

How DNA Works

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What does DNA look like in different cells?
- How does DNA help make proteins?
- What happens if a gene changes?

National Science Education Standards

LS 1c, 1e, 1f, 2b, 2c, 2d, 2e, 5c

What Does DNA in Cells Look Like?

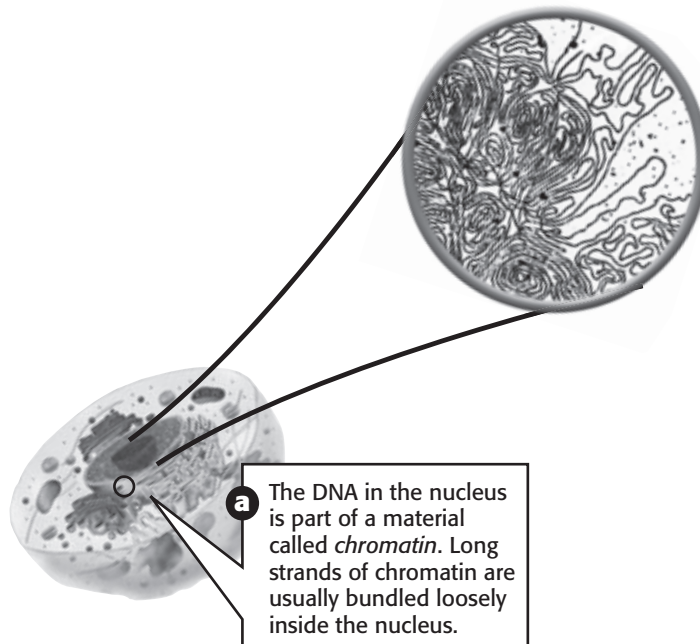
The human body contains trillions of cells, which carry out many different functions. Most cells are very small and can only be seen with a microscope. A typical skin cell, for example, has a diameter of about 0.0025 cm. However, almost every cell contains about 2 m of DNA. How can so much DNA fit into the nucleus of such a small cell? The DNA is bundled.



Compare After you read this section, make a table comparing chromatin, chromatids, and chromosomes.

Math Focus

1. **Convert** About how long is the DNA in a cell in inches?
1 in. = 2.54 cm



TAKE A LOOK

2. **Identify** In what form is the DNA in the nucleus?

SECTION 2 How DNA Works *continued*

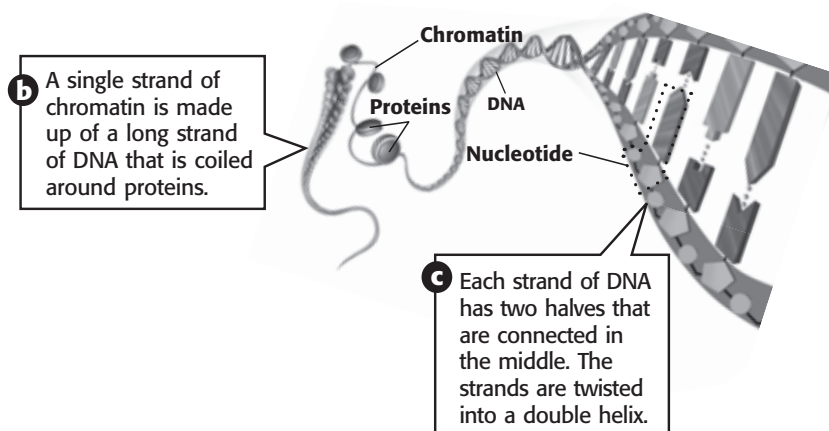
FITTING DNA INTO THE CELL

Large amounts of DNA can fit inside a cell because the DNA is tightly bundled by proteins. The proteins found with DNA help support the structure and function of DNA. Together, the DNA and the proteins it winds around make up a chromosome. ✓

READING CHECK

3. Identify What are two things that are found in a chromosome?

DNA's structure allows it to hold a lot of information. Remember that a gene is made of a string of nucleotides. That is, it is part of the 2 m of DNA in a cell. Because there is an enormous amount of DNA, there can be a large variety of genes.



TAKE A LOOK

4. Describe What is chromatin made of?

Critical Thinking

5. Predict Consequences Imagine that DNA did not replicate before cell division. What would happen to the amount of DNA in each of the new cells formed during cell division?

