CHAPTER 13

LESSON 1

Identifying the Substance of the Gene

READING TOOL **Sequence of Events** As you read, pay attention to the experiments that were carried out to help scientists understand genes and how DNA affects living things. Take notes on the importance of each experiment in the graphic organizer below.

Griffith	Avery	Hershey-Chase

Lesson Summary

As you read, circle the answers to each Key Question. Underline any words you do not understand.

Bacterial Transformation

KEY QUESTION *What clues did bacterial transformation yield about the gene?*

Through experimentation and watching the process of transformation in bacteria, scientists learned that DNA stores and transmits genetic information from one generation to the next.

About a century ago, scientists who wanted to understand genetics better began experimenting to learn the chemical nature of genes. In 1928, the British scientist Frederick Griffith was investigating how certain types of bacteria produce pneumonia, a serious lung disease. Griffith had isolated two very similar types of bacteria from mice. Both types grew very well in culture plates in Griffith's lab, but only one of them caused pneumonia. The disease-causing bacteria (the "S" type) grew into smooth-edged colonies on culture plates, whereas the harmless bacteria (the "R" type) produced colonies with rough edges. The difference in appearance made the two types easy to tell apart.

Griffith's Experiments When Griffith injected mice with disease-causing bacteria, they developed pneumonia, while those injected with harmless bacteria remained healthy. An injection combining heat-killed, disease-causing bacteria and harmless bacteria still made the test mice sick.

Transformation Griffith identified that a chemical factor turned dead and harmless bacteria into disease-causing bacteria through a process called **transformation**. He determined that the disease-causing ability was transferred to the bacteria's offspring; thus transformation was caused by a gene.

The Molecular Cause of Transformation In 1944, Oswald Avery and a team of scientists tried to repeat Griffith's experiments to identify the molecule in the heat-killed bacteria that caused the transformation. They first removed molecules from heat-killed bacteria and used enzymes that destroyed their proteins, lipids, carbohydrates, and RNA. Despite this, transformation still occurred. A second experiment, where enzymes were used to destroy DNA, proved that when this happened, transformation did not occur. Their experiment proved that DNA must be responsible for the process of transformation.

Bacterial Viruses

KEY QUESTION *What role did bacterial viruses play in identifying genetic material?*

Experiments with bacterial viruses demonstrated that DNA and not the cell's protein coat carried genetic material.

Bacteriophages A **bacteriophage** is a virus that infects bacteria. One way bacteriophages infect bacteria is by inserting genetic information into a cell and reproducing until the bacteria bursts.

The Hershey-Chase Experiment To determine which part of the virus entered the bacterium, Hershey and Chase grew viruses with radioactive isotopes. These identified which molecules entered the bacteria—showing that DNA, not the protein coat, held the genetic material.

READING TOOL

Active Reading

During his experiments, Griffith figured out that the "S" type bacteria caused pneumonia in mice, and the "R" type did not.

☑ **Why was Griffith surprised when the mice injected with both harmless and heat-killed bacteria developed pneumonia and died?**

BUILD Vocabulary

transformation process in which one strain of bacteria is changed by a gene or genes from another strain of bacteria

bacteriophage (bak-tir-ē-ə-fāj) type of virus that infects bacteria

ROOT WORDS If you break the term *bacteriophage* down into two parts—*bacterio* and *phage*—it may help you understand it better. From the definition, you can see that *phage* is a type of virus. With *bacterio* at the beginning of it, you can see the relation between the two parts of the word. ☑ **What does a bacteriophage inject into a bacterial cell?**

The Role of DNA

KEY QUESTION *What is the role of DNA in heredity?*

DNA stores and copies genetic information, and then transmits it to offspring. Through DNA, genes are expressed and cells develop with specific characteristics.

