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CHAPTER 11 DNA and the Language of Life

Summary of Key Concepts

Concept 11.1 Genes are made of DNA. (pp. 226–228)

Many scientists' work helped determine that DNA carries genetic information. In 1928, Frederick Griffith injected several mice with a harmless strain of bacteria and other mice with heat-treated deadly bacteria. All the mice survived. But when he injected mice with a mixture of the harmless bacteria and the heat-treated deadly bacteria, the mice died. The harmless bacteria had been "transformed" by something in the heat-treated deadly bacteria.

In 1944, Oswald Avery experimented to find out if Griffith's "transforming factor" was DNA or protein. Avery used Griffith's procedure, but treated the mixture of bacteria to destroy proteins. The transformation still occurred. When Avery treated the mixture of bacteria to destroy DNA, the transformation did not occur. Avery concluded that DNA was the "transforming factor."

In 1952, Alfred Hershey and Martha Chase used viruses to confirm Avery's conclusions. A *virus* is a package of nucleic acid wrapped in a protein coat. Viruses can reproduce only by inserting their genetic information into a living cell. A virus that infects bacteria is a *bacteriophage,* or phage for short. Hershey and Chase used radioactivity to label the protein coat of one batch of phages. When these phages infected bacteria, the radioactivity did not enter the bacteria. When Hershey and Chase labeled the DNA portion of phages instead of the protein coat, radioactivity did enter the bacteria. They concluded that DNA was the portion of the phage that carried the genetic information.

1. What question did Avery's experiments answer? _____

_____

2. How did the experiments performed by Hershey and Chase confirm Avery's findings? _____

_____

_____

Concept 11.2 Nucleic acids store information in their sequences of chemical units (pp. 229–232)

Deoxyribonucleic acid (DNA) is the molecule that stores genetic information. DNA is made up of units called *nucleotides*. Each nucleotide has three parts: a sugar, a phosphate group, and a nitrogenous base. A *nitrogenous base* is a single or double ring of carbon and nitrogen atoms with functional groups. Nitrogenous bases with single rings are *pyrimidines*. Nitrogenous bases with double rings are called *purines*. Bonds connect the sugar of one nucleotide to the phosphate of the next nucleotide, forming a sugar-phosphate "backbone."

In the 1950s, Rosalind Franklin and Maurice Wilkins used an X-ray process to take pictures of DNA molecules. Using information from these images, James Watson and Francis Crick built a model of a DNA molecule with a twisting shape called a *double helix*. In the double helix, two strands of DNA twist together with the sugar-phosphate backbone on the outside and nitrogenous

bases on the inside. The nitrogenous bases of the two strands can pair in only one way: Adenine pairs with thymine, and guanine pairs with cytosine.

3. What are the three building blocks of a nucleotide? _____

_____

4. Describe the structure of a DNA molecule. _____

_____

_____

Concept 11.3 DNA replication is the molecular mechanism of inheritance. (pp. 233–234)

DNA is copied before a cell divides. *DNA replication* is the process of copying the DNA molecule. During DNA replication, the two strands of the double helix separate. The cell uses each strand as a template, or pattern, for making a complementary strand. Nucleotides are added to the new strand, according to the rules of base pairing. For example, if the DNA template has an A at a particular position, only a T can be added to the new strand. Enzymes called *DNA polymerases* form the bonds between the nucleotides of the new DNA strand. Replication begins at many sites on the DNA molecule. Replication occurs in both directions from each of these sites, forming replication "bubbles." The bubbles merge, and two double-stranded DNA molecules are formed.

5. How do the rules of base pairing affect the process of DNA replication?

_____

_____

6. What is the role of DNA polymerase during DNA replication? _____

_____

Concept 11.4 A gene provides the information for making a specific protein. (pp. 235–237)

In the 1940s, George Beadle and Edward Tatum studied the relationship between genes and proteins. They proposed the "one gene–one enzyme" hypothesis, stating that each gene controls the production of a specific enzyme. Scientists now know that each gene codes for the production of a single polypeptide.

First, the DNA sequence is converted to the form of a single-stranded RNA molecule in a process called *transcription*. *RNA (ribonucleic acid)* is a nucleic acid with the sugar ribose rather than deoxyribose. Next, the RNA moves from the nucleus to the cytoplasm. *Translation* converts the nucleic acid sequence into a sequence of amino acids. A *codon,* or three-base sequence, codes for one amino acid. The order of the codons in the RNA determines the order in which amino acids will be put together to form a polypeptide. There are 64 codons and 20 amino acids. Some amino acids are coded for by more than one codon, but each codon codes for only one amino acid. Certain codons signal protein synthesis to start or stop.