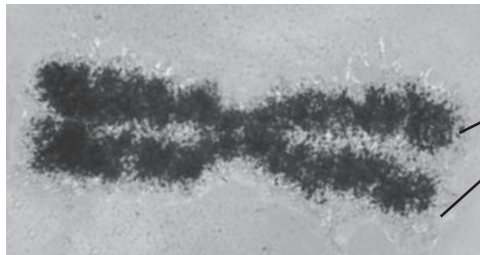
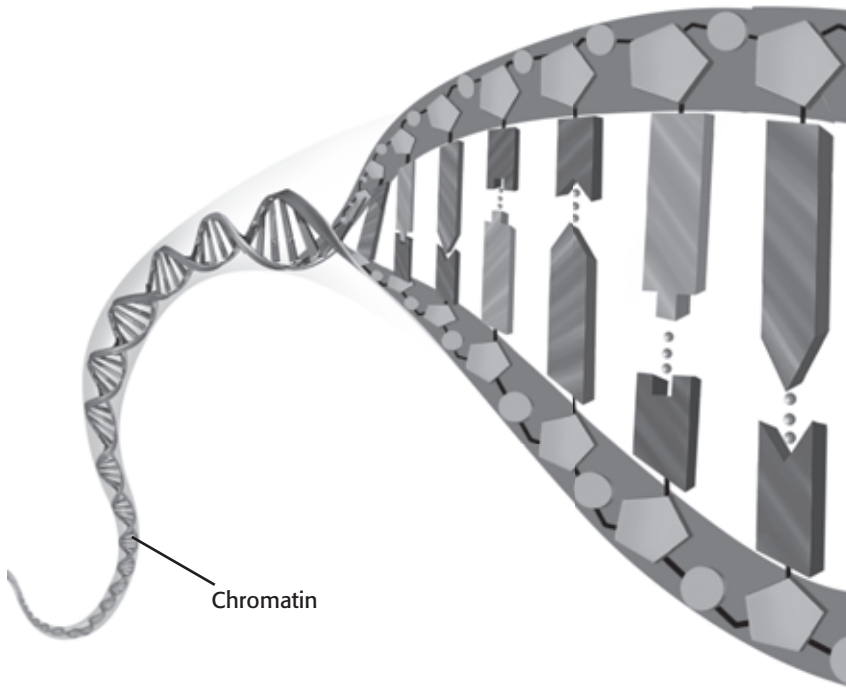
DNA IN DIVIDING CELLS

When a cell divides, its genetic material is spread equally into each of the two new cells. How can each of the new cells receive a full set of genetic material? It is possible because DNA replicates before a cell divides.

Remember that when DNA replicates, the strand of DNA splits down the middle. New strands are made when free nucleotide bases bind to the exposed strands. Each of the new strands is identical to the original DNA strand. This is because the DNA bases can join only in certain ways. *A* always pairs with *T*, and *C* always pairs with *G*.

SECTION 2 How DNA Works *continued*

When a cell is ready to divide, it has already copied its DNA. The copies stay attached as two chromatids. The two identical chromatids form a chromosome.



Chromatids

STANDARDS CHECK

LS 2d Hereditary information is contained in the genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.

6. Identify Where is DNA found in a eukaryotic cell?

How Does DNA Help Make Proteins?

Proteins are found throughout cells. They cause most of the differences that you can see among organisms. A single organism can have thousands of different proteins.

Proteins act as chemical messengers for many of the activities in cells, helping the cells to work together. They also affect traits, such as the color of your eyes and how tall you will grow.

Proteins are made from many subunits called *amino acids*. A long string of amino acids forms a protein.

The order of bases in DNA is a code. The code tells how to make proteins. A group of three DNA bases acts as a code for one amino acid. For example, the group of DNA bases *CAA codes for*, or stands for, the amino acid valine. A gene usually contains instructions for making one specific protein.

