

FIGURE 27.7 Differentiation of Sexual Characteristics

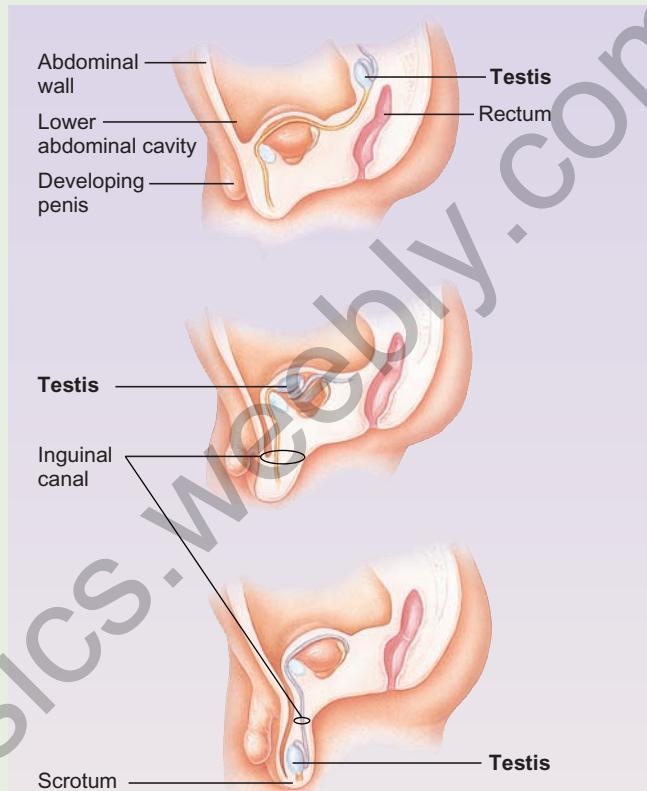
The early embryo grows without showing any sexual characteristics. The male and female sexual organs eventually develop from a common basic structure. (a) Shows the development of the internal anatomy. (b) Shows the development of the external anatomy.

OUTLOOKS 27.1

Cryptorchidism—Hidden Testes

At about the seventh month of pregnancy (gestation), in normal males each testis moves from a position in the abdominal cavity to an external sac, called the scrotum. The testes pass through an opening called the **inguinal canal**. This canal closes off but continues to be a weak area in the abdominal wall, and it may rupture later in life. This can happen when strain (for example, from improperly lifting heavy objects) causes a portion of the intestine to push through the inguinal canal into the scrotum, a condition known as an inguinal hernia.

Occasionally, the testes do not descend, resulting in a condition known as **cryptorchidism** (*crypt* = hidden; *orchid* = testes). Sometimes, the descent occurs normally during puberty; if not, there is a 25 to 50 times increased risk for testicular cancer. Because of this increased risk, surgery can be done to allow the undescended testes to be moved into the scrotum. Sterility will result if the testes remain in the abdomen. This happens because normal sperm cell development cannot occur in a very warm environment. The temperature in the abdomen is higher than the temperature in the scrotum. Normally, the temperature of the testes is very carefully regulated by muscles that control their distance from the body. Physicians have even diagnosed cases of male infertility as being caused by tight-fitting pants that hold the testes so close to the body that the temperature increase interferes with normal sperm development. Recent evidence has also suggested that teenage boys and young men working with computers in the laptop position for extended periods may also be at risk for lowered sperm counts.



27.4 CONCEPT REVIEW

- Describe the processes that cause about 50% of babies to be born male and 50% to be born female.
- Name two developmental abnormalities associated with nondisjunction of chromosomes.
- When in embryological development does sexual differentiation begin?
- What triggers sexual differentiation in embryos?

27.5 The Sexual Maturation of Young Adults

Following birth, sexuality plays only a small part in physical development for several years. However culture and environment shape the responses that the individual will come to recognize as normal behavior for his or her age. **Puberty** is the developmental period when the body changes to the adult

form and becomes able to reproduce. During puberty, which begins at about 10 years of age in females and about 12 years of age in males, an increased production of sex hormones causes major changes as the individual reaches sexual maturity. These changes are generally completed by 15–18 years of age.

The Maturation of Females

Girls typically begin to produce sex hormones from several glands, marking the onset of puberty. The hypothalamus, pituitary gland, ovaries, and adrenal glands begin to produce sex hormones at 9 to 12 years of age (figure 27.8). Table 27.1 lists the principal hormones involved in human reproduction.

The hypothalamus is a portion of the brain that controls the functioning of many glands throughout the body, including the **pituitary gland**. At puberty, the hypothalamus begins to release **gonadotropin-releasing hormone (GnRH)**, which stimulates the pituitary to release **luteinizing hormone (LH)** and **follicle-stimulating hormone (FSH)**. Increased levels of FSH stimulate the development of **follicles**, saclike structures that produce eggs in the ovaries. The increased luteinizing

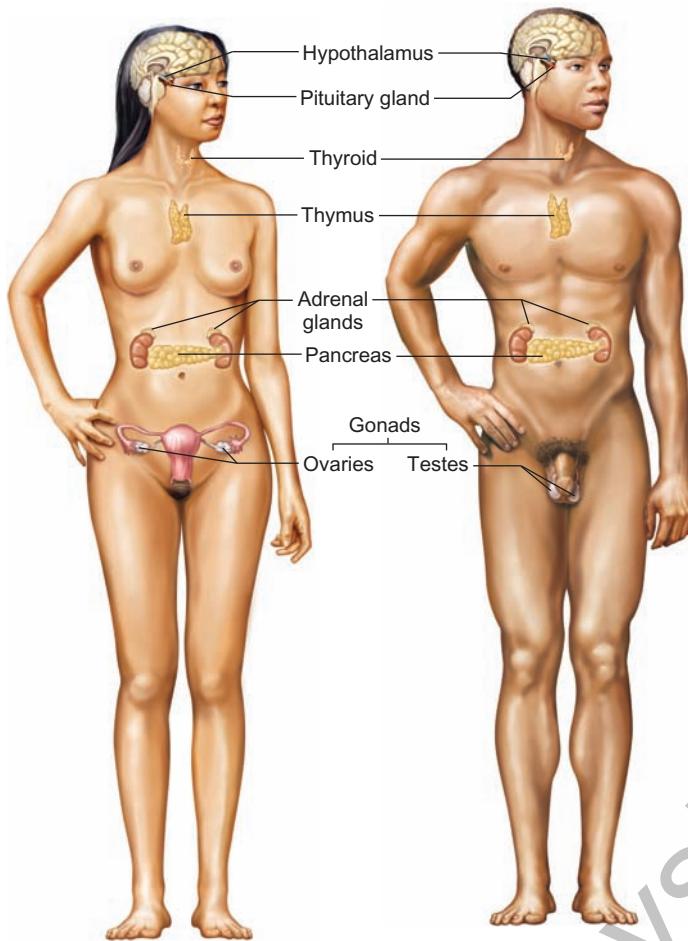


FIGURE 27.8 Hormones and Sexual Function

The hypothalamus, pituitary gland, adrenal gland, and ovaries and testes are the primary hormone-producing glands that affect sexual development and behavior.

