

# DNA

## as you read

### What You'll Learn

- **Identify** the parts of a DNA molecule and its structure.
- **Explain** how DNA copies itself.
- **Describe** the structure and function of each kind of RNA.

### Why It's Important

DNA helps determine nearly everything your body is and does.

### Review Vocabulary

**protein:** large organic molecule made of amino acid bases

### New Vocabulary

- DNA
- RNA
- gene
- mutation

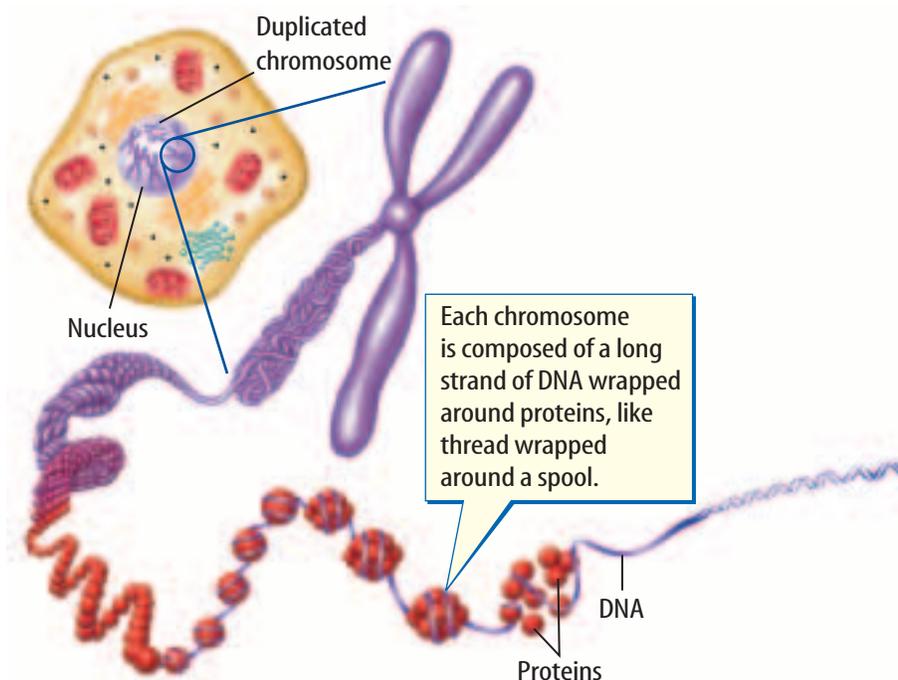
## What is DNA?

