# Understanding Heredity

## How is it that offspring resemble their parents? What is the mechanism that passes on characteristics from one generation to the next generation?

Every living thing looks pretty much like its parents. You look similar to, but not *exactly* like, your biological parents. Tomato plants look like their tomato-plant parents. Seems simple, but how does it happen?

Lambs resemble their parents because of heredity, the passing of traits from parents to offspring.

Clearly some kind of information passes from parents to offspring. This information includes instructions for how to develop into an adult like Mom and Dad. One **generation** passes information to the next. This **heredity** makes the new generation resemble the other members of their species, especially their parents. For thousands of years, people have recognized the usefulness of **inheritance**. They observed **variation** in the traits of organisms of the same kind. They selectively bred plants and animals so their offspring would have valuable traits. For example, a sheep with very long soft wool, or an apple tree with tasty fruit, would be selected for breeding. Often the offspring inherited the desired traits. But no one understood the actual mechanism that drives inheritance.

A tomato plant bears only tomatoes, but not all tomatoes are the same. Fruits with exceptional flavor, firmness, color, or ripening speed may become breeding stock.

## Mendel's Research

Gregor Mendel (1822–1884) was born in a poor farming community in what is now the Czech Republic. He was a bright student, but his family did not have the money to send him to a university. In order to continue his studies, Mendel joined a monastery, where he studied the patterns of inheritance in pea plants. He conducted careful experiments over many years. He concluded that parent plants have a "factor" that transfers traits to their offspring.

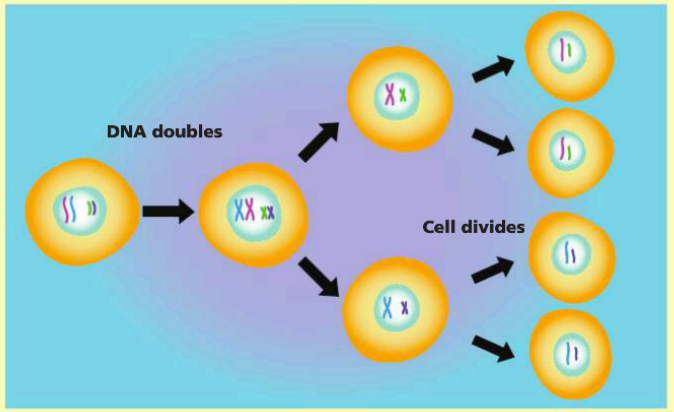
Mendel's findings were ignored for many years. Scientists did not understand what made inheritance possible. Before long, however, advances in technology provided a new way to examine inheritance.

Mendel's pioneering work led to our understanding of heredity.

Mendel experimented with pea plants in the monastery garden for 8 years, from 1856 to 1863. He wanted to find out how traits such as flower color, pod shape, and stem length were passed from parent to offspring.



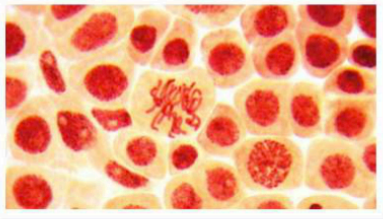
### Egg and Sperm Formation




Sex cells are formed by a two-part cell division called meiosis. Duplicated genetic material in the parent cell is distributed among four daughter cells.

## Discovery of Chromosomes

By the late 1880s, scientists were able to observe the nucleus of a cell. They discovered structures that looked like Xs and hot dogs inside the nucleus. They named these structures **chromosomes**. Scientists observed that when a cell prepared to divide, the chromosomes copied themselves. They separated into two identical sets of chromosomes. Each new cell enclosed a complete and identical set.



Chromosomes double before cells divide. These cells are typical body cells.

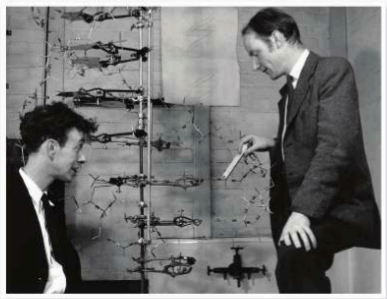
In 1902, Walter S. Sutton (1877–1916) observed that the chromosomes in a nucleus could be sorted into pairs. When some cells divided, the chromosome pairs separated and went into separate cells. These new cells were sex cells (egg and sperm). Each sex cell had just one set of chromosomes, not two.

This remarkable discovery confirmed Mendel's work. Sutton realized that Mendel's factors are located on chromosomes. During sexual reproduction, the chromosomes pass to the next generation, one set from the sperm, and one set from the egg. The fertilized egg has two sets of chromosomes, but the pairs are not exactly the same as those of either parent. The new pair of chromosomes is a mixture of the chromosomes of the parents. The information for an organism's traits is on the chromosomes it receives from both its parents.