hormone stimulates the ovary to produce larger quantities of estrogens. The increasing supply of estrogens is responsible for the many changes in sexual development. These changes include breast growth, changes in the walls of the uterus and vagina, changes in the pelvic bone structure, and increased blood supply to the **clitoris**, a small, elongated erectile structure located at the head of the labia; it develops from the same embryonic tissue as the male penis. Estrogens also stimulate the female adrenal gland to produce **androgens**, male sex hormones. The androgens are responsible for the production of pubic hair, and they seem to have an influence on the female sex drive.

The features that are not primarily involved in sexual reproduction but are characteristic of a sex are called **secondary sexual characteristics**. In women, breast development, the distribution of body hair, the patterns of fat deposits, wider hips, and a higher voice are secondary sexual characteristics.

Major developments during this time are **ovulation**, the release of eggs from the ovary, and the establishment of the **menstrual cycle**, the periodic growth and shedding of the lining

of the uterus. These changes are under the control of a number of hormones produced by the pituitary gland and ovaries.

Initially, as girls go through puberty, menstruation and ovulation may be irregular; however, in most women hormone production eventually becomes regulated, so that ovulation and menstruation take place on a monthly basis, although normal cycles vary from 21 to 45 days.

As girls progress through puberty, curiosity about their changing body form and new feelings lead to self-investigation. Studies have shown that sexual activity, such as stimulation of the clitoris, vagina, or anus, which causes a pleasurable sensation, orgasm, is performed by a large percentage of young women. This stimulation is termed **masturbation**, and it is a normal part of sexual development.

The Maturation of Males

Males typically reach puberty about 2 years later than females, but puberty in males also begins with a change in hormone levels. At puberty, the hypothalamus releases increased amounts of gonadotropin-releasing hormone (GnRH), resulting in increased levels of follicle-stimulating hormone (FSH) and luteinizing hormone (LH). These are the same changes that occur in female development. Luteinizing hormone is often called interstitial cell-stimulating hormone (ICSH) in males. LH stimulates the testes to produce testosterone, the primary sex hormone in males. The testosterone produced by the embryonic testes causes the differentiation of internal and external genital anatomy in the male embryo. At puberty, the increase in testosterone is responsible for the development of male secondary sexual characteristics and is important in the maturation and production of sperm.

The major changes during puberty include growth of the testes and scrotum, pubic hair development, and increased penis size. Secondary sex characteristics also begin to become apparent; facial hair, underarm hair, and chest hair are some of the most obvious. The male voice changes as the larynx (voice box) begins to change shape. Body contours also change, and a growth spurt increases height. In addition, the proportion of the body that is muscle increases and the proportion of body fat decreases. At this time, a boy's body begins to take on the characteristic adult male shape, with broader shoulders and heavier muscles.

In addition to these external changes, increased testosterone causes the production of **semen**, also known as **seminal fluid**, a mixture of sperm and secretions from three **accessory glands**—the *seminal vesicles*, *prostate*, and *bulbourethral glands*. They produce secretions that nourish and activate the sperm. Semen also lubricates the reproductive tract and acts as the vehicle to help carry the sperm.

Seminal vesicles secrete an alkaline fluid, containing fructose, and hormones. Its alkaline nature helps neutralize the acidic environment in the female reproductive tract, improving the sperm's chances of reaching the egg. The fructose provides energy for the sperm. Seminal vesicle secretions make up about 60% of the seminal fluid. The prostate gland

TABLE 27.1 Human Reproductive Hormones

| Hormone | Production Site | Target Organ | Function |
|--|--------------------------|--------------------|---|
| Prolactin, lactogenic, or luteotropic hormone | Anterior pituitary | Breast, ovaries | Stimulates milk production; also helps maintain normal ovarian cycle |
| Follicle-stimulating hormone (FSH) | Anterior pituitary | Ovaries, testes | Stimulates ovary and testis development; stimulates egg production in females and sperm production in males |
| Luteinizing hormone (LH) or interstitial cell-stimulating hormone (ICSH) | Anterior pituitary | Ovaries, testes | Stimulates ovulation in females and sex-hormone (estrogen and testosterone) production in both males and females |
| Estrogen | Ovaries | Entire body | Stimulates the development of the female reproductive tract and secondary sexual characteristics |
| Testosterone | Testes | Entire body | Stimulates the development of the male reproductive tract and secondary sexual characteristics |
| Progesterone | Corpus luteum of ovaries | Uterus, breasts | Causes uterine wall thickening and maturation; maintains pregnancy; contributes to milk production |
| Oxytocin | Posterior pituitary | Uterus, breasts | Causes the uterus to contract and breasts to release milk |
| Androgens | Testes, adrenal glands | Entire body | Stimulates the development of the male reproductive tract and secondary sexual characteristics in males and females |
| Gonadotropin-releasing hormone (GnRH) | Hypothalamus | Anterior pituitary | Stimulates the release of FSH and LH from the anterior pituitary |
| Human chorionic gonadotropin | Placenta | Corpus luteum | Maintains the corpus luteum, so that it continues to secrete progesterone and maintains pregnancy |

produces a thin, milky fluid, which makes up about 25% of semen. It contains sperm-activating enzymes. Bulbourethral gland secretions make up the remaining 15%; they, too, are alkaline.

FSH stimulates the production of sperm cells. The release of sperm cells and seminal fluid, ejaculation, begins during puberty. This release is generally accompanied by a pleasurable sensation, orgasm. During sleep, males frequently have erections, sometimes resulting in ejaculation of seminal fluid. This is termed a *wet dream*. It is normal and related to the amount of seminal fluid produced. Wet dreams occur less often in men who engage in frequent sexual intercourse or masturbation. Masturbation is a common and normal activity as a boy goes through puberty. Studies of adult sexual behavior have shown that nearly all men masturbate at some time during their lives.

27.5 CONCEPT REVIEW

- What are the effects of the secretions of the pituitary, the gonads, and the adrenal glands at puberty in females?
- What role does testosterone play in male sexual maturation?