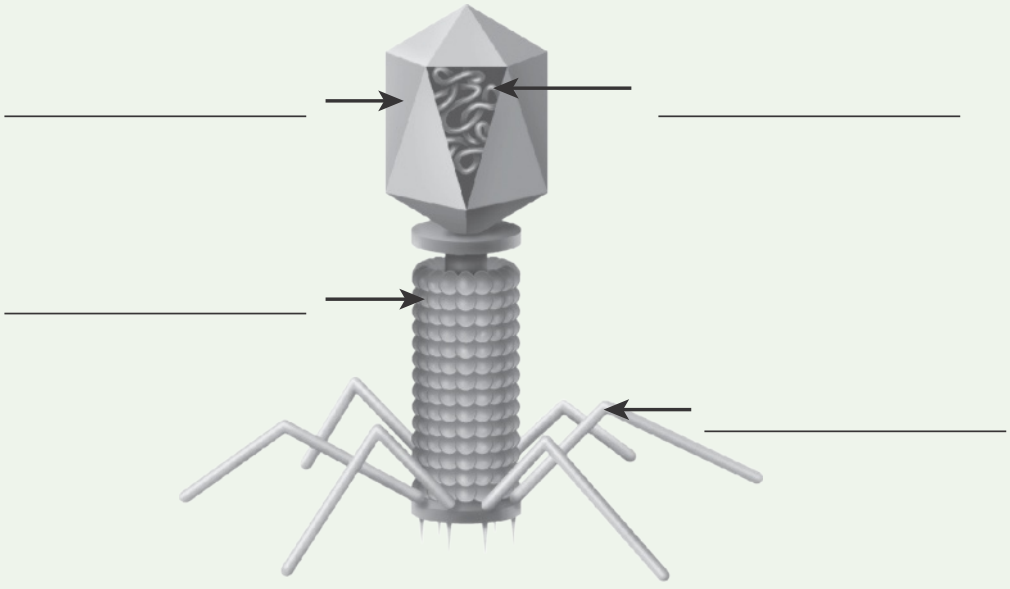
Storing Information DNA's primary job is to store genetic information. It is the heredity molecule, and it controls cell development. All information for a single cell to develop into a complex organism is stored in DNA.

Copying Information DNA's second job is to copy all of its genetic information exactly.

Gene Expression DNA's third job is to express the genetic information into other cells so they develop into exactly what they are coded to be.

Visual Reading Tool: Bacteriophages and the Hershey-Chase Experiment

T4 Bacteriophage



1. Label the parts of a bacteriophage.

2. What part of the bacteriophage gets injected into a bacterial cell?

_____

3. What part of the bacteriophage attaches and anchors itself to the bacteria?

_____

4. What type of organism is a bacteriophage? Circle your answer.

bacteria, virus, eukaryote

LESSON 2

The Structure of DNA

READING TOOL **Connect to Visuals** Refer to the given scientists and the associated textbook figure numbers to help you understand the events that led to solving the structure of DNA. In the boxes, write the names of the scientists and a short description of the experiment or discovery.

Scientist	Summary of Experiment
Chargaff (Figure 13-10)	
Franklin (Figure 13-7)	
Watson and Crick (Figure 13-8)	

Lesson Summary

As you read, circle the answers to each Key Question. Underline any words you do not understand.

READING TOOL

Cause and Effect Let's explore cause and effect for a moment.

If Franklin had never used X-ray technology to take pictures of DNA, how might Watson and Crick's work have been different?

The Components of DNA

KEY QUESTION *What are the chemical components of DNA?*

DNA is a nucleic acid made of nucleotides joined into long strands or chains by covalent bonds.

Nucleic Acids and Nucleotides The monomer of nucleic acids is a nucleotide. They are long chains that are somewhat acidic. Nucleotides include three basic components: a 5-carbon sugar molecule, a phosphate group, and a nitrogenous base. Nucleotides join together to form strands of DNA.

Nitrogenous Bases The nucleotides that make up DNA have four types of nitrogenous bases: adenine, guanine, cytosine, and thymine. Each of these is often referred to by its first initial: A, G, C, or T. Covalent bonds connect the sugar of one nucleotide with the phosphate group of another nucleotide—and these can join in any sequence.

Solving the Structure of DNA

KEY QUESTION *What clues helped scientists to determine the structure of DNA?*

The data in Franklin's X-ray pattern enabled Watson and Crick to build a model that explained the specific structure and properties of DNA.

Chargaff's Rule Biochemist Erwin Chargaff discovered similarities in the percentages of bases in DNA. He identified that each sample of DNA included an equal percentage of adenine (A) and thymine (T), as well as an equal percentage of guanine (G) and cytosine (C). This realization created what's known as Chargaff's rule: [A] = [T], and [G] = [C].

Franklin's X-Rays Scientist Rosalind Franklin used X-ray diffraction to study the structure of DNA molecules. After stretching the DNA fibers to make the strands as parallel as possible, she X-rayed the samples and recorded the patterns they created. Although she was not able to fully determine the structure of the molecule, her work provided insight into the helix shape of DNA strands.

The Work of Watson and Crick James Watson and Francis Crick were studying the structure of DNA at the same time as Franklin. Although they were able to build three-dimensional models of DNA, they still could not explain its properties. After seeing Franklin's X-ray of DNA, they determined that its structure was that of a double helix.

The Double-Helix Model

KEY QUESTION *What does the double-helix model show about DNA?*

The double-helix model explains Chargaff's rule of base pairing and how two strands of DNA are held together.

