Name _____ Class _____ Date _____

CHAPTER 13 DNA, RNA, and Proteins

SECTION 1

The Structure of DNA

KEY IDEAS

As you read this section, keep these questions in mind:

- What makes up genetic material?
- What experiments helped identify the role of DNA?
- What is the shape of a DNA molecule?
- How is information organized in a DNA molecule?
- What scientific investigations led to the discovery of DNA's structure?

What Is DNA?

In the 1800s, Austrian monk Gregor Mendel showed that parents can pass traits to their children. Scientists later discovered that **genes** carry the instructions for inherited traits. However, scientists did not learn what genes consist of until the 1950s.

We now know that genes consist of small segments of deoxyribonucleic acid, or **DNA**. DNA is the genetic material in cells.☑

READING TOOLBOX

Summarize After you read this section, make a chart summarizing the main results of the experiments of Griffith, Avery, and Hershey and Chase.

READING CHECK

1. Identify What are genes made of?

_____

SHOWING THAT DNA IS GENETIC MATERIAL

DNA consists of only four subunits. At first, many scientists did not think that it was complex enough to be genetic material. Three important experiments helped to show that DNA is genetic material.

In 1928, Frederick Griffith found that harmless live bacteria (R bacteria) became harmful when mixed with dead harmful bacteria (S bacteria), as shown below. The experiment proved that genetic material, which caused the bacteria to be harmful, can be transferred between cells.

❶ Live S bacteria kill the mouse.

❷ Live R bacteria do not kill the mouse.

❸ Dead S bacteria do not kill the mouse.

❹ A mixture of live R bacteria and dead S bacteria kills the mouse.

LOOKING CLOSER

2. Infer The mouse that received dead S bacteria and live R bacteria died. What would have happened to the mouse if genetic information could not be transferred between cells?

_____

_____

How Did Scientists Link DNA and Genes?

Griffith's experiment showed that genetic material can be transferred. However, it did not show whether genetic material is protein, ribonucleic acid (RNA), or DNA.

In the 1940s, Oswald Avery and his team followed up on Griffith's experiment. They found that dead bacteria that were missing protein or RNA could still change harmless cells into harmful cells. However, dead bacteria that were missing DNA did not transform the harmless cells. They concluded that DNA is the genetic material. ☑

READING CHECK

3. Explain How did Avery's experiments show that DNA is the genetic material?

_____

_____

_____

_____

_____

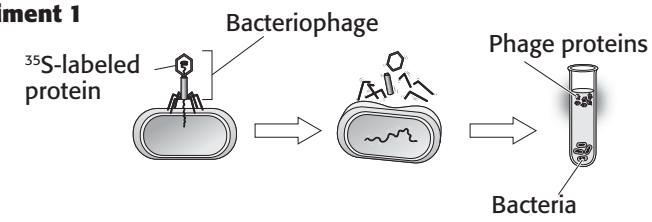
In 1952, Alfred Hershey and Martha Chase provided support for Avery's results by studying bacteriophages. *Bacteriophages* are viruses that contain both proteins and DNA. They infect bacterial cells, causing the bacteria to produce more viruses.

Hershey and Chase used radioactive atoms of sulfur and phosphorus to learn whether proteins or DNA entered cells. Proteins contain sulfur, but not phosphorus. DNA contains phosphorus, but not sulfur. The results of their experiment supported Avery's conclusion that DNA is the genetic material.

Hershey-Chase Experiment

1. First, the scientists grew two batches of bacteriophages. One batch grew in an environment rich in ^{32}P. The DNA in these viruses therefore contained a great deal of ^{32}P. The second batch grew in an environment rich in ^{35}S. The protein in those viruses contained a great deal of ^{35}S. Each batch of viruses was allowed to infect a separate batch of bacteria.
2. Then, the bacteria and viruses were broken apart in a blender. The scientists spun the mixture in a tool called a centrifuge. This separated the heavier bacteria from the lighter bacteriophage proteins.
3. Finally, the scientists used machines to detect radioactivity from the ^{32}P and ^{35}S. They found radioactivity from ^{32}P, but not from ^{35}S, in the bacteria. This showed that the DNA of the virus, but not the protein, was transferred to the bacteria.