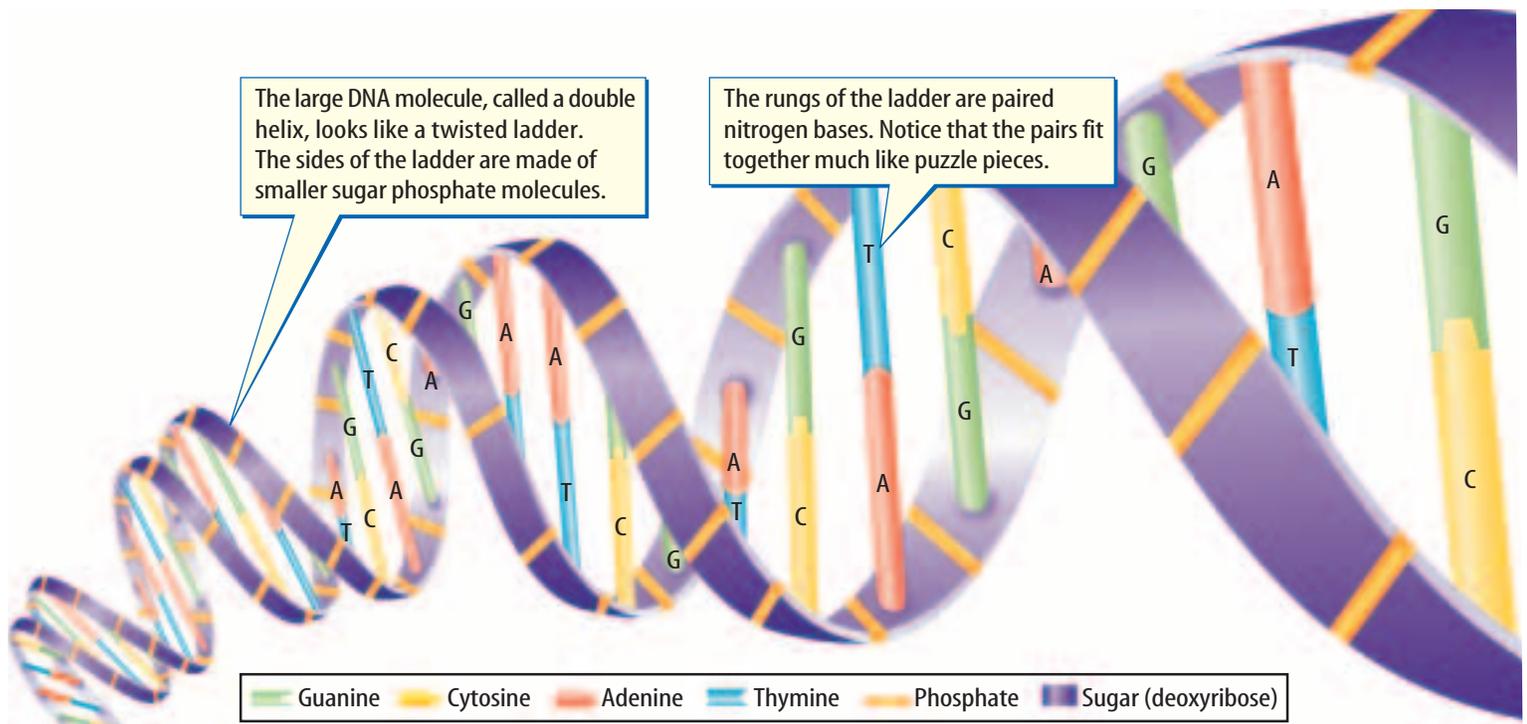
Why was the alphabet one of the first things you learned when you started school? Letters are a code that you need to know before you learn to read. A cell also uses a code that is stored in its hereditary material. The code is a chemical called deoxyribonucleic (dee AHK sih ri boh noo klay ihk) acid, or **DNA**. It contains information for an organism's growth and function. **Figure 14** shows how DNA is stored in cells that have a nucleus. When a cell divides, the DNA code is copied and passed to the new cells. In this way, new cells receive the same coded information that was in the original cell. Every cell that has ever been formed in your body or in any other organism contains DNA.



**Discovering DNA** Since the mid-1800s, scientists have known that the nuclei of cells contain large molecules called nucleic acids. By 1950, chemists had learned what the nucleic acid DNA was made of, but they didn't understand how the parts of DNA were arranged.

**Figure 14** DNA is part of the chromosomes found in a cell's nucleus.





The large DNA molecule, called a double helix, looks like a twisted ladder. The sides of the ladder are made of smaller sugar phosphate molecules.

The rungs of the ladder are paired nitrogen bases. Notice that the pairs fit together much like puzzle pieces.

— Guanine — Cytosine — Adenine — Thymine — Phosphate — Sugar (deoxyribose)

**DNA's Structure** In 1952, scientist Rosalind Franklin discovered that DNA is two chains of molecules in a spiral form. By using an X-ray technique, Dr. Franklin showed that the large spiral was probably made up of two spirals. As it turned out, the structure of DNA is similar to a twisted ladder. In 1953, using the work of Franklin and others, scientists James Watson and Francis Crick made a model of a DNA molecule.

**A DNA Model** What does DNA look like? According to the Watson and Crick DNA model, each side of the ladder is made up of sugar-phosphate molecules. Each molecule consists of the sugar called deoxyribose (dee AHK sih ri boh) and a phosphate group. The rungs of the ladder are made up of other molecules called nitrogen bases. DNA has four kinds of nitrogen bases—adenine (A duh neen), guanine (GWAH neen), cytosine (SI tuh seen), and thymine (THI meen). The nitrogen bases are represented by the letters A, G, C, and T. The amount of cytosine in cells always equals the amount of guanine, and the amount of adenine always equals the amount of thymine. This led to the hypothesis that the nitrogen bases occur as pairs in DNA. **Figure 14** shows that adenine always pairs with thymine, and guanine always pairs with cytosine. Like interlocking pieces of a puzzle, each base bonds only with its correct partner.

### Mini LAB

#### Modeling DNA Replication

##### Procedure

1. Suppose you have a segment of DNA that is six nitrogen base pairs in length. On **paper**, using the letters A, T, C, and G, write a combination of six pairs, remembering that A and T are always a pair and C and G are always a pair.
2. Duplicate your segment of DNA. On paper, diagram how this happens and show the new DNA segments.

