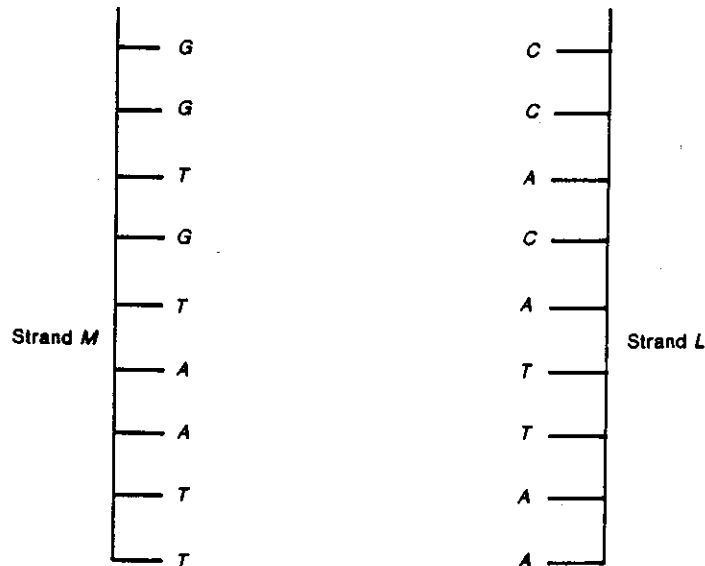


16. In the above diagram, the combination of parts *a*, *b*, and *c* is called a _____.

17. Regarding the above diagram, answer the following questions:

- a. Which letters in the above diagram represent the sugar - phosphate backbone? _____
 b. Which two letters represent pyrimidines? _____ Which letters represent purines? _____
 c. The number of purines will always _____ the number of pyrimidines.

18. When DNA is ready to divide or replicate itself, the hydrogen bonds are broken, and the 2 strands come apart as if they were unzipped. Then there are 2 separate strands that may look like the diagram below. Assume that replication has occurred, and complete this diagram by drawing in complementary strands.



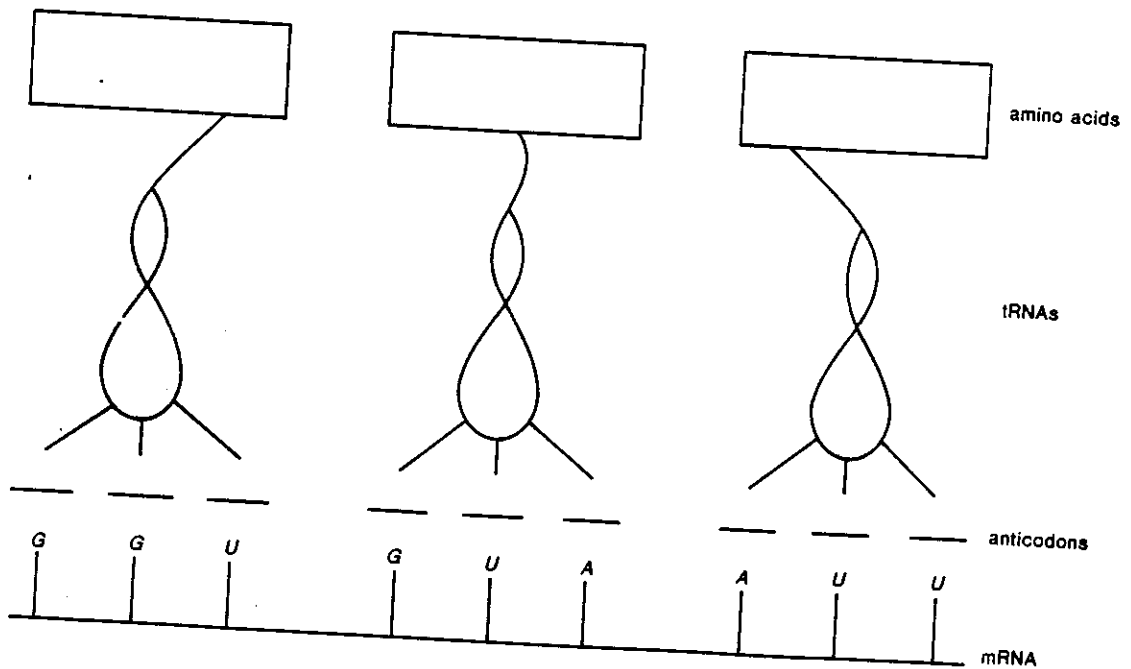
- a. In your drawing above,
 each G should attach itself to (1) _____
 each A should attach itself to (2) _____
 each C should attach itself to (3) _____
 each T should attach itself to (4) _____
- b. Assume that the completed diagram above represents a duplicated chromosome and that division is about to occur. Replication assures that each daughter cell will receive _____

19. Transcription.

- a. In the nucleus, DNA serves as a template for the production of messenger RNA (mRNA). Let us assume that strand L in the preceding diagram will serve as the template. What will be the message that mRNA brings to the ribosomes? _____
- b. Whereas DNA has a triplet code (that is, every three _____ stand for an _____), mRNA contains _____, which are complementary to the code.