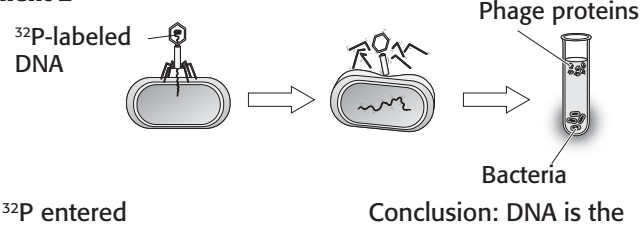
Experiment 1



Result: ^{35}S did not enter bacterial cells.

Conclusion: Protein is not the genetic material.

Experiment 2



Result: ^{32}P entered bacterial cells.

Conclusion: DNA is the genetic material.

LOOKING CLOSER

4. Identify Which radioactive atom was found in the infected bacteria?

_____

_____

_____

Critical Thinking

5. Infer Describe how the results of the Hershey-Chase experiment would have been different if proteins were the genetic material.

_____

_____

_____

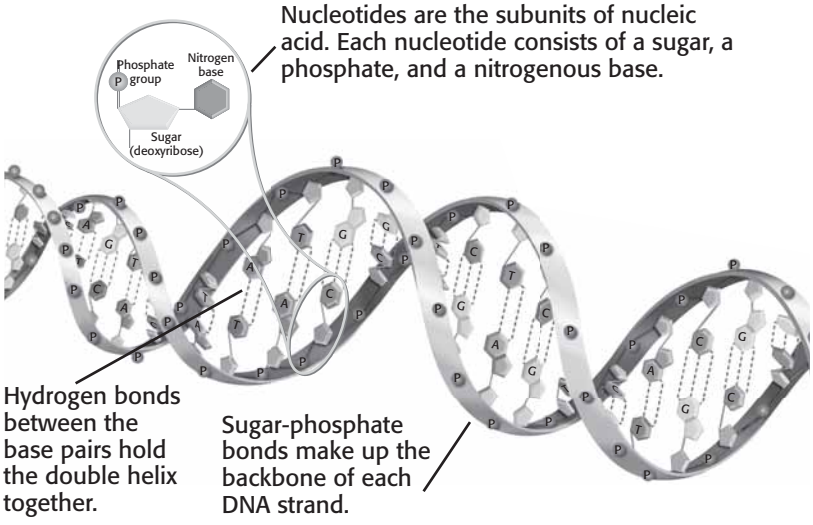
_____

What Does DNA Look Like?

By the late 1950s, scientists accepted that genes consisted of DNA. However, they still knew nothing about the DNA's structure. Several groups set out to discover this structure and the role of DNA in the transfer of genetic information. The research of many scientists helped James Watson and Francis Crick to determine the structure of DNA. ☑

The structure of DNA is a *double helix*. It looks like a spiral staircase made of two parallel, winding strands of linked subunits called nucleotides. Each **nucleotide** consists of three chemical groups: a phosphate group, a five-carbon sugar, and a nitrogen-containing, or *nitrogenous*, base. The five-carbon sugar, called deoxyribose, gives DNA its name.

Phosphate and sugar groups link together to form the "backbone" of a DNA strand. Bases link up to connect the two strands. The figure below shows the structure of DNA. ☑



READING CHECK

6. Identify Which two scientists determined the structure of DNA?

_____

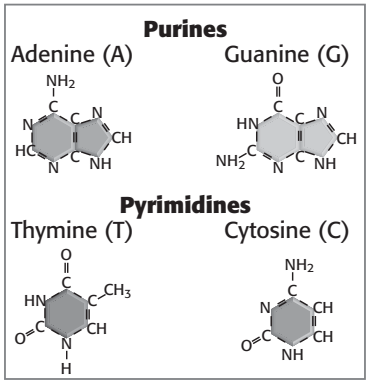
_____

READING CHECK

7. Describe What are the two chemical groups that form the backbone of a DNA strand?

_____

_____



Purines contain two rings of carbon and nitrogen atoms. Adenine (represented by the letter A) and guanine (G) are purines.