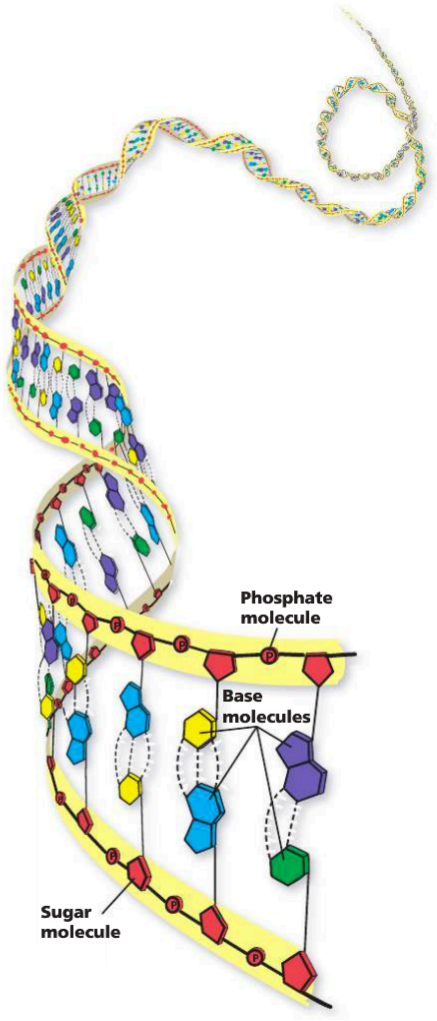
## A Remarkable Molecule

How do chromosomes carry information? The answer lies in a remarkable molecule, deoxyribonucleic acid (DNA). DNA was first extracted from the nuclei of cells in 1869. Its importance was not recognized for many years. In the early 1950s, two young scientists, James D. Watson (1928– ) and Francis H. Crick (1916–2004), studied the molecule. They used imaging data provided by their colleague Rosalind Franklin (1920–1958) to understand the structure of the molecule. They concluded that the DNA molecule is a complex double strand of molecules. It has two "backbones" that run parallel to each other.

Watson and Crick started building a model. Their model began to look like a twisted ladder. The backbones (sides of the ladder) are alternating sugar and phosphate molecules. The steps of the ladder are pairs of four base molecules. The base molecule cytosine (C) always pairs with base guanine (G). The base molecule adenine (A) always pairs with base thymine (T). The sequence of these base pairs encode an organism's genetic information.



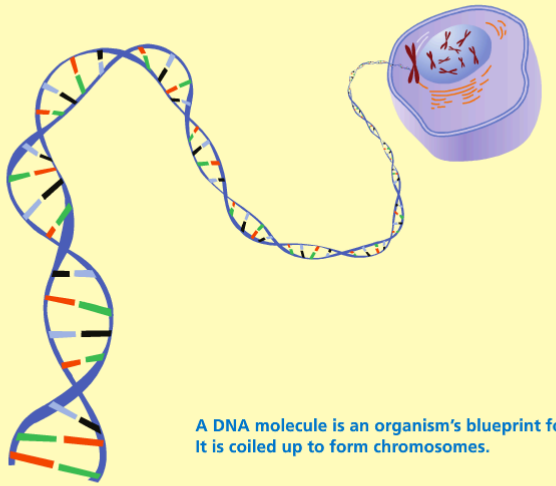
Watson and Crick examine their DNA model.




Scientists use the term double helix to describe the twisted ladder shape of a DNA molecule.



**DNA**



A DNA molecule is an organism's blueprint for life. It is coiled up to form chromosomes.

How does a large "ladder" fit in the nucleus of a cell? The DNA molecule is twisted and twisted into a compact structure. That's what a chromosome is—a twisted DNA molecule.

## Genes and Heredity

On a chromosome, sections of DNA, called **genes**, contain coded instructions to make molecules called **proteins**. Humans have thousands of different proteins. Each protein plays a different role. In fact, proteins organize all the other molecules in the human body. They help build cell structures and cells. You could say that genes carry the instructions to make proteins, which determine the traits of an individual.

An organism receives one set of chromosomes from its mother and one set from its father. So it ends up with two copies of every gene, one from each parent. But how does the organism choose which genetic information to use? Well, it doesn't. Mendel's great insight was that an organism's genetic information (its **genotype**), received from its parents, follows an orderly predictable pattern to determine the organism's traits.

The discovery of chromosomes and genes provided a model that explains Mendel's observations. Watson and Crick's model of DNA helped describe how heredity works. Researchers are now working to understand heredity on a more individual level. Can gene sequences be modified? Can inherited conditions be prevented? You will learn more about these developments at the end of the course.