Math Focus

7. Calculate How many DNA bases are needed to code for five amino acids?

SECTION 2 How DNA Works *continued*

HELP FROM RNA

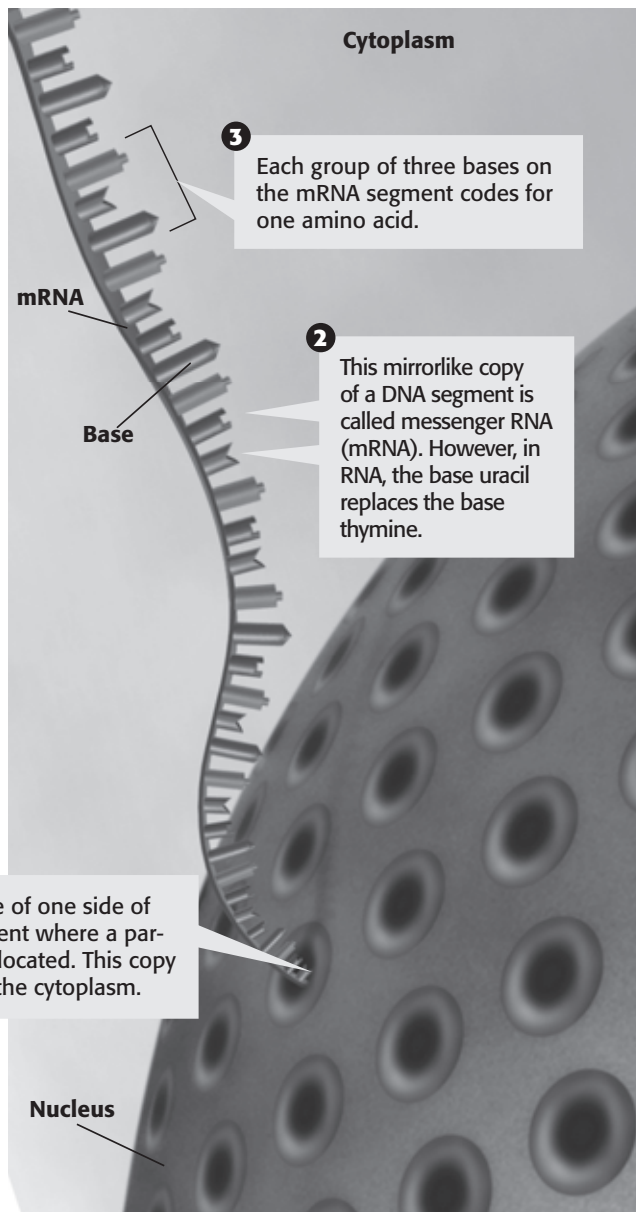
RNA, or *ribonucleic acid*, is a chemical that helps DNA make proteins. RNA is similar to DNA. It can act as a temporary copy of part of a DNA strand. One difference between DNA and RNA is that RNA contains the base *uracil* instead of thymine. Uracil is often represented by *U*. ✓

READING CHECK

8. Identify What is one difference between RNA and DNA?

How Are Proteins Made in Cells?

The first step in making a protein is to copy one side of part of the DNA. This mirrorlike copy is made of RNA. It is called *messenger RNA* (mRNA). It moves out of the nucleus and into the cytoplasm of the cell.