20. Translation.

- a. In the cytoplasm there are at least twenty RNA molecules called transfer RNA (tRNA). At one end, these have a(n) _____, and at the other end they have one of the 20 _____.
- b. What is the role of tRNA? _____
- c. Assume the mRNA molecule in question 19a above has arrived at the ribosomes. What are the anticodon _____ each of the tRNA molecules in the diagram below, in sequence? _____
- d. By using figure 24.9 in the textbook, fill in the three amino acids, in sequence, that will be coded for by the mRNA shown below.



21. Summary. DNA contains a(n) (a) _____ for protein synthesis; it is a(n) (b) _____ code because three bases indicate one particular (c) _____. During transcription, (d) _____ RNA is produced, having bases that are (e) _____ to the bases in DNA. Thus it is said that DNA serves as a(n) (f) _____ for mRNA production. The bases in DNA are called the code, and the bases in mRNA are called (g) _____. Messenger RNA moves into the cytoplasm and becomes associated with the (h) _____, which contain (i) _____ RNA molecules. Also in the cytoplasm there are (j) _____ RNA molecules with a(n) (k) _____ at one end and one of the 20 amino acids at the other. During translation the tRNA molecules bring amino acids to the ribosomes in the order dictated by the DNA code; thus the original sequence of bases in DNA orders the (l) _____ of amino acids in a protein.

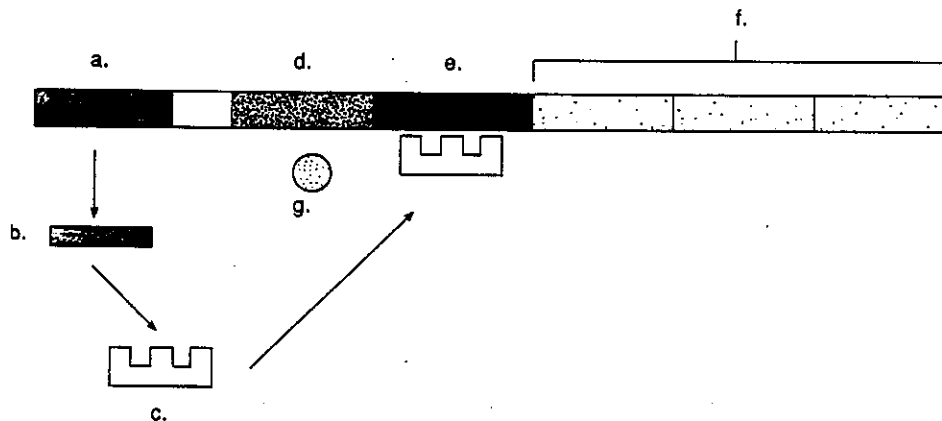
22. Complete this table to indicate the different types of mutations.

Type of Mutation	Definition
a.	Change in regard to entire chromosomes
b.	Change in regard to a single gene
c.	Change that affects the body cells
d.	Change that affects the gametes

23. Complete the following table to distinguish the different levels of gene expression that occur in eukaryotic cells.

Type of Regulation	Site of Occurrence	Description
a. Transcriptional control:		
b.	Nucleus	different mRNA processes
c.	Cytoplasm	how soon and long mRNA is active
d. Post-translational control:		

24. The diagram below represents the *lac* operon in bacteria. Identify the following components of this inducible operon.



25. In relationship to the above diagram, the inducible operon is normally (a) _____ . The repressor molecule attaches to the (b) _____ gene, thereby preventing transcription from occurring. When the repressor joins with a(n) (c) _____ molecule, in this case, lactose, the complex is unable to bind with the operator and (d) _____ can carry out transcription of the structural gene.

26. In the chart below, compare cancer cells with normal cells.

	Cancer Cells	Normal Cells
a. Cell growth:		
b. Number of cell divisions:		
c. Contact inhibition:		
d. Ability to differentiate:		
e. Ability to cause vascularization:		
f. Ability to undergo metastasis:		

27. List several carcinogens that are initiators of cancer in each of the following categories:

Chemical

- a. _____
b. _____

Radiation

- c. _____
d. _____

28. Proto-oncogenes are normal cellular genes that can mutate and form _____. The oncogenes cause malfunction of various elements, such as growth factors or receptors for those factors on the surface of the cell.
29. Put the following phrases in the correct order to describe protein synthesis.

- _____ a. mRNA is produced in nucleus
_____ b. ribosomes move along mRNA
_____ c. DNA has a code
_____ d. polypeptide results
_____ e. tRNA brings amino acids to ribosomes
_____ f. mRNA moves to ribosomes

Multiple Choice Questions

30. Which of the following pairs is *not* a valid comparison between DNA and RNA?

DNA

RNA

- | | |
|-----------------|-----------------|
| a. double helix | single-stranded |
| b. replicates | replicates |
| c. deoxyribose | ribose |
| d. thymine | uracil |

31. Which pair is mismatched?

- a. DNA — code
b. mRNA — codon
c. tRNA — anticodon
d. rRNA — one subunit

32. Protein synthesis takes place in the

- a. nucleus where DNA codes for amino acids.
b. cytoplasm where the ribosomes code for amino acids.
c. nucleus where the tRNAs code for amino acids.
d. cytoplasm where mRNA codons pair with tRNA anticodons.