Antiparallel Strands The two strands of DNA's double helix run antiparallel, or in opposite directions. This structure connects the nitrogenous bases on each strand, and allows DNA to carry nucleotides in a specific sequence.

Hydrogen Bonds DNA strands are held together by hydrogen bonds formed between nucleotides. Nitrogenous bases bond with certain other bases in a process called **base pairing**. For DNA, adenine (A) bonds with thymine (T), and guanine (G) bonds with cytosine (C).

Base Pairing Base pairing clarified how Chargaff's rule applied to DNA, and why (A) = (T) and (G) = (C). This led to a Nobel Prize for Watson, Crick, and Franklin. Although base pairing explained DNA structure and sequences, it did not explain how DNA carried or used the genetic information.

BUILD Vocabulary

base pairing principle that bonds in DNA can form only between adenine and thymine and between guanine and cytosine

Related Words In genetics, the word *base* is shorthand for *nitrogenous base* and generally refers to A's, T's, C's, and G's.

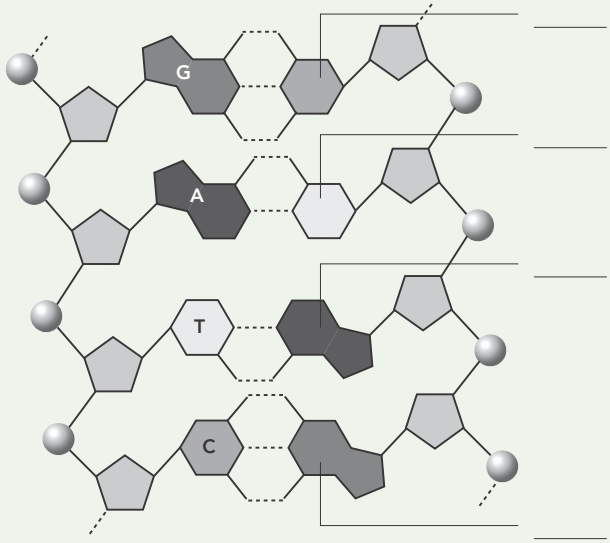
☑ **What are the three main parts of a nucleotide?**

_____

_____

Visual Reading Tool: Identifying Base Pairs

1. Fill in the missing nucleotides in the diagram.



2. What do you notice about the number of hydrogen bonds that exist between the nucleotides?

_____

3. Who was the scientist who discovered the rule of base pairing? _____

4. On the diagram, what do the pentagons and spheres represent?

_____

_____

CHAPTER 13

LESSON 3

DNA Replication

READING TOOL **Main Idea and Details** As you read through this lesson, write the main ideas and supporting details in the chart below.

Copying the Code	• Main Idea: _____ • Supporting Detail: _____
The Replication Process	• Main Idea: _____ • Supporting Detail: _____
The Role of Enzymes	• Main Idea: _____ • Supporting Detail: _____
Telomeres	• Main Idea: _____ • Supporting Detail: _____
Replication of Living Cells	• Main Idea: _____ • Supporting Detail: _____
Prokaryotic DNA Replication	• Main Idea: _____ • Supporting Detail: _____
Eukaryotic DNA Replication	• Main Idea: _____ • Supporting Detail: _____

Lesson Summary

Copying the Code

KEY QUESTION *What is the role of DNA polymerase in copying DNA?*

DNA polymerase, or the main enzyme involved in DNA replication, joins nucleotides to synthesize a new complementary strand of DNA.

The Replication Process The DNA duplication process is called **replication**. During replication, DNA strands separate, and two complementary strands are created—one from each matching the opposite. Each new DNA molecule has one original and one new strand, making it identical to the original.

The Role of Enzymes An enzyme disconnects bonds between base pairs and unwinds the strands. Each strand becomes the model for the complementary strand. Then an enzyme called **DNA polymerase** creates the bonds connecting nucleotides, and ensures that each new strand is an exact copy of its original.

Telomeres The tips of eukaryotic chromosomes are called **telomeres**. These are hard to replicate, so the telomerase enzyme makes this happen. Telomerase adds short, repeated DNA sequences to telomeres during replication, and helps prevent the genes near the ends of chromosomes from getting lost or damaged during replication.

As you read, circle the answers to each Key Question. Underline any words you do not understand.

