6.3: Chromosomes and Genes

Identical Twins, Identical Genes

You probably can tell by their close resemblance that these two individuals are identical twins. Identical twins develop from the same fertilized egg, so they inherit copies of the same chromosomes and have all the same genes. Unless you have an identical twin, no one else in the world has exactly the same genes as you. What are genes? How are they related to chromosomes? And how do genes make you the person you are?

Figure 1: (CC BY 2.0; Christopher Michel via Wikimedia Commons)
Chromosomes are coiled structures made of DNA and proteins. Chromosomes are encoded with genetic instructions for making proteins. These instructions are organized into units called genes. Most genes contain the instructions for a single protein. There may be hundreds or even thousands of genes on a single chromosome.

**Human Chromosomes**

Each species is characterized by a set number of chromosomes. The human number is 23. Human cells normally have two sets of chromosomes in each of their cells, one set inherited from each parent. There are 23 chromosomes in each set, for a total of 46 chromosomes per cell. Each chromosome in one set is matched by a chromosome of the same type in the other set, so there are actually 23 pairs of chromosomes per cell. Each pair consists of chromosomes of the same size and shape, and they also contain the same genes. The chromosomes in a pair are known as homologous chromosomes. As see in the figure below, there are two types of chromosomes, autosomal and sex chromosomes. Read more about this in the genetics chapter.

Figure: All human cells (except gametes, which are sperm and egg cells) have the 23 pairs of chromosomes shown here. There are two types of chromosomes, autosomal (pairs 1-22) and sex (23rd pair). The stripes on the chromosomes represent genes. (Public domain; National Human Genome Research Institute via Wikimedia.org)

**Human Genes**

Humans have an estimated 20,000 to 22,000 genes. This may sound like a lot, but it really isn’t. Far simpler species have almost as many genes as humans. However, human cells use splicing and other processes to make multiple proteins from the instructions encoded in a single gene. Only about 25 percent of the nitrogen base pairs of DNA in human chromosomes make up genes and their regulatory elements. Out of this 25 percent, only two percent code for...
genes. The functions of many of the other base pairs are still unclear.

The majority of human genes have two or more possible versions, called alleles. Differences in alleles account for the considerable genetic variation among people. In fact, most human genetic variation is the result of differences in individual DNA base pairs within alleles.

### Linkage

Genes that are located on the same chromosome are called **linked genes**. Linkage explains why certain characteristics are frequently inherited together. For example, genes for hair color and eye color are linked, so certain hair and eye colors tend to be inherited together, such as blonde hair with blue eyes and brown hair with brown eyes. Can you think of other human traits that seem to occur together? Do you think they might be controlled by linked genes?

Genes located on the sex chromosomes are called **sex-linked genes**. Most sex-linked genes are on the X chromosome because the Y chromosome has relatively few genes. Strictly speaking, genes on the X chromosome are **X-linked genes**, but the term sex-linked is often used to refer to them. The diagram below is called a linkage map. A linkage map shows the locations of specific genes on a chromosome. The linkage map below shows the locations of a few of the genes on the human X chromosome.

![Linkage Map for the Human X Chromosome](https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/06%3A_DNA_and...)

**Figure**: Linkage Map for the Human X Chromosome. This linkage map shows the locations of several genes on the X chromosome. Some of the genes code for normal proteins. Others code for abnormal proteins that lead to genetic disorders. (CC BY 3.0; Sam McCabe via [CK-12 Foundation](https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/06%3A_DNA_and...)
Summary

Chromosomes are coiled structures made of DNA and proteins. The instructions are organized into units called genes, most of which contain instructions for a single protein.

Each species is characterized by a set number of chromosomes. The normal chromosome complement of a human cell is 23 pairs of chromosomes. Of these, 22 pairs are autosomes, which contain genes for characteristics unrelated to sex. The other pair consists of sex chromosomes (XX in females, XY in males). Only the Y chromosome contains genes that determine sex.

Humans have an estimated 20,000 to 22,000 genes. The majority of human genes have two or more possible versions, called alleles.

Genes that are located on the same chromosome are called linked genes. Linkage explains why certain characteristics are frequently inherited together. A linkage map shows the locations of specific genes on a chromosome.

Review

1. What are chromosomes and genes, and how are the two related?
2. Describe human chromosomes and genes.
3. Explain the difference between autosomes and sex chromosomes.
4. What are linked genes, and what does a linkage map show?
5. Explain why females are considered the default sex in humans.

6. True or False. Humans have 46 pairs of chromosomes.

7. True or False. Autosomes refer to any chromosome other than sex chromosomes.

8. True or False. The majority of human DNA does not encode for proteins.

9. Explain the relationship between genes and alleles.

10. Put the following in order of size, from smallest to largest:
    
    chromosome; gene; base pair

11. Sex-linked genes are usually found on which chromosome? Explain why these genes are called sex-linked.

12. Which of the following are considered homologous chromosomes?

   A. Chromosome 22 and the X chromosome
   
   B. The two copies of chromosome 22 that make up a pair
   
   C. All of the chromosomes in a skin cell and all of the chromosomes in a muscle cell
   
   D. Chromosomes 21 and 22

13. What is the one chromosome that is different between genetic males and females? Explain your answer.

14. Most males and females have two sex chromosomes. Explain why then, do only females have Barr bodies.

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Explore More

https://bio.libretexts.org/link?16748#Explore_More

Watch the video below to learn about noncoding DNA.

https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/06%3A_DNA_and...
Watch the video below to learn about sex chromosomal disorders, such as Turner syndrome.
Media, iframe, embed and object tags are not supported inside of a PDF.