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Chapter 12

DNA and RNA

Section 12–1 DNA (pages 287–294)

This section tells about the experiments that helped scientists discover the relationship between genes and DNA. It also describes the chemical structure of the DNA molecule.

Griffith and Transformation (pages 287–289)

1. What did Frederick Griffith want to learn about bacteria? He wanted to learn how certain types of bacteria produce pneumonia.

2. The strain of bacteria that caused pneumonia grew into smooth colonies on culture plates; harmless bacteria produced colonies with rough edges.

3. Circle the letter of each sentence that is true about Griffith's experiment.
   - **a.** Mice injected with bacteria from smooth colonies died.
   - **b.** Mice injected with bacteria from rough colonies died.
   - **c.** Mice injected with heat-killed bacteria from smooth colonies died.
   - **d.** Mice injected with a mixture of bacteria from heat-killed smooth colonies and live rough colonies died.

4. What result from Griffith's experiment suggested that the cause of pneumonia was not a chemical poison released by the disease-causing bacteria? The mice survived after being injected with heat-killed disease-causing bacteria.

5. What is transformation? It is the process by which one strain of bacteria changes into another.

6. What hypothesis did Griffith form from the results of his experiments? Some factor, which might contain a gene, was transferred from the heat-killed bacteria cells into the live cells.

Avery and DNA (page 289)

7. Is the following sentence true or false? Avery and his colleagues thought that the molecule required in transformation might also be the molecule of the gene. true

8. Briefly describe how Avery and his group determined which molecule was most important for transformation? They treated the extract of heat-killed bacteria with enzymes that destroyed proteins, lipids, carbohydrates, and other molecules, including RNA and DNA.

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9. Transformation did not occur when DNA was destroyed.

10. What was the conclusion from Avery's experiments? DNA was the transforming factor.

The Hershey-Chase Experiment (pages 289–290)

11. What is a bacteriophage? It is a virus that infects and kills bacteria.

12. Circle the letter of each part that makes up a bacteriophage.

a. lipid coat **c.** carbohydrate core

b. protein coat **d.** DNA core

13. What happens when a bacteriophage infects a bacterial cell? The bacteriophage injects its DNA into the cell. The viral genes act to produce many new bacteriophages, which burst out when the cell splits open.

14. How would Hershey and Chase learn whether genes were made of protein or DNA? If they could determine which part of the virus entered the infected cell, they would learn whether genes were made of protein or DNA.

15. Circle the letter of the molecule for which phosphorus-32 (32P) is used as a radioactive marker.

a. protein **b.** lipid **c.** DNA **d.** carbohydrate

16. Is the following sentence true or false? If 35S was found in the bacteria, it would mean that the viruses' DNA had been injected into the bacteria. false

17. What results did Hershey and Chase observe? Nearly all of the radioactivity in the bacteria was from phosphorus, the marker found in DNA.

18. Hershey and Chase concluded that the genetic material of the bacteriophage was DNA.

The Structure of DNA (pages 291–294)

19. List the three critical things that genes were known to do.

a. Genes had to carry information from one generation to the next.

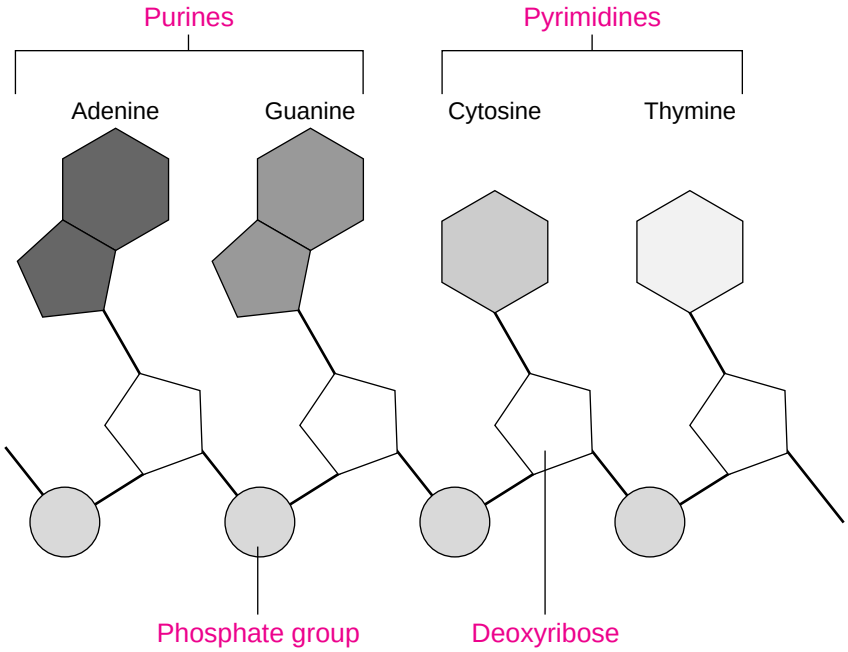
b. Genes had to determine the heritable characteristics of organisms.

c. Genes had to be easily copied.

