LESSON 2

From Generation to Generation

HEALTH TERMS

chromosomes

genes

amniocentesis

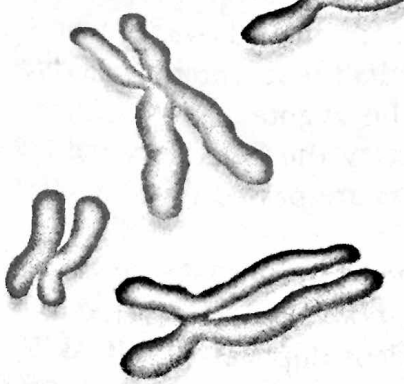
ultrasound

chorionic villi sampling

HEALTH CONCEPTS

- Heredity is the passing on of traits from parents to offspring.
- Some traits passed along from parents lead to the development of genetic disorders.
- Tests for the presence of genetic disorders can be performed on the mother-to-be.

What color eyes do you have? What color is your hair? Would you describe yourself as tall, short, or medium compared with other people your age? These and related questions are determined by heredity, the passing on of traits from parents to offspring.



Chromosome pairs, magnified

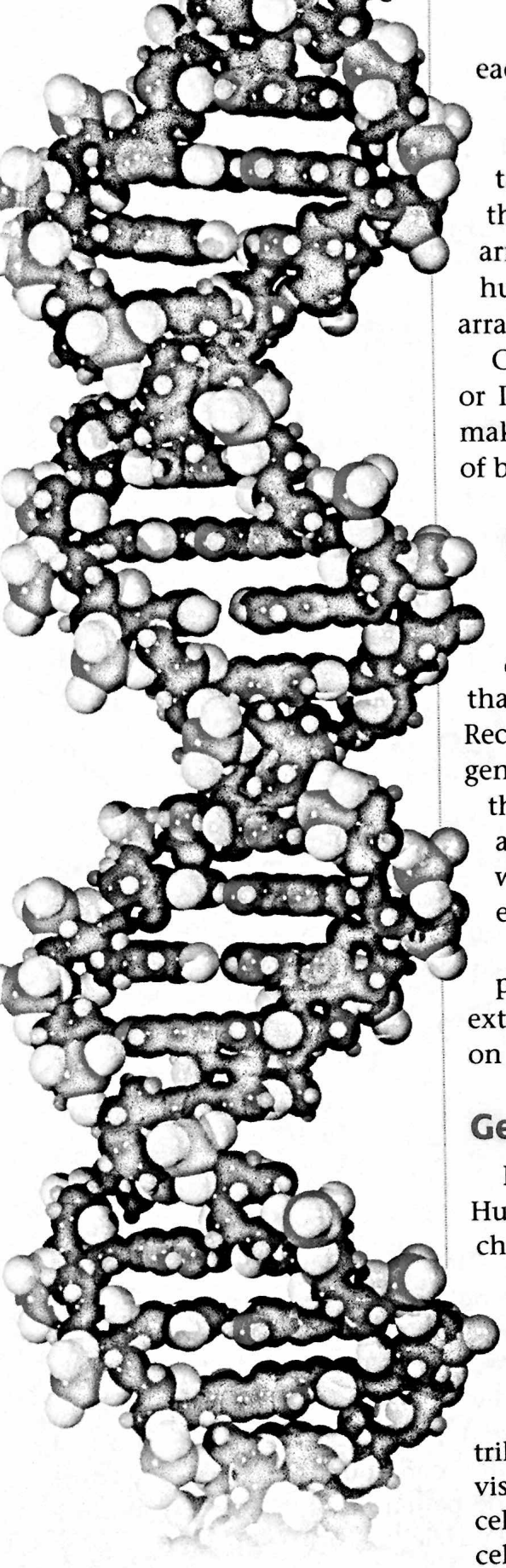
Chromosomes

Heredity is determined by **chromosomes**, *tiny structures within the nuclei of cells that carry information about hereditary traits.* Most cells in the body contain 46 chromosomes—23 pairs each.

At the foundation of chromosomes is the chemical compound *deoxyribonucleic acid,* or *DNA.* All living things are made of DNA. The DNA molecule resembles a twisted ladder, or helix, the rungs of which are made up of more chemical compounds, called *bases.* There are four kinds of bases that can be paired only in certain combinations, much like pieces of a jigsaw puzzle.

Genes

Specific information about hereditary traits are carried within sections of chromosomes called *genes.* **Genes** are *segments of DNA molecules* and, like chromosomes, are paired. A pair of genes—one from



All living cells contain the genetic material DNA.

ACTIVITY **Give an example of a physical trait determined by dominant genes.**

each parent—contributes to a single genetic trait such as hair color or hair straightness.