27.6 Spermatogenesis

The process of producing gametes is called **gametogenesis**. It includes meiosis and other processes involved in producing mature sex cells. **Spermatogenesis** is gametogenesis that takes place in the testes of males, producing sperm (figure 27.9). The two, olive-shaped testes are composed of many small, sperm-producing tubes, called **seminiferous tubules**. The seminiferous tubules empty into collecting ducts that eventually empty into the epididymis—a long, narrow, twisted tube in which sperm cells are stored and mature before ejaculation. The testes and their associated ducts are held together by a thin covering membrane (figure 27.10). Leading from the epididymis is the vas deferens, or sperm duct; this empties into the urethra, which conducts the sperm out of the body through the penis (figure 27.11).

Before puberty, the seminiferous tubules are packed solid with diploid cells. These cells, which are found just inside the tubule wall, undergo *mitosis*, thus providing a continuous supply of cells. Beginning at puberty, some of these cells specialize and begin the process of *meiosis*, whereas others continue to divide by mitosis. Spermatogenesis needs to occur below body temperature, which is why the testicles are in a sac, the scrotum, outside the body cavity. Once spermatogenesis begins, the seminiferous tubules become hollow and can transport the mature sperm.

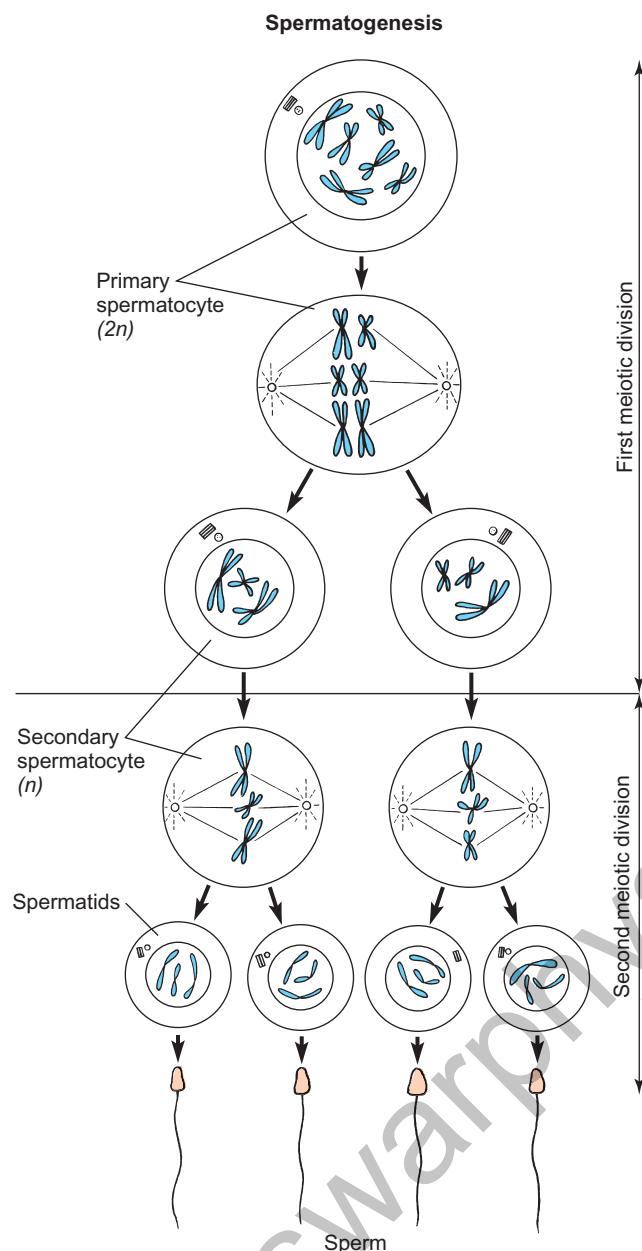


FIGURE 27.9 Spermatogenesis

This diagram illustrates the process of spermatogenesis in human males. Not all of the 46 chromosomes are shown. Carefully follow the chromosomes as they segregate, recalling the details of the process of meiosis.

Spermatogenesis consists of several steps. It begins when some of the cells in the walls of the seminiferous tubules differentiate and enlarge. These diploid cells undergo the first meiotic division, which produces two haploid cells. These cells go through the second meiotic division, resulting in four haploid cells called spermatids. Spermatids then lose much of their cytoplasm, develop long tails, and mature into sperm. Sperm have only a small amount of food reserves. Therefore, once they are released and become active swimmers, they live

no more than 72 hours. However, if the sperm are placed in a protective solution, the temperature can be lowered drastically to -196°C . Under these conditions, the sperm become deactivated, freeze, and can survive for years outside the testes. This has led to the development of sperm banks. The artificial insemination (placing stored sperm into the reproductive tract of a female) of cattle, horses, and other domesticated animals with sperm from sperm banks is a common breeding practice. This technique is also used in humans who experience infertility.

Spermatogenesis takes place continuously throughout a male's reproductive life, although the number of sperm produced decreases as a man ages. A healthy male releases about 150 million sperm per milliliter with each ejaculation. A man must be able to release at least 100 million sperm per milliliter to be fertile. Sperm counts can be taken and used to determine the probability of successful fertilization. Many men with sperm counts under 50 million per milliliter are infertile; those with sperm counts below 20 million per milliliter are clinically infertile. These vast numbers of sperm are necessary because so many die during their journey. Large numbers are needed in order for the few survivors to reach the egg. In addition, each sperm contains enzymes in its cap that are able to digest through the mucus and protein found in the female reproductive tract. Millions of sperm contribute in this way to the process of fertilization, but only one fertilizes the egg.

27.6 CONCEPT REVIEW

13. What structures are associated with the human male reproductive system? What are their functions?
14. How is meiosis involved in spermatogenesis?

27.7 Oogenesis, Ovulation, and Menstruation

Oogenesis is the production of egg cells. This process starts before a girl is born, during prenatal development of the ovaries. This occurs when diploid cells in each ovary cease dividing by mitosis and enlarge in preparation to divide by meiosis. These are the potential egg cells. All of these cells form in the embryonic ovaries before a female is born. At birth, they number approximately 2 million, but that number has been reduced by cell death to between 300,000 and 400,000 cells by puberty. These cells stop their development in an early stage of meiosis and remain in the ovary inside a follicle.