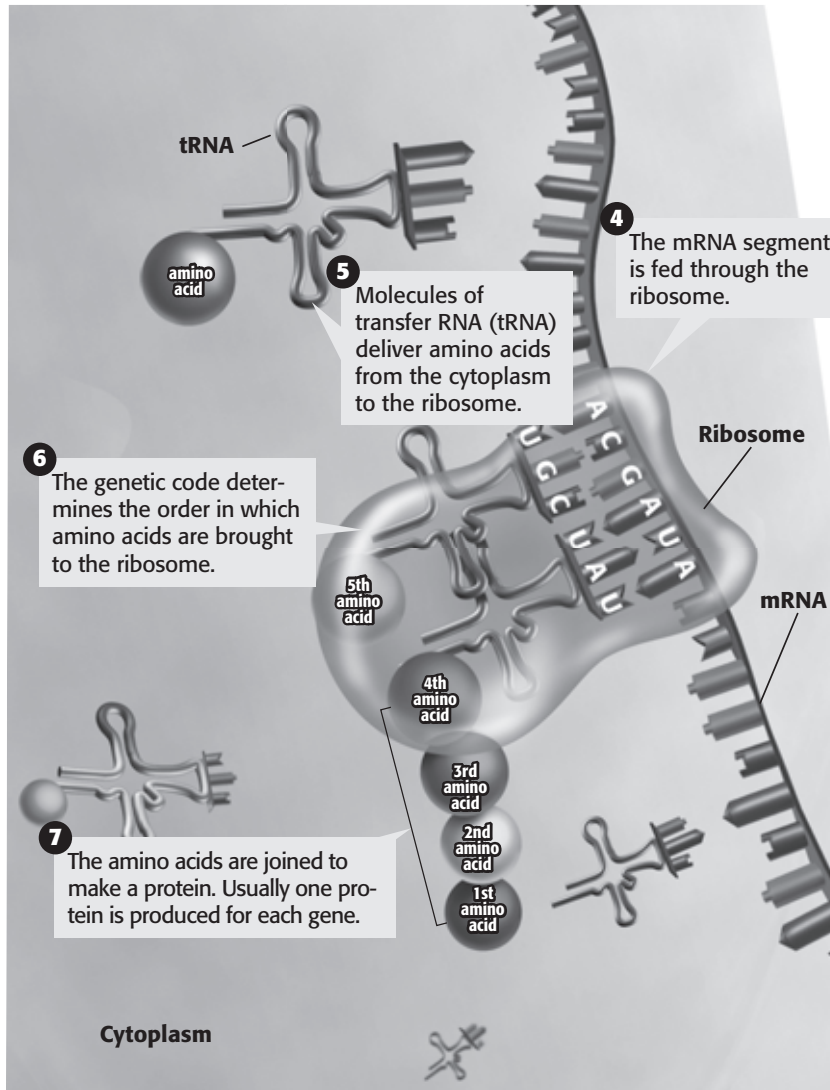
TAKE A LOOK

9. Compare How does the shape of RNA differ from the shape of DNA?

SECTION 2 How DNA Works *continued*

RIBOSOMES

In the cytoplasm, the messenger RNA enters a protein assembly line. The “factory” that runs this assembly line is a ribosome. A **ribosome** is a cell organelle composed of RNA and protein. The mRNA moves through a ribosome as a protein is made.



Critical Thinking

10. Explain Proteins are made in the cytoplasm, but DNA never leaves the nucleus of a cell. How does DNA control how proteins are made?

TAKE A LOOK

11. Identify What does tRNA do?

What Happens If Genes Change?

Read this sentence: “Put the book on the desk.” Does it make sense? What about this sentence: “Rut the zook in the tesk.”? Changing only a few letters in a sentence can change what the sentence means. It can even keep the sentence from making any sense at all! In a similar way, even small changes in a DNA sequence can affect the protein that the DNA codes for. A change in the nucleotide-base sequence of DNA is called a **mutation**. ✓

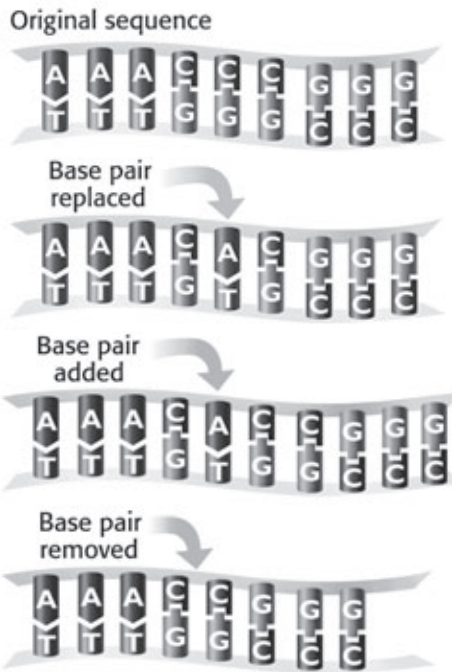
READING CHECK

12. Define What is a mutation?

SECTION 2 How DNA Works *continued*

HOW MUTATIONS HAPPEN

Some mutations happen because of mistakes when DNA is copied. Other mutations happen when DNA is damaged. Things that can cause mutations are called *mutagens*. Examples of mutagens include X rays and ultraviolet radiation. Ultraviolet radiation is one type of energy in sunlight. It can cause suntans and sunburns.



Mutations can happen in different ways. A nucleotide may be replaced, added, or removed.

TAKE A LOOK

13. Compare What happens to one strand of DNA when there is a change in a base on the other strand?

 **Say It**

Brainstorm Whether a mutation is helpful or harmful to an organism often depends on the organism’s environment. In a group, discuss how the same mutation could be helpful in one environment but harmful in another.

HOW MUTATIONS AFFECT ORGANISMS

Mutations can cause changes in traits. Some mutations produce new traits that can help an organism survive. For example, a mutation might allow an organism to survive with less water. If there is a drought, the organism will be more likely to survive.

Many mutations produce traits that make an organism less likely to survive. For example, a mutation might make an animal a brighter color. This might make the animal easier for predators to find.