20. Adenine, guanine, cytosine, and thymine are four kinds of nitrogenous bases in DNA.

Chapter 12, DNA and RNA *(continued)*

21. Identify the parts of a nucleotide in the diagram below. Label the bases as purines or pyrimidines.



22. Is the following sentence true or false? Adenine and guanine are larger molecules than cytosine and thymine because they have two rings in their structure. true

23. What forms the backbone of a DNA chain? It is formed by the sugar and phosphate groups of each nucleotide.

24. Is the following sentence true or false? The nucleotides must be joined together in a specific order. false

25. According to Chargaff's rules, the percentages of adenine are equal to thymine and the percentages of cytosine are equal to guanine in the DNA molecule.

26. Rosalind Franklin's work with X-ray diffraction showed that the DNA molecule is shaped like a(an) helix and contains two strands.

27. How did Francis Crick and James Watson try to understand the structure of DNA? They built three-dimensional models of the DNA molecule from cardboard and wire.

28. How did Watson and Crick describe the structure of DNA? DNA was a double helix, in which two strands were wound around each other.

29. Is the following sentence true or false? According to the principle of base pairing, hydrogen bonds could form only between adenine and cytosine. false

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Section 12–2 Chromosomes and DNA Replication (pages 295–299)

This section describes how DNA is packaged to form chromosomes. It also tells how the cell duplicates its DNA before cell division.

DNA and Chromosomes (pages 295–296)

1. Circle the letter of the location of DNA in prokaryotic cells.
   a. nucleus **b.** mitochondria **c.** cytoplasm **d.** vacuole
2. Is the following sentence true or false? Most prokaryotes contain a single, circular DNA molecule. true
3. Eurkaryotic DNA is generally located in the cell nucleus in the form of a number of chromosomes.
4. Is the following sentence true or false? All organisms have the same number of chromosomes. false
5. Is the following sentence true or false? The *E. coli* chromosome is longer than the diameter of an individual *E. coli* bacterium. true
6. Circle the letter of each sentence that is true about chromosome structure.
   a. The DNA in eukaryotic cells is very loosely packed.
   b. Prokaryotic cells contain more DNA than eukaryotic cells.
   c. A human cell contains more than 1 meter of DNA.
   d. The DNA of the smallest human chromosome is nearly 10 times as long as many bacterial chromosomes.
7. Eukaryotic chromosomes contain both DNA and protein, packed together to form chromatin.
8. What are histones? Histones are proteins around which DNA is tightly coiled.
9. Why are individual chromosomes visible only during mitosis? The fibers formed from nucleosomes packing together are dispersed in the nucleus during most of the cell cycle.
10. Is the following sentence true or false? Changes in chromatin structure and histone-DNA binding may be associated with changes in gene activity. true
11. List two roles of nucleosomes.
    a. They fold enormous lengths of DNA into the cell nucleus.
    b. They help regulate how genes are "read" to make proteins.

DNA Replication (pages 297–299)

12. What occurs during the process of replication? The cell duplicates its DNA in a copying process.

13. Complete the flowchart to describe the process of DNA replication.

The DNA molecule **separates**, or unzips, into two strands.

↓

Each strand serves as a(an) **template**, or model, to produce the new strands.

↓

Two new **complementary** strands are produced, following the rules of **base-pairing**.

14. Is the following sentence true or false? In eukaryotic chromosomes, DNA replication begins at a single point in the chromosome and proceeds in two directions. **false**

15. The sites where DNA replication and separation occur are called **replication forks**.

16. What occurs when a molecule of DNA is "unzipped"? The hydrogen bonds between the base pairs are broken, and the two strands of the molecule unwind.

17. What is the complimentary strand of bases for a strand with the bases TACGTT? The complimentary strand is ATGCAA.

18. Is the following sentence true or false? Each DNA molecule resulting from replication has one original strand and one new strand. **true**

19. List two major roles of DNA polymerase in the process of DNA replication.

a. It polymerizes individual nucleotides to produce DNA.

b. It "proofreads" each new DNA strand.