At puberty and on a regular monthly basis thereafter, the sex hormones stimulate one of these cells to continue meiosis. However, in telophase I, the two cells that form receive unequal portions of cytoplasm, a kind of lopsided division

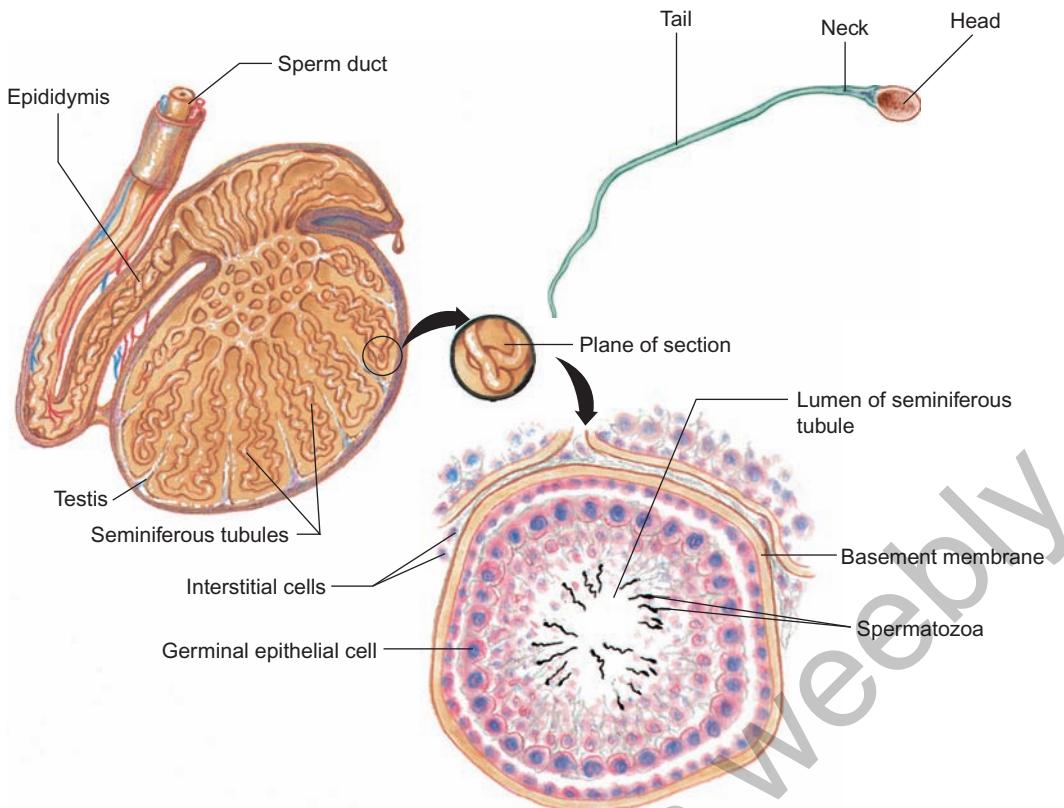


FIGURE 27.10 Sperm Production

The testis consists of many tiny tubes called seminiferous tubules. The walls of the tubes consist of cells that continually divide, producing large numbers of sperm. The sperm leave the seminiferous tubules and enter the epididymis, where they are stored prior to ejaculation through the sperm duct. Sperm cells have a head region, with an enzyme-containing cap and the DNA. They also have a neck region, with ATP-generating mitochondria, and a tail flagellum, which propels the sperm.

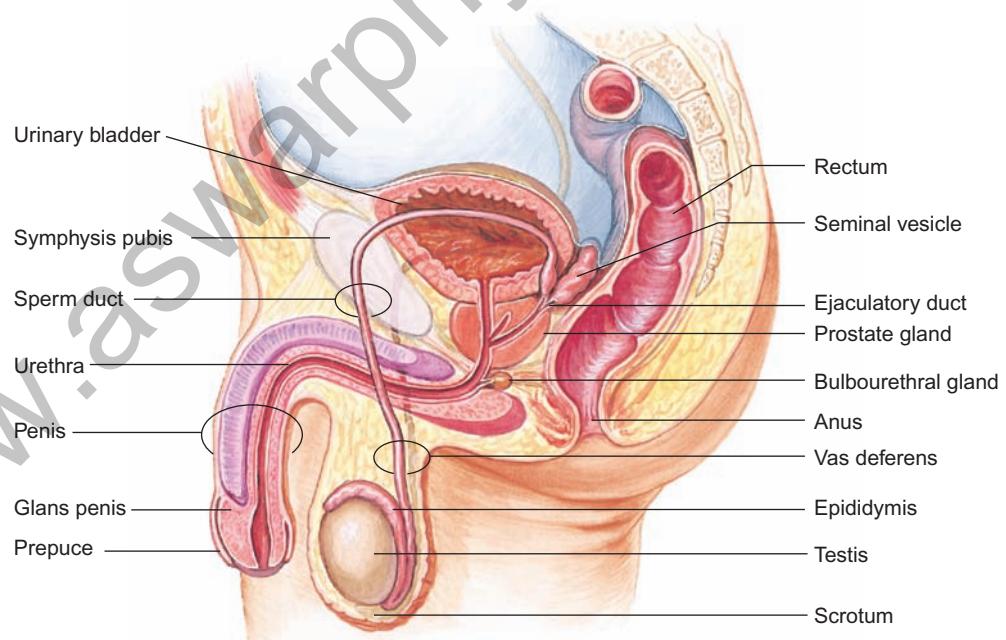


FIGURE 27.11 The Human Male Reproductive System

The male reproductive system consists of two testes, which produce sperm; ducts, which carry the sperm; and various glands. Muscular contractions propel the sperm through the vas deferens past the seminal vesicles, prostate gland, and bulbourethral gland, where most of the liquid of the semen is added. The semen passes through the urethra of the penis to the outside of the body.