Pyrimidines contain one ring of carbon and nitrogen atoms. Thymine (T) and cytosine (C) are pyrimidines.

LOOKING CLOSER

8. Identify Give one difference between purines and pyrimidines.

_____

_____

_____

_____

Background

Recall that a *hydrogen bond* is a weak attraction between a hydrogen atom and an oxygen, nitrogen, or fluorine atom.

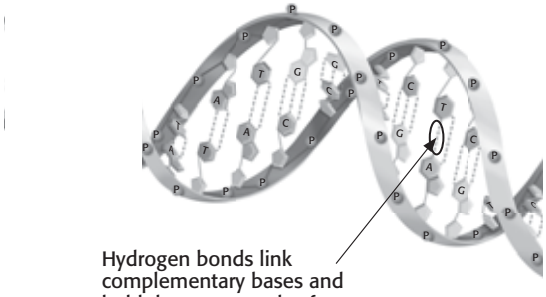
Talk About It

Explain In a small group, discuss how you could determine the order of bases on one DNA strand if you knew the order of bases on the other strand.

How Do Bases in DNA Link Together?

A purine on a DNA strand always pairs with a pyrimidine on the other strand, as shown below. Weak hydrogen bonds keep those base pairs close to each other. They also hold the two strands of DNA together.

You know that letters placed in a certain order can carry information in the form of words. In a similar way, the order of bases in a DNA strand carries information. Because the bases in DNA pair only in specific ways, each strand of a DNA molecule contains the same information. However, the bases on one strand are in the opposite order from those on the other strand, as shown below.



Hydrogen bonds link complementary bases and hold the two strands of DNA together.

This diagram shows how complementary base pairs join together. Note that adenine (A) always pairs with thymine (T), and cytosine (C) always pairs with guanine (G). In other words, the bases are *complementary*.

LOOKING CLOSER

9. Identify Which base always pairs with cytosine?

_____

Critical Thinking

10. Explain Why must an organism have the same amount of adenine as thymine?

_____

_____

_____

_____

_____

_____

DETERMINING THE STRUCTURE OF DNA

As is common in science, Watson and Crick built on information gathered by many other scientists. For example, in 1949, Erwin Chargaff found that the DNA of all organisms he studied contains the same amounts of cytosine and guanine. It also contains the same amounts of adenine and thymine. Three years later, Rosalind Franklin and Maurice Wilkins developed high-quality X-ray images that showed the shape of DNA.

Watson and Crick put those results together. They built models based on the findings that finally revealed DNA's unique structure.

Name _____ Class _____ Date _____

Section 1 Review

SECTION VOCABULARY

DNA deoxyribonucleic acid, the material that contains the information that determines inherited characteristics

gene the most basic physical unit of heredity; a segment of nucleic acids that codes for a functional unit of RNA and/or a protein

nucleotide an organic compound that consists of a sugar, a phosphate, and a nitrogenous base; the basic building-block of a nucleic-acid chain

purine a nitrogenous base that has a double-ring structure; one of the two general categories of nitrogenous bases found in DNA and RNA; either adenine or guanine

pyrimidine a nitrogenous base that has a single-ring structure; one of the two general categories of nitrogenous bases found in DNA and RNA; thymine, cytosine, or uracil

1. **List** Describe the results of three experiments that helped to show that DNA is the genetic material.

2. **Describe** What is the shape of a DNA molecule?

3. **Apply Concepts** Give the sequence of bases that is complementary to the sequence AATGCCGTATAG.

4. **Explain** How does the complementary pairing of bases allow both strands of a DNA molecule to contain the same information?

5. **Describe** Explain how the results of Chargaff's experiment may have helped Watson and Crick determine the structure of DNA.