You have thousands of genes in every cell, and they each contain the same four bases. The variation among genes—which is the reason no two people are exactly alike—is a result of the arrangement of the bases along the DNA molecule. Because several hundred pairs of bases are in each gene, a countless number of arrangements is possible.

Cells make proteins when they interpret the order of these bases, or DNA code. Proteins help build and maintain body tissues. Cells make different proteins when they interpret different arrangements of bases. Different kinds of proteins will result in individual traits.

Dominant and Recessive Genes

As the chromosomes divide and separate, the two genes for a particular trait line up next to each other. Some genes will be *dominant,* while others will be *recessive.* Dominant genes are genes that generally show up in the offspring whenever they are present. Recessive genes are genes that usually show up only when dominant genes are not present. Suppose, for example, one parent has one of the genes that contributes to brown eyes (B), which is dominant, and the other parent has a gene that contributes to blue eyes (b), which is recessive. The likelihood that their child will have brown eyes is greater than that of his or her having blue eyes.

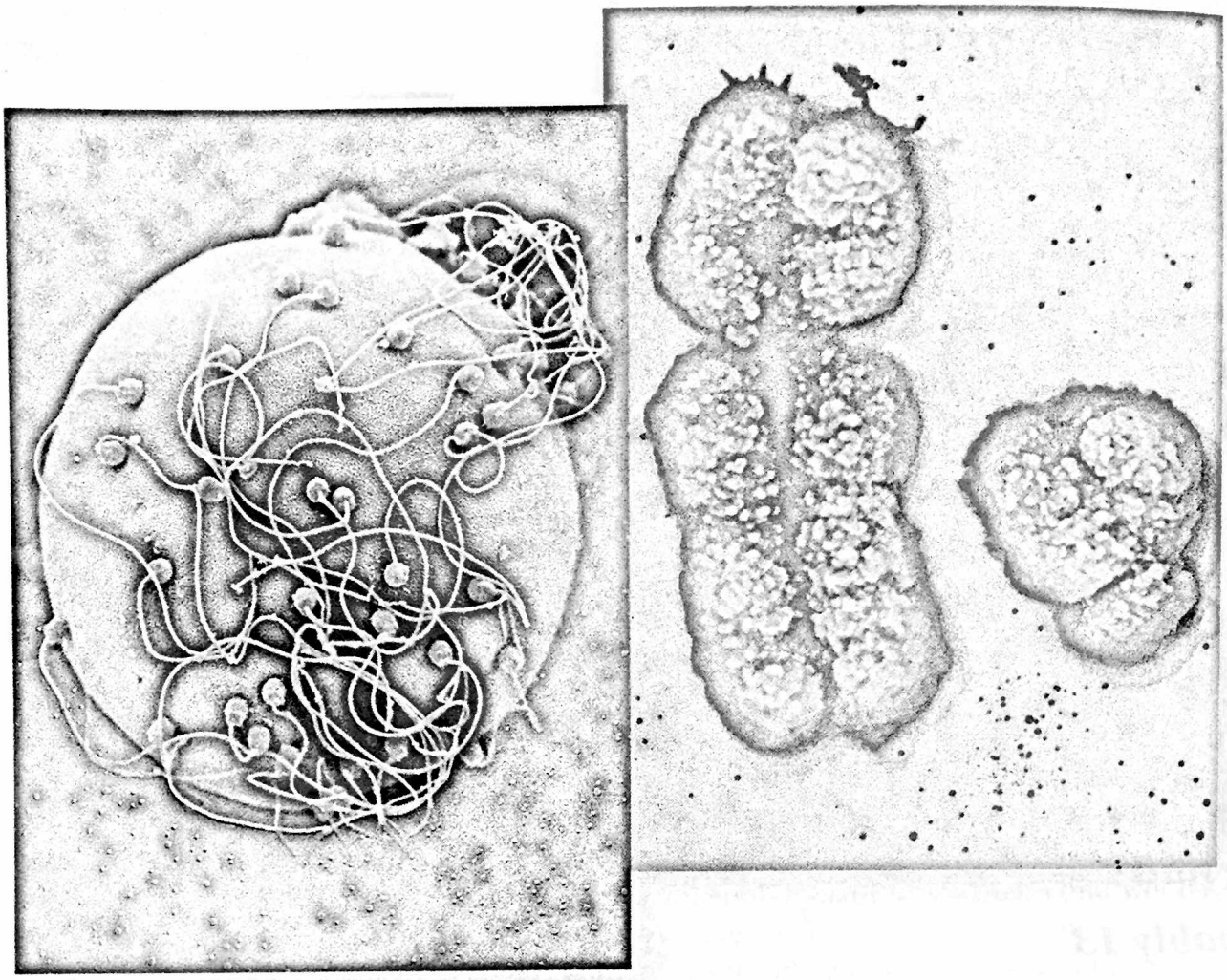
In actuality, the situation is slightly more complex than in the previous example. That is because traits that express a quantity or extent—such as height, weight, or degree of color—usually depend on many gene pairs, not just one.