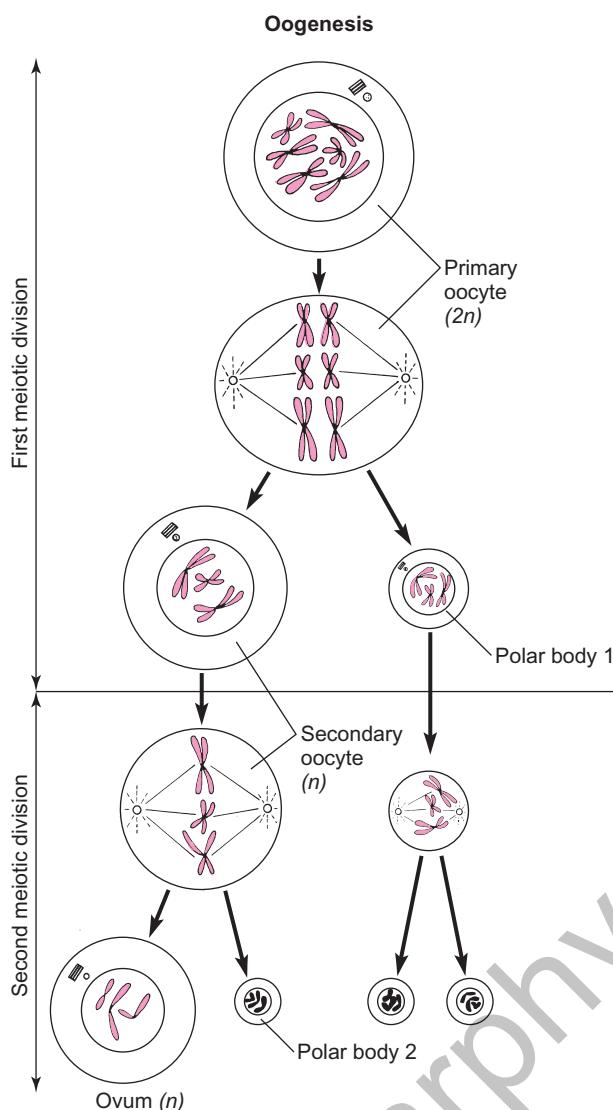


FIGURE 27.12 Oogenesis

This diagram illustrates the process of oogenesis in human females. Not all of the 46 chromosomes are shown. Carefully follow the chromosomes as they segregate, recalling the details of the process of meiosis.

(figure 27.12). The smaller of the two cells is called a **polar body**, and the larger haploid cell is commonly referred to as an **egg** or **ovum**, although technically it is not. Just prior to ovulation, the follicle of the soon-to-be-released egg grows and moves near the surface of the ovary. When this maturation is complete, ovulation occurs when the follicle ruptures and the egg is released. It is swept into the **oviduct** (fallopian tube) by ciliated cells and travels toward the uterus (figure 27.13). Because of the action of luteinizing hormone, the follicle from which the egg was ovulated develops into a glandlike structure, the **corpus luteum**. This gland produces hormones (progesterone and estrogen), which prevent the release of other eggs. If the egg is fertilized, it completes meiosis with the sperm DNA inside and the haploid egg and sperm

nuclei unite to form the zygote. If the egg is not fertilized, it passes through the vagina to the outside of the body during menstruation (figure 27.14).

One distinguishing characteristic between eggs and sperm is their relative age. In males, sperm production continues throughout the life span. Sperm do not remain in the tubes of the male reproductive system for very long; they are either released shortly after they form or they die and are harmlessly absorbed. In females, meiosis begins before birth, but the oogenesis process is not completed, and an egg cell is not released for many years. An egg released when a woman is 37 years old began meiosis 37 years earlier. During that time, the cell was exposed to many influences, a number of which may have damaged the DNA or interfered with the meiotic process. The increased risk for abnormal births in older mothers may be related to the age of their eggs. Damaged DNA in sperm is less likely to be a problem because new sperm are being produced daily.

Hormones control the cycle of changes in breast tissue, the ovaries, and the uterus. In particular, estrogen and progesterone stimulate milk production by the breasts and cause the uterine lining to become thicker and filled with blood vessels prior to ovulation. This ensures that, if fertilization occurs, the resultant embryo will be able to attach itself to the uterine wall and receive nourishment. If the cell is not fertilized, the lining of the uterus, known as the **endometrium**, is shed. This is known as **menstruation**, **menstrual flow**, the **menses**, or a **period**. Once the endometrium has been shed, it begins to build up again (figure 27.15).

The activities of the ovulatory cycle and the menstrual cycle are coordinated. During the first part of the menstrual cycle, increased amounts of FSH cause the follicle to increase in size. Simultaneously, the follicle secretes increased amounts of estrogen, which cause the uterine lining to thicken. When ovulation occurs, the remains of the follicle are converted into a corpus luteum by LH. The corpus luteum begins to secrete progesterone and the nature of the uterine lining changes as a result of the development of many additional blood vessels. This is organized so that, if an embryo arrives in the uterus shortly after ovulation, the uterine lining is prepared to accept it. If pregnancy does not occur, the corpus luteum degenerates, resulting in a reduction in the amount of progesterone needed to maintain the uterine lining, and it is shed. At the same time that hormones are regulating ovulation and the menstrual cycle, changes are taking place in the breasts. The same hormones that prepare the uterus to receive the embryo also prepare the breasts to produce milk. These changes in the breasts, however, are relatively minor unless pregnancy occurs.

27.7 CONCEPT REVIEW

15. What structures are associated with the human female reproductive system? What are their functions?
16. What are the differences between oogenesis and spermatogenesis in humans?