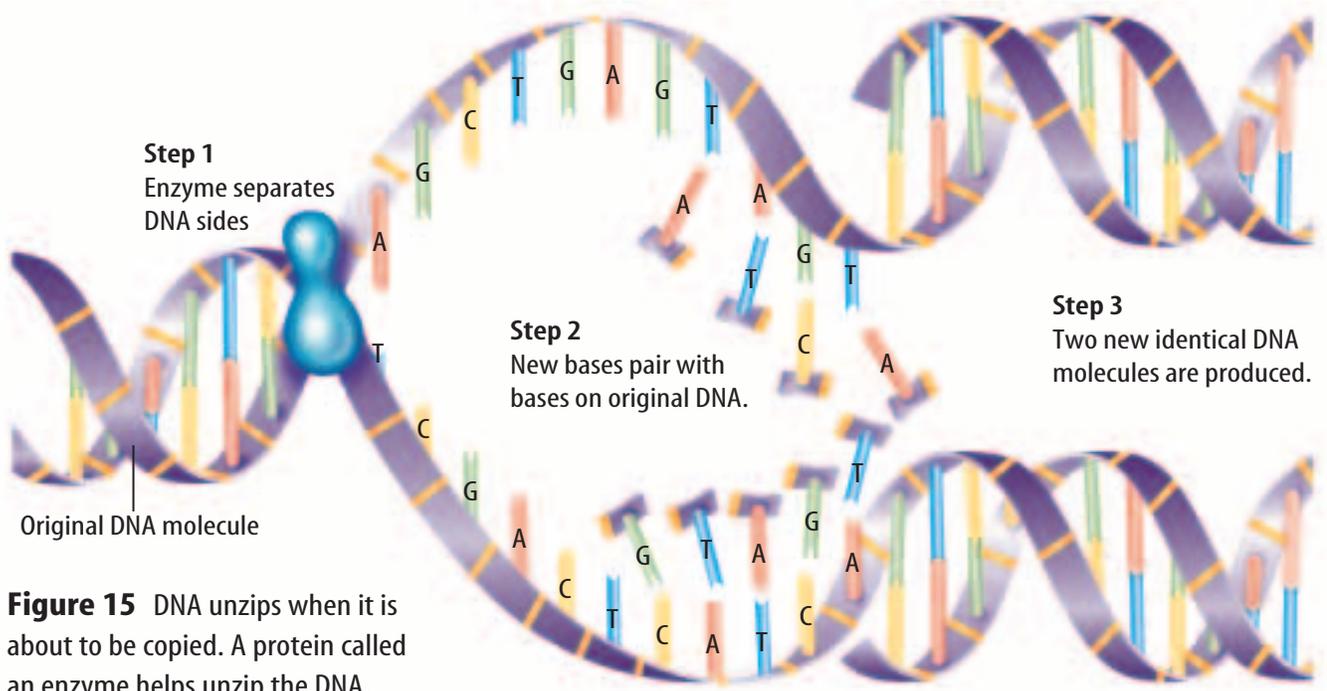
##### Analysis

Compare the order of bases of the original DNA to the new DNA molecules.

#### Reading Check

What are the nitrogen base pairs in a DNA molecule?

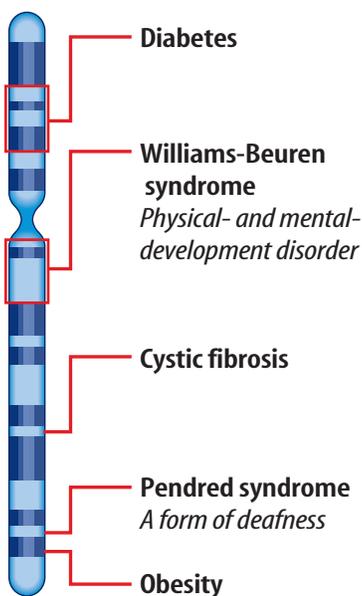




**Figure 15** DNA unzips when it is about to be copied. A protein called an enzyme helps unzip the DNA.

**Figure 16** This diagram shows just a few of the genes that have been identified on human chromosome 7. The bold print is the name that has been given to each gene.

### Chromosome 7



**Copying DNA** When chromosomes are duplicated before mitosis or meiosis, the amount of DNA in the nucleus is doubled. The Watson and Crick model shows how this takes place. The two sides of DNA unwind and separate. Each side then becomes a pattern on which a new side forms, as shown in **Figure 15**. The new DNA has bases that are identical to those of the original DNA and are in the same order.