BUILD Vocabulary

replication process of copying DNA prior to cell division

DNA polymerase principal enzyme involved in DNA replication

telomere repetitive DNA at the end of a eukaryotic chromosome

Using Prior Knowledge There are three main differences between prokaryotes and eukaryotes. One difference is that one does not have a nucleus while the other does. Another difference is that the prokaryote is unicellular, while the eukaryote can be either unicellular or multicellular. ☑ **What is the third difference that you have learned about in this lesson?**

_____

_____

Visual Reading Tool: Structure Identification

1. Identify the following structures on the diagram: *DNA polymerase, new strand, nitrogenous bases, old strand, replication fork.*
2. On each side of the diagram, draw arrows to show the direction in which DNA replication is moving.
3. What is the job of DNA polymerase?

_____

_____

_____

_____

READING TOOL

Apply Prior Knowledge A normal human cell will have 46 chromatids before the S phase of the cell cycle: 23 from the mother and 23 from the father. ☑ **How many chromatids will a cell contain after DNA replication?**

Replication in Living Cells

KEY QUESTION *How does DNA replication differ in prokaryotic cells and eukaryotic cells?*

DNA replication in prokaryotic cells starts from one point and continues in two directions until replication is complete. In eukaryotic cells, it begins at multiple points and continues outward until complete.

Prokaryotic DNA Replication

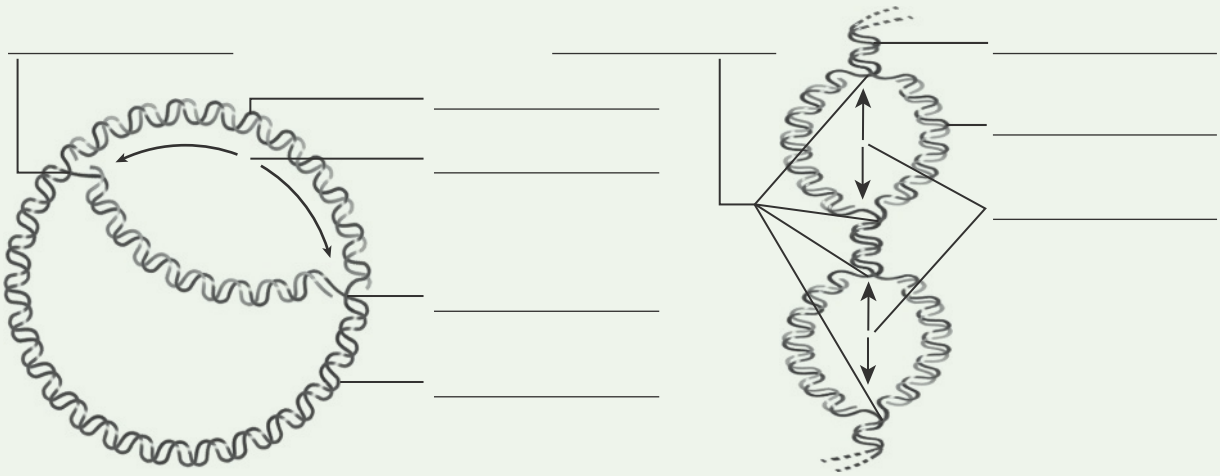
Replication in most prokaryotes begins at a single point and moves in two directions until the entire chromosome is copied. Regulatory proteins bind at a single point on a chromosome, sparking the S phase and DNA replication. The two chromosomes produced in this process are connected to separate points within a cell's membrane and get separated during cell division.

Eukaryotic DNA Replication

Replication in eukaryotes is more complex and begins at multiple places on the DNA molecule, fanning out in two directions. Proteins ensure that base pairs are matched correctly and no damage occurs. Sometimes these proteins fail, and damaged sections of DNA are replicated. This causes changes to DNA base sequences and may have serious consequences for cell development.

Visual Reading Tool: Compare and Contrast

On each diagram below, label the following structures: *New DNA, Origin of replication, Replication fork, Unreplicated DNA.*



Prokaryotic DNA

Eukaryotic DNA

13 Chapter Review

Review Vocabulary

Match the vocabulary term to its definition.

1. _____ a kind of virus that infects bacteria

2. _____ the process in which bacteria is changed by a gene

3. _____ principle that explains how bonds in DNA will form between specific nucleotides

4. _____ process of copying DNA prior to cell division

a. transformation

b. bacteriophage

c. base pairing

d. replication

Fill in the blanks with the correct terms to complete the sentence.

5. _____ are unicellular organisms that have circular DNA, while _____ have linear DNA and can be unicellular or multicellular.

Review Key Questions

Provide evidence and details to support your answers.

6. Explain how studying viruses led to the discovery that DNA contains genetic material.

7. If DNA is charged with storing, copying, and expressing genetic traits, what might happen if DNA got damaged?

8. Explain how the sugars, phosphate groups, and nitrogenous bases in one strand of DNA connect to a complementary strand during replication.

9. Enzymes serve several functions during DNA replication. Name two of these functions.