Genes and Gender

Every living organism has a certain number of chromosomes. Human body cells, with the exception of sperm and ova, contain 46 chromosomes each. Ova and sperm have half that amount—23 chromosomes each. After fertilization, the zygote has 46 chromosomes (23 from each parent) that carry the hereditary traits of the mother and the father. The traits are passed on to another generation.

As you have learned, the zygote divides, eventually producing trillions of cells that make up the human body. Between each cell division, each chromosome in the cell nucleus duplicates itself. As the cell divides, the two sets of 46 chromosomes separate and each new cell contains one set of 46 chromosomes, identical to those in the first cell. This process continues throughout life.

Of the 46 chromosomes in a zygote, two are specialized sex chromosomes. In females, these two chromosomes look exactly alike and are called *X* chromosomes. In males, one chromosome is shorter and does not match the other. This shorter one is the *Y* chromosome. The longer one is the *X* chromosome.



Left: Only one sperm cell will penetrate the ovum for fertilization. Right: Human X and Y chromosomes determine gender.

Remember that sperm and ova contain only half the number of chromosomes as other cells. This means that these cells contain only one sex chromosome, not two. Sperm may contain either an *X* or a *Y* chromosome. The ovum can have only an *X* chromosome. If an ovum is fertilized with a like chromosome, the combination is *XX*, resulting in a girl. If the sperm is carrying a *Y* chromosome, the pairing forms an *XY* combination, resulting in a boy. Thus, the determination of the gender of a child is based on which type of sperm finds the egg, an *X* or a *Y*.

Genetic Disorders

Sometimes the genes children inherit contain mutations, or abnormalities, in the genetic code. The resulting health problems and diseases, which can be severe, are known as *genetic disorders*. Some genetic disorders are observable at birth—in the form of birth defects such as cleft lip and cleft palate—whereas others tend to show up in childhood or adult life. In addition to a genetic cause, some disorders may also be affected by environmental factors, such as the lifestyle habits of one or both parents. There is an especially high rate of birth defects among children born to teenage girls, largely due to ignorance about proper prenatal care.

Types of Genetic Disorders

There are more than 4,000 hereditary disorders. A number of these disorders are recessive—caused by two defective genes, one from each parent. Others result from chromosomal abnormalities. The following are among the more common genetic disorders:

- **Sickle cell anemia.** This disease occurs when a child inherits the hemoglobin "Hbs" gene from both parents. The red blood cells develop a sickle shape and clump together, obstructing blood

update

Looking at the Issues

Genetic Testing, Genetic Discrimination?

In the past few years, researchers have begun to link specific genes or gene mutations with various diseases. Soon, access to even a tiny sample of a person's DNA will enable trained professionals to run a battery of genetic tests. As the number of genetic tests—and of people tested—increases, a great many legal and ethical questions are being raised. Perhaps the most troubling is the question of how these test results will be used and whether or not they may lead to certain kinds of discrimination, for example, in trying to get a job or health insurance.

ANALYZING DIFFERENT VIEWPOINTS

Viewpoint One

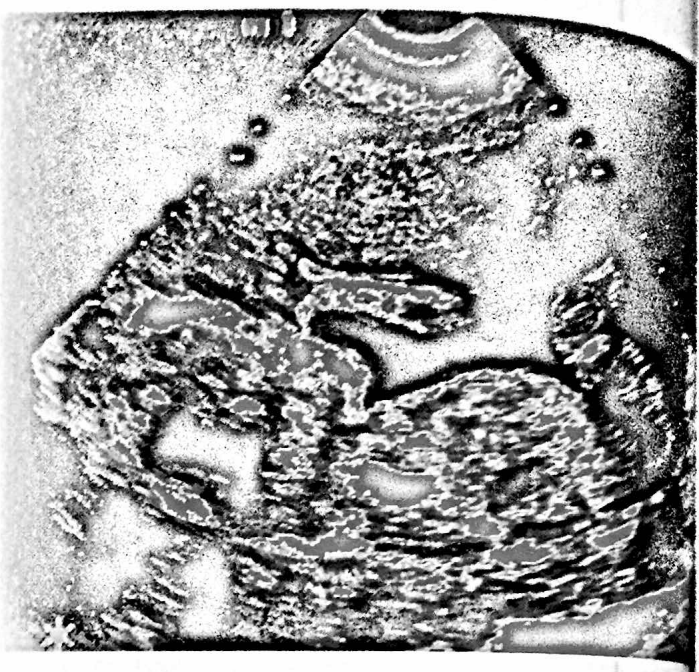
Those who favor genetic testing say that having the knowledge of whether a gene has been carried on can better prepare people for the future. Results of genetic tests, they add, can help decrease the risk of developing certain diseases, such as breast, ovarian, or colon cancer. Frequent screenings or even preventive surgeries can increase the potential for longer lives.