## Genes

Most of your characteristics, such as the color of your hair, your height, and even how things taste to you, depend on the kinds of proteins your cells make. DNA in your cells stores the instructions for making these proteins.

Proteins build cells and tissues or work as enzymes. The instructions for making a specific protein are found in a **gene** which is a section of DNA on a chromosome. As shown in **Figure 16**, each chromosome contains hundreds of genes. Proteins are made of chains of hundreds or thousands of amino acids. The gene determines the order of amino acids in a protein. Changing the order of the amino acids makes a different protein. What might occur if an important protein couldn't be made or if the wrong protein was made in your cells?

**Making Proteins** Genes are found in the nucleus, but proteins are made on ribosomes in cytoplasm. The codes for making proteins are carried from the nucleus to the ribosomes by another type of nucleic acid called ribonucleic acid, or **RNA**.

**Ribonucleic Acid** RNA is made in the nucleus on a DNA pattern but is different from DNA. If DNA is like a ladder, RNA is like a ladder that has all its rungs cut in half. Compare the DNA molecule in **Figure 14** to the RNA molecule in **Figure 17**. RNA has the nitrogen bases A, G, and C like DNA but has the nitrogen base uracil (U) instead of thymine (T). The sugar-phosphate molecules in RNA contain the sugar ribose, not deoxyribose.

The three main kinds of RNA made from DNA in a cell's nucleus are messenger RNA (mRNA), ribosomal RNA (rRNA), and transfer RNA (tRNA). Protein production begins when mRNA moves into the cytoplasm. There, ribosomes attach to it. Ribosomes are made of rRNA. Transfer RNA molecules in the cytoplasm bring amino acids to these ribosomes. Inside the ribosomes, three nitrogen bases on the mRNA temporarily match with three nitrogen bases on the tRNA. The same thing happens for the mRNA and another tRNA molecule, as shown in **Figure 17**. The amino acids that are attached to the two tRNA molecules bond. This is the beginning of a protein.

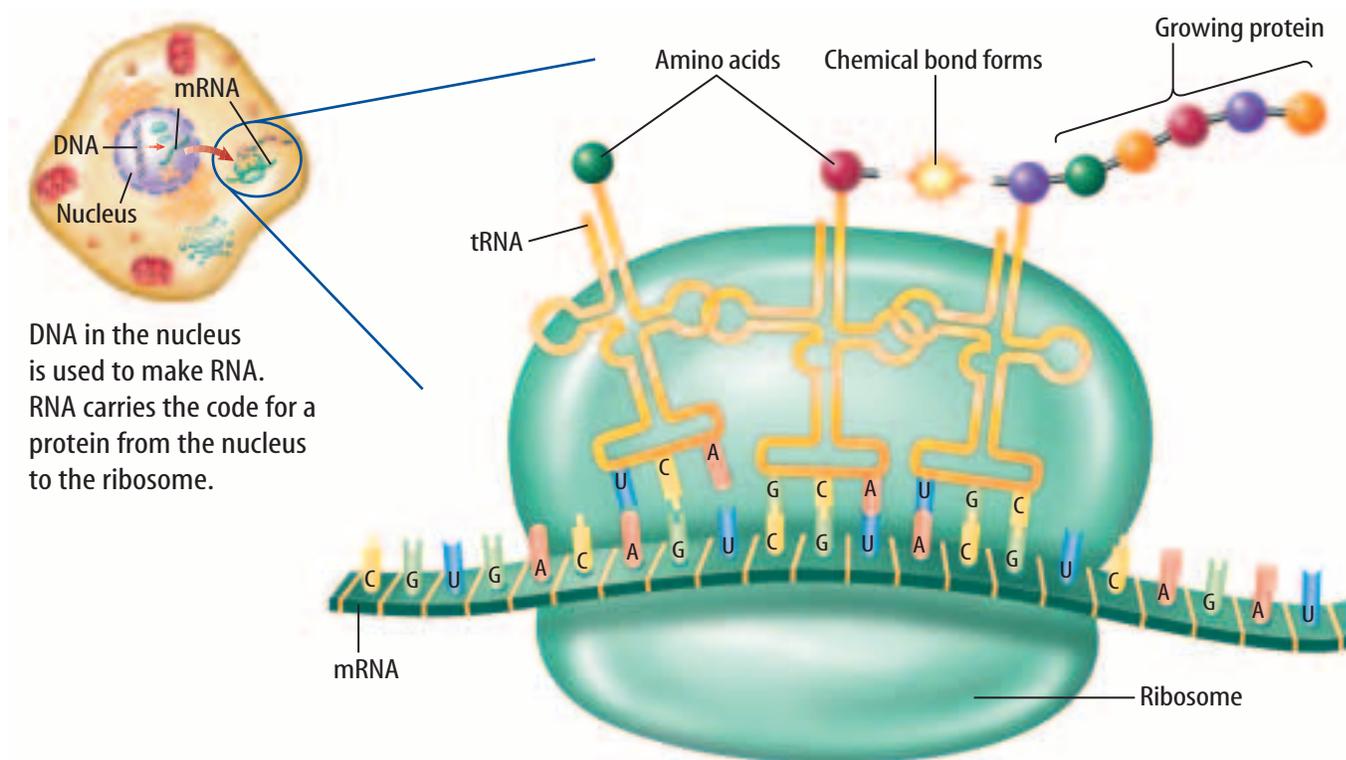
The code carried on the mRNA directs the order in which the amino acids bond. After a tRNA molecule has lost its amino acid, it can move about the cytoplasm and pick up another amino acid just like the first one. The ribosome moves along the mRNA. New tRNA molecules with amino acids match up and add amino acids to the protein molecule.