33. The anticodon differs from the codon in that the anticodon
- contains thymine, but the codon contains uracil.
 - attaches to ribosomes, but the codon attaches to amino acids.
 - is a sequence of three bases complementary to the bases of a codon.
 - stands for a particular amino acid, but the codon codes for nucleotide bases.
34. If mutation occurred, then
- the code would change.
 - some particular codon or codons would change.
 - some particular anticodon or anticodons would change.
 - All of the above are true.
 - Answers *a* and *b* above are true.
35. RNA nucleotides are joined together during transcription by
- helicase.
 - DNA polymerase.
 - RNA polymerase.
 - ribozymes.
36. During transcription in eukaryotes, which statement is not true?
- This process occurs in the nucleus.
 - Introns are DNA segments found within a gene but not expressed.
 - Exons are portions of a gene that are ultimately expressed.
 - Ribozymes are protein enzymes that remove introns during RNA processing.
 - Ribozymes are always found in the nucleus.
37. ___ are specific DNA sequences that have the remarkable ability to move within and out of chromosomes.
- Transposons
 - Introns
 - Exons
 - Operator genes
38. Which of these is happening when translation takes place?
- mRNA still in the nucleus
 - tRNAs bringing amino acids to the ribosomes
 - rRNA exposing their anticodons
 - DNA being replicated
 - All of the above are true.
39. Which of the following will not help you to prevent the formation of cancer?
- avoid carcinogenic chemicals
 - stop smoking
 - lower total fat intake
 - eat less high-fiber foods
 - eat more broccoli and cauliflower
40. Which of these is a true statement concerning translation?
- Each polypeptide is synthesized one amino acid at a time.
 - The amino acids are joined by RNA polymerase at the same time.
 - Each ribosome is responsible for adding a single amino acid to each polypeptide.
 - The same type of polypeptide often contains a different sequence of amino acids.
 - All of the above statements are true.
41. A regulator gene
- turns on and off the transcription of a set of structural genes.
 - controls the rate with which amino acids are joined to form a polypeptide.
 - codes for the enzymes that are necessary for the transcription of polypeptides.
 - is an intron that breaks up a structural gene.

IV. Subjective Chapter Test

42. DNA has been shown to be the hereditary material in the cell. For a cell to live and species to undergo change, what three things must DNA be able to perform? Why are these functions important?

43. Describe the relationship between the structure of eukaryotic genes and how RNA is processed.

IV. Subjective Chapter Test

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Answers to Chapter Test

1. phosphoric acid (phosphate) 2. T 3. double, inside 4. U 5. semiconservative 6. bases (nucleotides) 7. transcription 8. template 9. codon 10. anticodon, amino acid 11. enzyme 12. code 13.a. DNA b. RNA 14.a. Ribose is used instead of deoxyribose. b. It is single stranded. c. Uracil is substituted for thymine. 15.a. phosphate b. deoxyribose sugar c. thymine base d. hydrogen bonds e. adenine f. 5' end of sugar g. cytosine base h. guanine base 16. nucleotide 17.a. letters a and b b. letters c and g (cytosine and thymine), e and h are purines c. equal 18.a. (1) C (2) T (3) G (4) A b. a chromosome carrying one copy of each gene and carrying a complete code 19.a. G, G, U, G, U, A, A, U, U b. bases, amino acid, codons 20.a. anticodon, amino acids b. carries amino acids to ribosomes c. anticodons are CCA, CAU, UAA d. amino acids are glycine, valine, and isoleucine 21.a. code b. triplet c. amino acid d. messenger e. complementary f. template g. codons h. ribosomes i. ribosomal j. transfer k. anticodon l. sequence 22.a. chromosomal b. genetic c. somatic d. germinal 23.a. nucleus, determines which genes are transcribed and transcription rate b. Post-transcriptional control c. Translational control d. cytoplasm, how soon translated protein becomes functional 24.a. regulator gene b. mRNA c. active repressor protein d. promoter gene e. operator gene f. structural genes g. RNA polymerase 25.a. inactive b. operator c. induced d. RNA polymerase 26.a. uncontrolled and disorganized, controlled and organized b. unlimited, about 50 times c. no, yes d. no, yes e. yes, no f. yes, no 27.a. pesticides b. cigarette smoke c. ultraviolet d. radon 28. oncogenes 29. c, a, f, b, e, d 30. b 31. d 32. d 33. c 34. e 35. c 36. d 37. a 38. b 39. d 40. a 41. a 42. a. store information b. be stable so that it can be replicated with high fidelity and transmitted to the next generation c. able to mutate in order to generate genetic variability for evolution 43. Genes called exons are expressed, whereas the RNA from intron genes, when transcribed, are enzymatically removed by ribozymes.

Test Results: _____ NUMBER RIGHT + 43 = _____ X 100 = _____ %

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