Viewpoint Two

Critics of genetic testing say that having such test results only adds to a person's fear. They point out that just because a person is genetically predisposed to a disease such as cancer doesn't mean that the person will necessarily develop it. They also point out that people who undergo genetic testing are at great risk of being discriminated against both by insurance companies, who won't insure people at risk for these diseases, and by employers, who may not want to hire those at increased risk because of large medical bills and lost productivity.

EXPLORING YOUR VIEWS

1. If there were a test that could alert you to the possibility of developing a life-threatening illness later in life, would you want to be tested? Why or why not?
2. Do you think genetic test information should be released only with a person's consent? Why or why not?



Ultrasound images allow doctors to see an image of the fetus.

ACTIVITY ***Identify the head and hand in this ultrasound image.***

flow and oxygen to the tissues. The symptoms of sickle cell anemia are severe joint and abdominal pain, weakness, and kidney disease.

- **Phenylketonuria.** In Phenylketonuria (FEE-nuhl-kee-toh-NOOR-ee-uh)—or *PKU*—a protein called *phenylalanine* accumulates in the body, interfering with the development of brain cells and causing mental retardation. In many states, babies are screened at birth for PKU by a blood test. If results are positive, treatment can begin before mental retardation sets in. Diet can stop the retardation from happening.
- **Tay-Sachs disease.** Tay-Sachs disease affects 1 in 3,600 Americans of Eastern European Jewish ancestry. Tay-Sachs disease causes the destruction of the nervous system, blindness, paralysis, and death during early childhood. A blood test can detect carriers, and a test can diagnose the disease prenatally.
- **Cystic fibrosis.** One in every 2,000 infants is born with cystic fibrosis. The disease, which makes breathing and digestion difficult, is caused by two abnormal genes, one coming from each parent. If both parents are carriers, their offspring have a 25 percent chance of having the disease.
- **Down syndrome.** Down syndrome is primarily caused by a chromosomal abnormality known as *trisomy-21,* the presence of three copies of the twenty-first chromosome. As a result, the affected individual has an extra forty-seventh chromosome in all body cells. Down syndrome affects approximately 1 in 700 births, but the risk varies with the mother's age. By the time a woman reaches 40, the chances are about 1 in 40 that her child will be affected by Down syndrome. Children with Down syndrome share certain characteristics such as mental retardation, which can range from severe to moderate.

HEALTH Online

What do genetic counselors do? What educational background do they have? Find the answers to these questions at **health.glencoe.com**. Compile information presented into a career profile for students interested in genetic counseling.

Identifying Genetic Disorders

There are several methods used to investigate the health of the fetus. These include the following:

- **Amniocentesis.** **Amniocentesis** (am-nee-oh-sen-TEE-sis) is *a procedure in which a syringe is inserted through the pregnant female's abdominal wall into the amniotic fluid surrounding the developing fetus.* The physician removes a small amount of the fluid to

examine the chromosomes, study the body chemistry, and determine the sex of the fetus. Amniocentesis is performed usually 16 to 20 weeks after fertilization.

- **Ultrasound.** **Ultrasound** is *a test in which sound waves are used to project light images on a screen.* The sound waves are directed at the pregnant female's abdomen and reflected onto a screen. The reflected waves act like an echo and form an image of the fetus. Ultrasound is used to determine the position of a fetus, and if there is more than one fetus in the uterus.
- **Chorionic villi sampling.** Also known as *CVS,* **chorionic villi** (kor-ee-ON-ik VIL-eye) **sampling** is *a test in which a small piece of membrane is removed from the chorion, a layer of tissue that develops into the placenta.* This material is examined for possible genetic defects. The procedure takes place around the eighth week of fetal development, so it is a procedure that can be done earlier than amniocentesis.

Genetic Counseling

Knowledge about genetically related diseases and about new research for diagnosing, preventing, and treating them has produced a wide variety of programs to deal with genetic disorders and birth defects. One way to help prevent genetically caused birth defects is to identify carriers. Genetic counselors can advise families about the probability of having a child with a genetically related disease. They also can guide families of children with genetic disorders about possible treatment options.