Reading Skill Practice

The illustrations in textbooks can help you better understand a difficult concept. Look at Figure 12–10 on page 297. List in order, beginning with DNA, the levels of organization of eukaryotic DNA to form chromosomes. Do your work on a separate sheet of paper.

DNA, histones, nucleosomes, coils, supercoils, chromosome

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Section 12–3 RNA and Protein Synthesis (pages 300–306)

This section describes RNA and its role in transcription and translation.

The Structure of RNA (page 300)

1. List the three main differences between RNA and DNA.
   a. RNA has ribose sugar instead of deoxyribose.
   b. RNA is generally single-stranded, instead of double-stranded.
   c. RNA contains uracil in place of thymine.
2. Is the following sentence true or false? RNA is like a disposable copy of a DNA segment. true
3. What is the importance of the cell's ability to copy a single DNA sequence into RNA? It makes it possible for a single gene to produce large numbers of RNA molecules.

Types of RNA (pages 300–301)

4. What is the one job in which most RNA molecules are involved? Most are involved in protein synthesis.
5. Complete the compare-and-contrast table about the types of RNA.

TYPES OF RNA

Type	Function
Messenger RNA	Carries copies of the instructions for assembling amino acids from DNA to the rest of the cell
Ribosomal RNA	Is a part of ribosomes
Transfer RNA	Transfers each amino acid to the ribosome to help assemble proteins.

Transcription (page 301)

6. Circle the letter of each sentence that is true about transcription.
   a. During transcription, DNA polymerase binds to RNA and separates the DNA strands.
   (b.) RNA polymerase uses one strand of DNA as a template to assemble nucleotides into a strand of RNA.
   (c.) RNA polymerase binds only to DNA promoters, which have specific base sequences.
   d. Promoters are signals in RNA that indicate to RNA polymerase when to begin transcription.

RNA Editing (page 302)

7. Many RNA molecules from eukaryotic genes have sections, called _____introns_____, edited out of them before they become functional. The remaining pieces, called _____exons_____, are spliced together.
8. Is the following sentence true or false? RNA editing occurs in the cytoplasm of the cell. _____false_____
9. What are two explanations for why some RNA molecules are cut and spliced?
   a. It makes it possible for a single gene to produce several different forms of RNA.
   b. It may play a role in evolution, making it possible for small changes in DNA to have dramatic effects in gene expression.

The Genetic Code (pages 302–303)

10. Proteins are made by joining _____amino acids_____ into long chains called polypeptides.
11. How can only four bases in RNA carry instructions for 20 different amino acids? The genetic code is read three letters at a time, so that each "word" of the coded message is three bases long.
12. What is a codon? It consists of three consecutive nucleotides that specify a single amino acid that is to be added to a polypeptide.
13. Circle the letter of the number of possible three-base codons.
    a. 4 **b.** 12 **(c.)** 64 **d.** 128
14. Is the following sentence true or false? All amino acids are specified by only one codon. _____false_____
15. Circle the letter of the codon that serves as the "start" codon for protein synthesis.
    a. UGA **b.** UAA **c.** UAG **(d.)** AUG

Translation (pages 303–305)

16. What occurs during the process of translation? The cell uses information from messenger RNA to produce proteins.
17. Where does translation occur? Translation occurs on the ribosomes.

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18. Circle the letter of each sentence that is true about translation.

a. Before translation can occur, messenger RNA must be transcribed from DNA in the nucleus.

b. Translation occurs in the nucleus.

c. It is the job of transfer RNA to bring the proper amino acid into the ribosome to be attached to the growing peptide chain.

d. When the ribosome reaches a stop codon, it releases the newly formed polypeptide and the mRNA molecule.

19. What is an anticodon? The three bases on a tRNA molecule that are complementary to one of the mRNA codons.

The Roles of RNA and DNA (page 306)

Match the roles with the molecules. Molecules may be used more than once.

	Roles	Molecules
a	**20.** Master plan	**a.** DNA
b	**21.** Goes to the ribosomes in the cytoplasm	**b.** RNA
b	**22.** Blueprint	
a	**23.** Remains in the nucleus	

Genes and Proteins (page 306)

24. Many proteins are enzymes, which catalyze and regulate chemical reactions.

25. Is the following sentence true or false? Genes are the keys to almost everything that living cells do. false

Reading Skill Practice

A flowchart is useful for organizing the steps in a process. Make a flowchart that shows the steps in the process of translation. Look at Figure 12–18 on pages 304–305 for help. For more information about flowcharts, see Appendix A. Do your work on a separate sheet of paper.