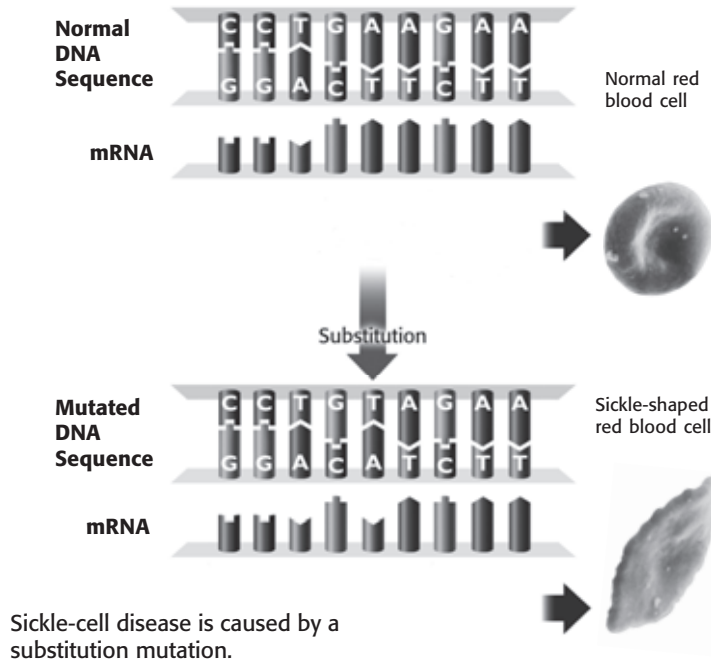
Some mutations are neither helpful nor harmful. If a mutation does not cause a change in a protein, then the mutation will not help or hurt the organism.

SECTION 2 How DNA Works *continued*

PASSING ON MUTATIONS

Cells make proteins that can find and fix many mutations. However, not all mutations can be fixed.

If a mutation happens in egg or sperm cells, the changed gene can be passed from one generation to the next. For example, sickle cell disease is caused by a genetic mutation that can be passed to future generations.



TAKE A LOOK

14. Identify What kind of mutation causes sickle cell disease: deletion, insertion, or substitution?

How Can We Use Genetic Knowledge?

Scientists use their knowledge of genetics in many ways. Most of these ways are helpful to people. However, other ways can cause ethical and scientific concerns.

GENETIC ENGINEERING

Scientists have learned how to change individual genes within organisms. This is called *genetic engineering*. In some cases, scientists transfer genes from one organism to another. For example, scientists can transfer genes from people into bacteria. The bacteria can then make proteins for people who are sick. ✓

GENETIC IDENTIFICATION

Your DNA is unique, so it can be used like a fingerprint to identify you. *DNA fingerprinting* identifies the unique patterns in a person's DNA. Scientists can use these genetic fingerprints as evidence in criminal cases. They can also use genetic information to determine whether people are related.

READING CHECK

15. Define What is genetic engineering?

Section 2 Review

NSES LS 1c, 1e, 1f, 2b, 2c, 2d, 2e, 5c

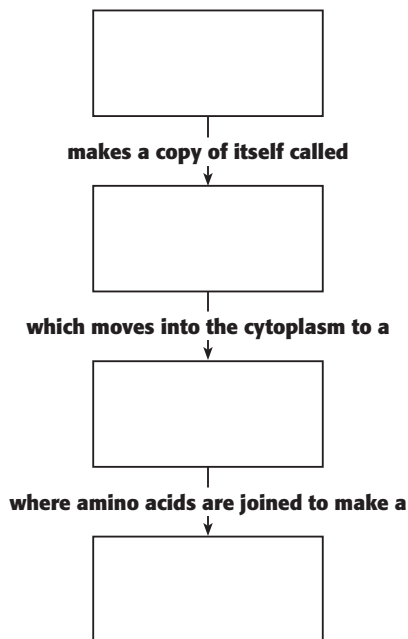
SECTION VOCABULARY

<p>mutation a change in the nucleotide-base sequence of a gene or DNA molecule</p> <p>ribosome a cell organelle composed of RNA and protein; the site of protein synthesis</p>	<p>RNA ribonucleic acid, a molecule that is present in all living cells and that plays a role in protein production</p>
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1. **Identify** What structures in cells contain DNA and proteins?

2. **Calculate** How many amino acids can a sequence of 24 DNA bases code for?

3. **Explain** Fill in the flow chart below to show how the information in the DNA code becomes a protein.



4. **Draw Conclusions** How can a mutation in a DNA base sequence cause a change in a gene and a trait? What determines whether the mutation is passed on to offspring?

5. **Identify** Give two ways that genetic fingerprinting can be used.