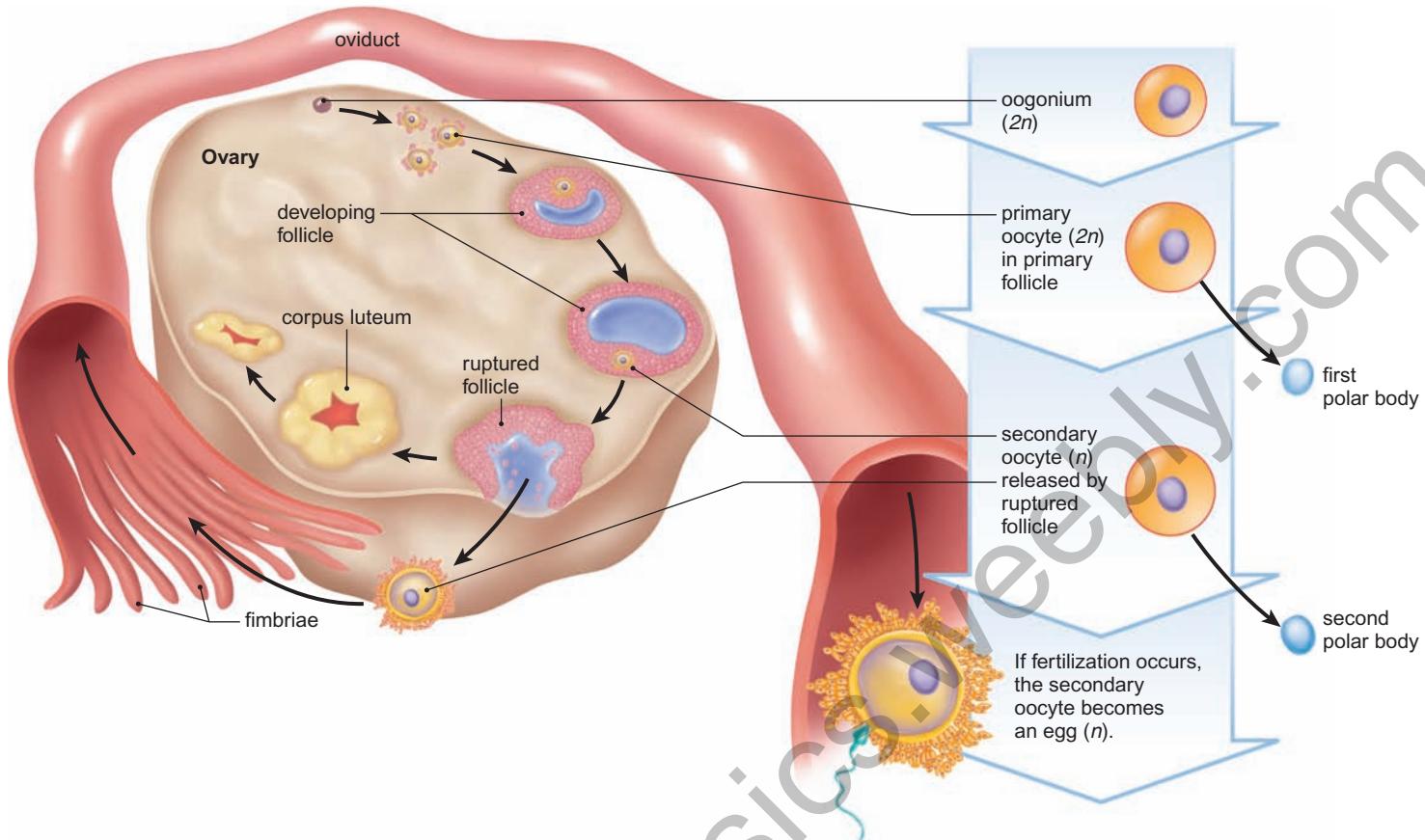


FIGURE 27.13 Ovarian Cycle and Ovulation

After puberty the ovary goes through a regular monthly cycle that involves growth of follicles, ovulation, and the development of a corpus luteum.

27.8 The Hormonal Control of Fertility

An understanding of how various hormones influence the menstrual cycle, ovulation, milk production, and sexual behavior has led to the medical use of certain hormones. Some women are unable to have children because they do not release eggs from their ovaries, or they release them at the wrong time (Outlooks 27.2). Physicians can regulate the release of eggs using certain hormones, commonly called *fertility drugs*. These hormones can be used to stimulate the release of eggs for capture and use in what is called *in vitro* fertilization (IVF), also called *test-tube* fertilization. The hormones can also be used to stimulate the release of eggs in women with irregular cycles to increase the probability of natural conception; that is, *in vivo* fertilization (*in-life* fertilization) (How Science Works 27.1).

The use of these techniques often results in multiple embryos being implanted in the uterus. This is likely to occur because the drugs may cause too many eggs to be released at one time. In the case of *in vitro* fertilization, because there is a high rate of failure and the process is expensive, typically several early-stage embryos are inserted into the uterus to increase the likelihood that one will implant. If several are successful, multiple embryos implant. The implantation of multiple embryos makes it difficult for one embryo to develop properly and be carried through the entire

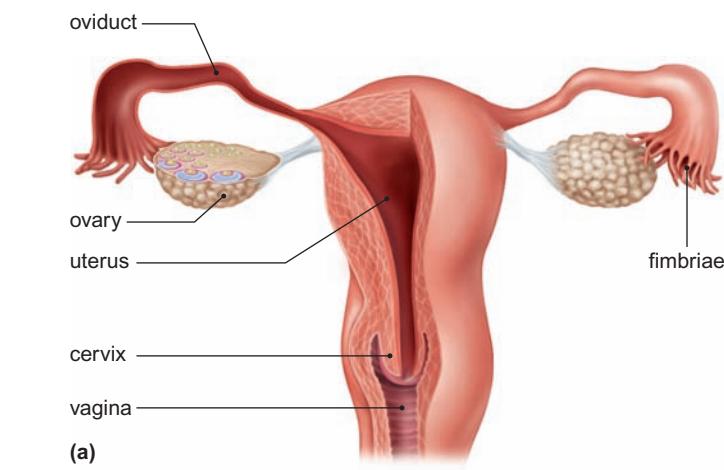
nine-month pregnancy. When scientists understand the action of hormones better, they may be able to control the effects of fertility drugs and eliminate the problem of multiple implantations.

Another medical use of hormones is the control of conception with birth-control pills—oral contraceptives. Birth-control pills have the opposite effect of fertility drugs. They raise the levels of estrogen and progesterone, which slows the production of FSH and LH, preventing the release of eggs from the ovaries. They can also help relieve premenstrual syndrome (PMS), which causes irritability, emotional instability, depression, headache, and other aches and pains.

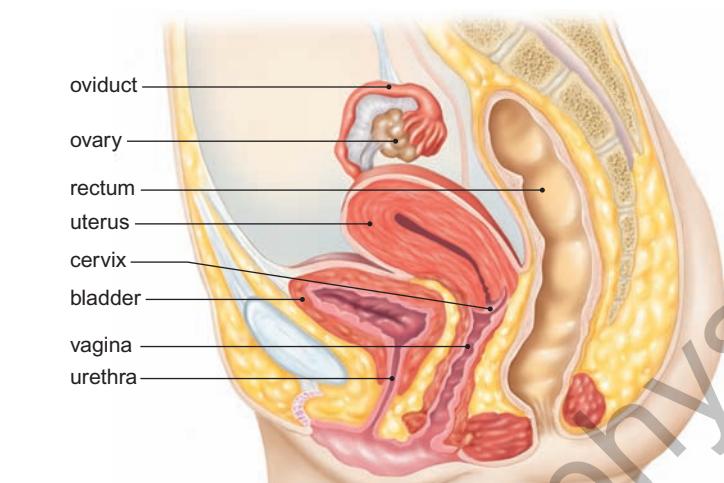
The hormonal control of fertility is not as easy to achieve in men, because there is no comparable cycle of gamete release. However a new, reversible male conception control method for males has been developed. It relies on using a combination of progestin, a hormone used in female contraceptive pills, and testosterone. The combination of the two hormones temporarily turns off the normal brain signals that stimulate sperm production.