Flowcharts should at least show the four major steps in translation as described in Figure 12–18 on pages 304–305.

Section 12–4 Mutations (pages 307–308)

This section describes and compares gene mutations and chromosomal mutations.

Introduction (page 307)

1. What are mutations? Mutations are changes in the DNA sequence that affect genetic information.

2. Is the following sentence true or false? Chromosomal mutations result from changes in a single gene. false

Gene Mutations (pages 307–308)

3. Mutations that occur at a single point in the DNA sequence are point mutations.
4. A mutation involving the insertion or deletion of a nucleotide is a(an) frameshift mutation.
5. Circle the letter of each sentence that is true about gene mutations.
   - (a.) Point mutations affect just one nucleotide.
   - b. The substitution of one nucleotide for another in the gene never affects the function of the protein.
   - (c.) Point mutations that involve the insertion or deletion of a nucleotide change the reading frame of the genetic message.
   - (d.) Frameshift mutations affect every amino acid that follows the point of the mutation.

Chromosomal Mutations (page 308)

6. Complete the compare-and-contrast table of types of chromosomal mutations.

CHROMOSOMAL MUTATIONS

Type	Description	Examples
Deletion	The loss of all or part of a chromosome	ABC•DEF → AC•DEF
Duplication	A segment of a chromosome is repeated	ABC•DEF → ABBC•DEF
Inversion	Part of a chromosome becomes oriented in the reverse of its usual direction	ABC•DEF → AED•CBF
Translocation	Part of one chromosome breaks off and attaches to another, nonhomologous chromosome	ABC•DEF + GH•IJKL → ABC•JKL + GH•IDEF

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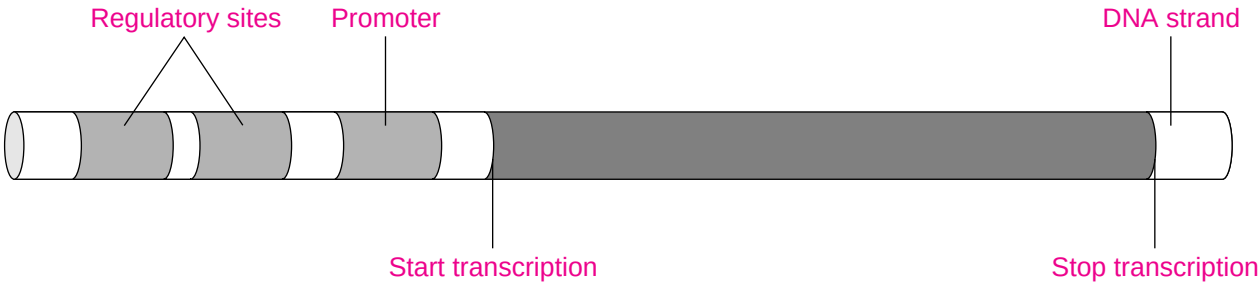
Section 12–5 Gene Regulation (pages 309–312)

This section explains how some genes in prokaryotes and eukaryotes are controlled.

Introduction (page 309)

1. Label the parts of a typical gene in the diagram below.



2. Where does RNA polymerase bind? It binds to the promoter.

3. Is the following sentence true or false? The actions of DNA-binding proteins help to determine whether a gene is turned on or turned off. true

Gene Regulation: An Example (pages 309–310)

4. What is an operon? It is a group of genes that is operated together.

5. What is the function of the genes in the *lac* operon? They must be expressed for *E. coli* to use lactose as a food.

6. Circle the letter of each sentence that is true about lactose.

a. Lactose is a simple sugar.

b. To use lactose for food, *E. coli* must take lactose across its cell membrane.

c. The bond between glucose and galactose must be broken in order for *E. coli* to use lactose for food.