7. Where in the cell is DNA transcribed? Where is it translated? _____

_____

8. What is a codon? _____

_____

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Concept 11.5 There are two main steps from gene to protein. (pp. 238–241)
Three kinds of RNA are involved in making proteins. First, *messenger RNA (mRNA)* is transcribed from the DNA molecule. An enzyme called *RNA polymerase* joins the RNA nucleotides together during transcription. The mRNA molecule contains sections, called *introns*, that do not code for amino acids. The process of *RNA splicing* removes the introns and joins the coding regions, which are called *exons*. After RNA splicing is complete, the mRNA molecule moves from the nucleus to the cytoplasm.

Transfer RNA (tRNA) is a molecule with an amino acid binding site at one end and a three-base anticodon at the other end. An *anticodon* is a sequence that is complementary to a codon in the mRNA. The tRNA anticodon binds to the mRNA codon, bringing an amino acid into position to be added to the polypeptide. This process takes place on a ribosome, which is made up of *ribosomal RNA (rRNA)*.

9. Describe the process of RNA splicing. _____

_____

_____

10. What is the role of tRNA in translation? _____

_____

_____

Concept 11.6 Mutations can change the meaning of genes. (pp. 242–243)
A change in the nucleotide sequence of DNA is called a *mutation*. A mutation can be a change in a single nucleotide or a change in a large part of a chromosome.

Mutations include substitutions, in which one nucleotide is replaced by another. Other mutations are insertions or deletions, in which one or more nucleotides are added to or removed from a gene. Insertions and deletions usually have more serious effects than substitutions.

Mutations can be caused by errors in crossing over or DNA replication. A physical or chemical agent that causes a mutation is called a *mutagen.* Most mutations are harmful changes, but occasionally a mutation occurs that is beneficial. Mutations that are present in gametes, or sex cells, can be passed to an organism's offspring.

11. What are three types of mutations that can affect genes? _____

_____

_____

12. Define the term *mutagen*. _____

_____

_____

Reading Skills Practice

Creating a flowchart Use the information on page 236 to create a flowchart that shows how the information in DNA is used to make a polypeptide.

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Vocabulary Review and Reinforcement

In 1–5, fill in the blanks in the paragraph below with the appropriate terms from the chapter.

The molecule called **1.** _____ stores the genetic information of an organism. It forms a twisting shape, known as a(n)

2. _____. The process of copying the DNA molecule is called **3.** _____. Enzymes called

4. _____ make the covalent bonds between the nucleotides of the new DNA strand. DNA's nucleotide sequence is converted to the form of a single-stranded RNA molecule in a process called

5. _____.

In 6-15, write the letter of the correct definition on the line next to each term.

_____ **6.** RNA (ribonucleic acid)
_____ **7.** RNA polymerase
_____ **8.** RNA splicing
_____ **9.** bacteriophage
_____ **10.** pyrimidine
_____ **11.** nitrogenous base
_____ **12.** virus
_____ **13.** messenger RNA (mRNA)
_____ **14.** transfer RNA (tRNA)
_____ **15.** ribosomal RNA (rRNA)

a. virus that infects bacteria
b. type of RNA found in a ribosome
c. type of RNA that translates the codons of mRNA to amino acids
d. package of nucleic acid wrapped in a protein coat
e. nucleic acid with the sugar ribose
f. nitrogenous base with a single-ring structure
g. single or double ring of carbon and nitrogen atoms with functional groups
h. RNA molecule transcribed from a DNA template
i. process of removing the introns from RNA
j. enzyme that links RNA nucleotides together

WordWise

Use the clues to unscramble the Key Terms. Then write the terms in the appropriate blanks.

tudenoelic rinpue slantrintor norint nexo donticano tutinmoa

1. change in the nucleotide sequence of DNA _____
2. conversion of nucleic acid sequence into amino acid sequence _____
3. coding region of an RNA transcript _____
4. triplet of bases at one end of a folded tRNA molecule _____
5. building block of nucleic acid polymers _____
6. internal noncoding regions of RNA _____
7. nitrogenous base with double ring structure _____