27.8 CONCEPT REVIEW

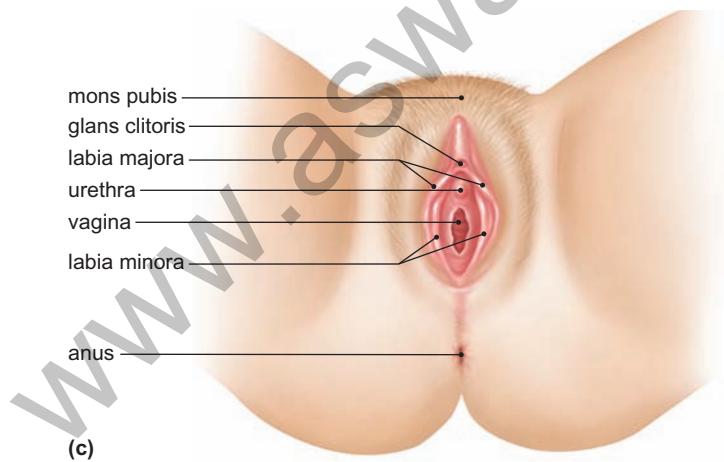
17. How do birth control pills prevent ovulation?



(a)



(b)



(c)

FIGURE 27.14 The Human Female Reproductive System

(a) After ovulation, the cell travels down the oviduct to the uterus. If it is not fertilized, it is shed when the uterine lining is lost during menstruation. (b) The human female reproductive system, side view. (c) External view of female reproductive structures.

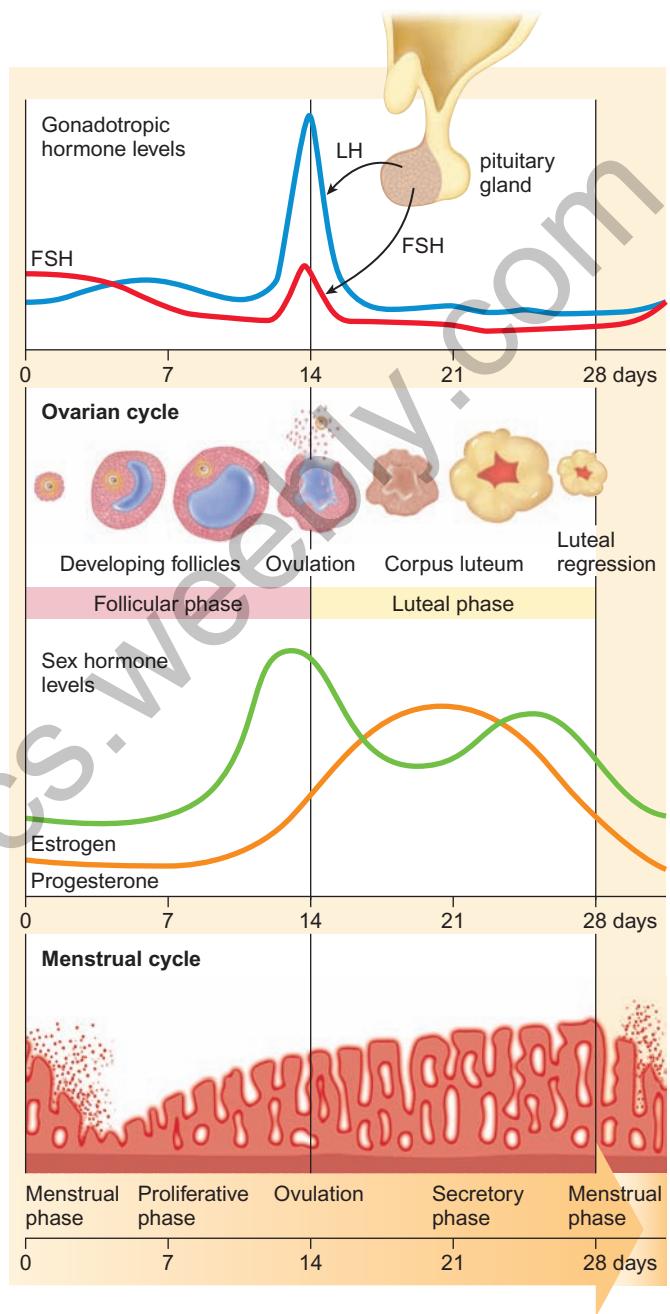


FIGURE 27.15 The Ovarian and Uterine Cycles in Human Females

The release of an egg (ovulation) is timed to coincide with the thickening of the lining of the uterus. The uterine cycle in humans involves the preparation of the uterine wall to receive the embryo if fertilization occurs. Knowing how these two cycles compare, it is possible to determine when pregnancy is most likely to occur by noting when menstruation begins.

OUTLOOKS 27.2

Causes of Infertility

Infertility is a problem that has generated a major branch of medicine to diagnose and treat the causes. Either or both partners can be the cause of the infertility in a relationship, so both need to be assessed in the process of diagnosis and treatment. In about 35% of cases, the fertility problem involves the female; in about 35%, of cases, the fertility problem involves the male. In about 20% of cases, both partners have a problem, and no cause has been identified in about 10% of cases.

Common Causes of Infertility

Lifestyle Causes

Heavy use of alcohol and drugs

Low body fat or anorexia in women

Tight clothing in men may raise the temperature in the scrotum and affect sperm development.

Stress may cause irregular ovulation in women or reduce sperm count in men.

Infections

Sexually transmitted diseases often result in scarring or blockage of reproductive tubes.

Pelvic inflammatory disease (PID) is the most common cause of infertility in women.



Physical Causes

Fibroids and endometriosis may cause blockage.

Retrograde ejaculation—the semen is forced into the bladder rather than being ejaculated.

Developmental Causes

Undescended testes

Swollen veins (varicocoele) in scrotum

Undeveloped ovaries or testes
(developmental defect, infection, etc.)

Hormonal Causes

Any imbalance in the timing and quantity of the several sex hormones can result in lack of ovulation.

The uterus may not be prepared to accept the embryo.

Low progesterone levels may cause premature shedding of the uterine lining.

Low testosterone levels results in low sperm counts.

Immune System Causes

Females may develop antibodies against her partner's sperm.

Males may develop an autoimmune response to their own sperm.

Illness and Medication Causes

Diseases such as diabetes, kidney disease, and high blood pressure contribute to infertility.

Tranquilizers and blood pressure drugs may interfere with erection.