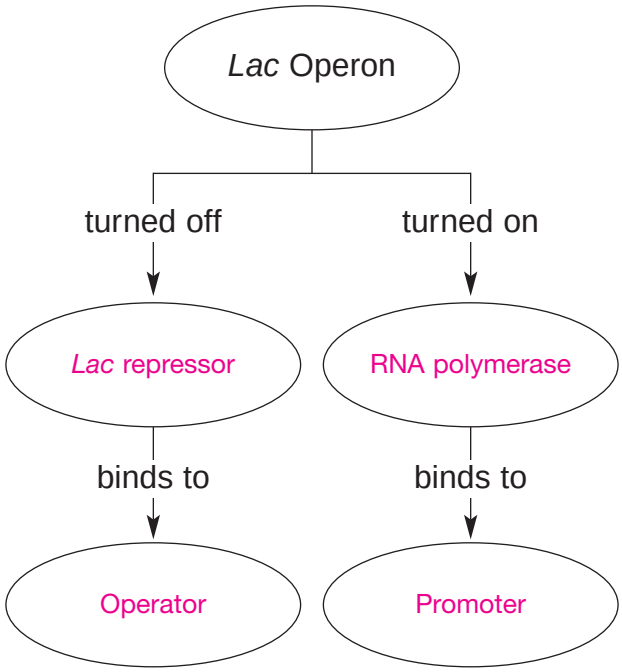
d. Proteins encoded by the genes of the *lac* operon are needed only when *E. coli* is grown on a medium containing glucose.

7. Circle the letter of the number of genes in the *lac* operon found in *E. coli.*

a. 1 **b.** 2 **c.** 3 **d.** 4

8. What turns the *lac* operon off and on? The *lac* genes are turned off by repressors and turned on by the presence of lactose.

9. Complete the concept map to show how the *lac* operon is regulated.



10. How does the repressor protein prevent transcription? It prevents RNA polymerase from binding to the operator.

11. How does lactose cause the *lac* operon to turn on? Lactose molecules bind to the repressor protein, causing it to change shape so that the repressor releases the operator. This allows RNA polymerase to bind to the promoter and transcribe the genes of the operon.

12. Circle the letter of each sentence that is true about gene regulation in prokaryotic genes.

a. The *lac* operon is the only example of genes regulated by repressor proteins.

b. Many other genes are regulated by repressor proteins.

c. Some genes are regulated by proteins that enhance the rate of transcription.

d. Cells cannot turn their genes on and off as needed.

Eukaryotic Gene Regulation (page 311)

13. Is the following sentence true or false? Operons are frequently found in eukaryotes. false

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14. How are eukaryotic genes usually controlled? Most are controlled individually and have regulatory sequences that are much more complex than those of the *lac* operon.

15. What is the function of the TATA box? It seems to help position RNA polymerase by marking a point just before the point where transcription begins.

16. Eukaryotic promoters are usually found just before the TATA box, and they consist of a series of short DNA sequences.

17. List three ways in which proteins that bind to enhancer sequences of a gene can work to regulate gene expression.

a. They open up tightly packed chromatin.

b. They help to attract RNA polymerase.

c. They block access to genes.

18. Why is gene regulation in eukaryotes more complex than in prokaryotes? All of the cells in a multicellular organism carry the complete genetic code in their nucleus, but only a few of the available genes can be expressed in cells of different tissues. Complex regulation allows for this specificity.

Regulation and Development (page 312)

19. What role do the hox genes play in the development of an organism? They determine an animal's basic body plan by controlling which organs and tissues develop in various parts of the embryo.

20. Circle the letter of each sentence that is true about hox genes.

a. A mutation in a hox gene has no effect on the organs that develop in specific parts of the body.

b. In fruit flies, a mutation affecting the hox genes can replace a fly's antennae with a pair of legs.

c. The function of the hox genes in humans seems to be almost the same as it is in fruit flies.

d. A copy of the gene that controls eye growth in mice does not function in fruit flies.

21. Why do common patterns of genetic control for development exist among animals? All the genes that control development have descended from the genes of common ancestors.

WordWise

Answer the questions by writing the correct vocabulary term in the blanks. Use the circled letter from each term to find the hidden word. Then, write a definition for the hidden word.

1. What is the substance that is made up of DNA and protein tightly packed together?

c (h) r o m a t i n

2. What are the three bases on the tRNA molecule that are complimentary to mRNA?

a n t (i) c o d o n

3. What is the process in which one strain of bacteria has been changed into another?

t r a n (s) f o r m a t i o n

4. What is a change in the DNA sequence that affects genetic information?

m u (t) a t i o n

5. What is a group of genes that is operated together?

o p e r (o) n

6. What are the intervening sequences of RNA molecules that are cut out before the messenger RNA leaves the nucleus?

i n t r o (n)

7. What is the region of DNA to which RNA polymerase binds?

p r o m o t (e) r

Hidden Word: h i s t o n e

Definition: A histone is a protein around which DNA is tightly coiled in chromatin.