**Topic: The Human Genome Project**

Visit [life.msscience.com](http://life.msscience.com) for Web links to information about the Human Genome Project.

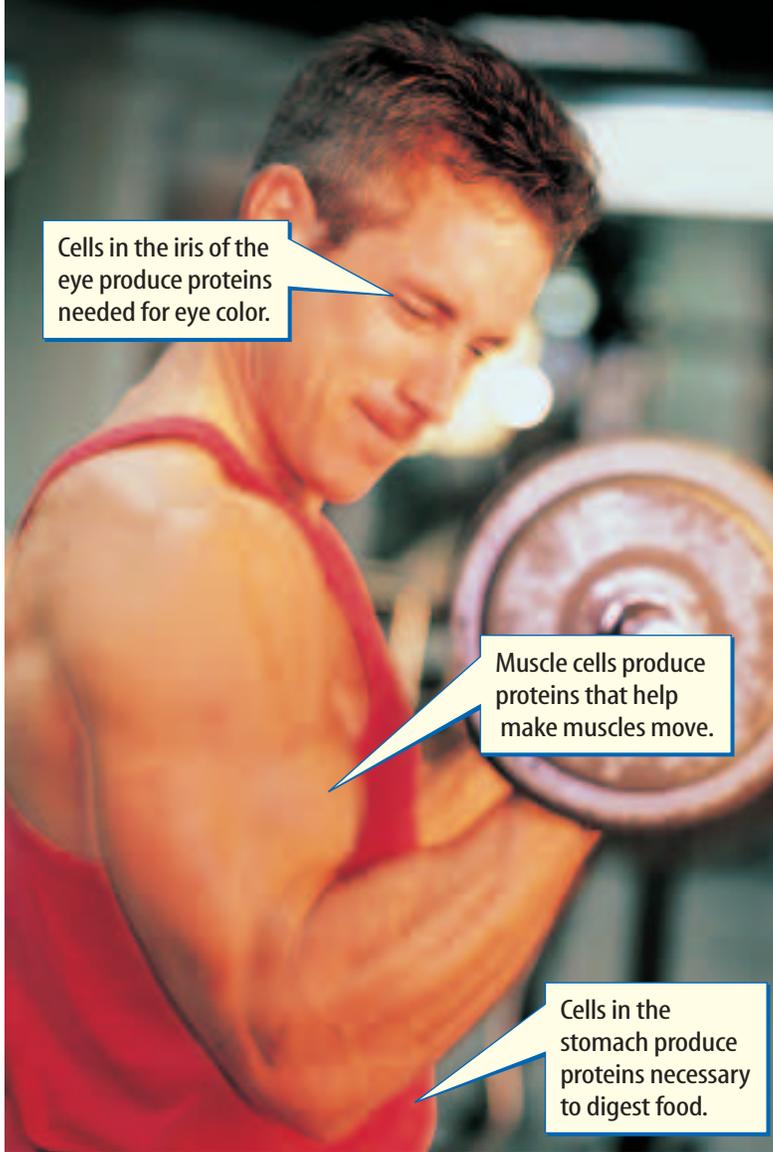
**Activity** Find out when chromosomes 5, 16, 29, 21, and 22 were completely sequenced. Write about what scientists learned about each of these chromosomes.

**Figure 17** Cells need DNA, RNA, and amino acids to make proteins.



DNA in the nucleus is used to make RNA. RNA carries the code for a protein from the nucleus to the ribosome.

At the ribosome, the RNA's message is translated into a specific protein.



Cells in the iris of the eye produce proteins needed for eye color.

Muscle cells produce proteins that help make muscles move.

Cells in the stomach produce proteins necessary to digest food.

**Controlling Genes** You might think that because most cells in an organism have exactly the same chromosomes and the same genes, they would make the same proteins, but they don't. In many-celled organisms like you, each cell uses only some of the thousands of genes that it has to make proteins. Just as each actor uses only the lines from the script for his or her role, each cell uses only the genes that direct the making of proteins that it needs. For example, muscle proteins are made in muscle cells, as represented in **Figure 18**, but not in nerve cells.

Cells must be able to control genes by turning some genes off and turning other genes on. They do this in many different ways. Sometimes the DNA is twisted so tightly that no RNA can be made. Other times, chemicals bind to the DNA so that it cannot be used. If the incorrect proteins are produced, the organism cannot function properly.

**Figure 18** Each cell in the body produces only the proteins that are necessary to do its job.

## Mutations

Sometimes mistakes happen when DNA is being copied. Imagine that the copy of the script the director gave you was missing three pages. You use your copy to learn your lines. When you begin rehearsing for the play, everyone is ready for one of the scenes except for you. What happened? You check your copy of the script against the original and find that three of the pages are missing. Because your script is different from the others, you cannot perform your part correctly.

If DNA is not copied exactly, the proteins made from the instructions might not be made correctly. These mistakes, called **mutations**, are any permanent change in the DNA sequence of a gene or chromosome of a cell. Some mutations include cells that receive an entire extra chromosome or are missing a chromosome. Outside factors such as X rays, sunlight, and some chemicals have been known to cause mutations.



### Reading Check

*When are mutations likely to occur?*

**Figure 19** Because of a defect on chromosome 2, the mutant fruit fly has short wings and cannot fly.

**Predict** Could this defect be transferred to the mutant's offspring? Explain.



**Results of a Mutation** Genes control the traits you inherit. Without correctly coded proteins, an organism can't grow, repair, or maintain itself. A change in a gene or chromosome can change the traits of an organism, as illustrated in **Figure 19**.

If the mutation occurs in a body cell, it might or might not be life threatening to the organism. However, if a mutation occurs in a sex cell, then all the cells that are formed from that sex cell will have that mutation. Mutations add variety to a species when the organism reproduces. Many mutations are harmful to organisms, often causing their death. Some mutations do not appear to have any effect on the organism, and some can even be beneficial. For example, a mutation to a plant might cause it to produce a chemical that certain insects avoid. If these insects normally eat the plant, the mutation will help the plant survive.

Science **online**

**Topic: Fruit Fly Genes**

Visit [life.msscience.com](http://life.msscience.com) for Web links to information about what genes are present on the chromosomes of a fruit fly.

**Activity** Draw a picture of one of the chromosomes of a fruit fly and label some of its genes.

section **3** review

**Summary**

**What is DNA?**

- Each side of the DNA ladder is made up of sugar-phosphate molecules, and the rungs of the ladder are made up of nitrogen bases.
- When DNA is copied, the new DNA has bases that are identical to those of the original DNA.

**Genes**

- The instructions for making a specific protein are found in genes in the cell nucleus. Proteins are made on ribosomes in the cytoplasm.
- There are three main kinds of RNA—mRNA, rRNA, and tRNA.

**Mutations**

- If DNA is not copied exactly, the resulting mutations may cause proteins to be made incorrectly.

**Self Check**

1. **Describe** how DNA makes a copy of itself.
2. **Explain** how the codes for proteins are carried from the nucleus to the ribosomes.
3. **Apply** A strand of DNA has the bases AGTAAC. Using letters, show a matching DNA strand.
4. **Determine** how tRNA is used when cells build proteins.
5. **Think Critically** You begin as one cell. Compare the DNA in your brain cells to the DNA in your heart cells.

**Applying Skills**

6. **Concept Map** Using a Venn diagram, compare and contrast DNA and RNA.
7. **Use a word processor** to make an outline of the events that led up to the discovery of DNA. Use library resources to find this information.