27.9 Fertilization, Pregnancy, and Birth

In most women, an egg (actually a secondary oocyte) is released from the ovary about 14 days before the next menstrual period. The menstrual cycle is usually said to begin on the first day of menstruation. Therefore, if a woman has a regular 28-day cycle, the egg is released approximately on day 14 (review figure 27.15). If a woman normally has a regular 21-day menstrual cycle, ovulation occurs about day 7 in the cycle. If a woman has a regular 40-day cycle, ovulation occurs about day 26. Some women, however, have very irregular menstrual cycles, and it is difficult to determine just when the egg will be released to become available for fertilization. Once the egg is released, it is swept into the oviduct and moved toward the uterus. If sperm are present, they swarm around the egg as it passes down the oviduct, but only one sperm penetrates the outer layer to fertilize it and cause it to complete meiosis. The other sperm contribute enzymes, which digest away the protein and mucous barrier between the egg and the successful sperm.

During the second meiotic division, the second polar body is pinched off and the larger of the two cells, the true ovum, is formed. Because chromosomes from the sperm are already inside, they simply intermingle with those of the ovum, forming a diploid zygote. As the zygote continues to travel down the oviduct, it begins to divide by mitosis into smaller and smaller cells, without an increase in the mass of cells (figure 27.16). This division process is called *cleavage*.

Eventually, a solid ball of cells is produced, known as the morula stage of embryological development. The morula continues down the oviduct and continues to divide by mitosis. The result is called a *blastocyst*. The blastocyst becomes embedded or implanted in the uterine lining when it reaches the uterus (How Science Works 27.2).

The blastocyst stage of the embryo eventually develops a tube, which becomes the gut. The formation of the primitive digestive tract is just one of a series of changes that result in an embryo that is recognizable as a miniature human being.

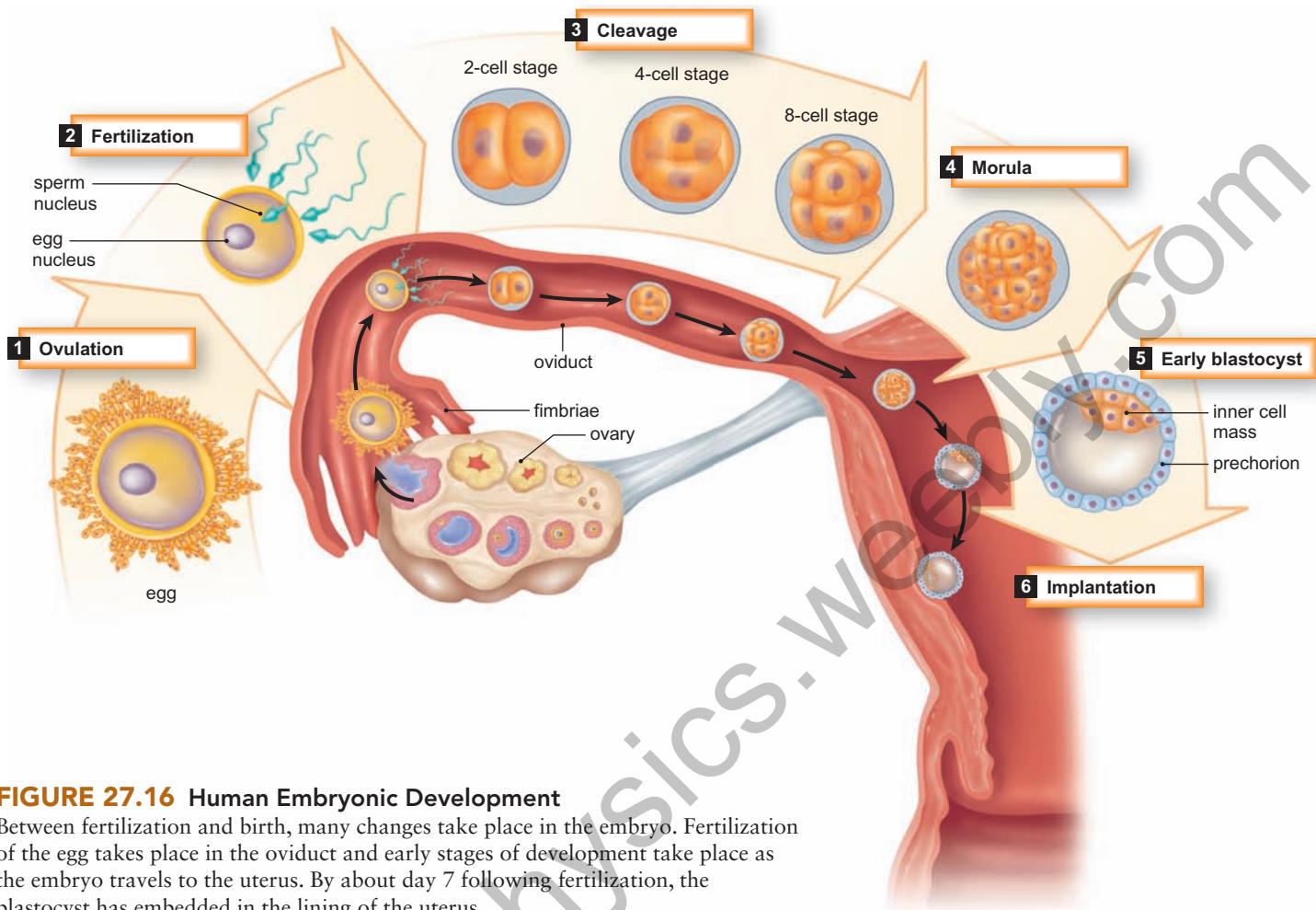


FIGURE 27.16 Human Embryonic Development

Between fertilization and birth, many changes take place in the embryo. Fertilization of the egg takes place in the oviduct and early stages of development take place as the embryo travels to the uterus. By about day 7 following fertilization, the blastocyst has embedded in the lining of the uterus.

Most of the time during its development, the embryo is enclosed in a water-filled membrane, the amnion, which protects it from blows and keeps it moist. Two other membranes, the chorion and allantois, fuse with the lining of the uterus to form the placenta (figure 27.17). A fourth sac, the yolk sac, is well developed in reptiles, fish, amphibians, and birds. The yolk sac in these animals contains a large amount of food used by the developing embryo. Although a yolk sac is present in mammals, it is small and does not contain yolk. The embryo's nutritional needs are met through the placenta. The placenta also produces the hormone chorionic gonadotropin, which stimulates the corpus luteum to continue producing progesterone and thus prevents menstruation and ovulation during pregnancy.

As the embryo's cells divide and grow, some of them become differentiated into nerve cells, bone cells, blood cells, or other specialized cells. In order to divide, grow, and differentiate, cells must receive nourishment. This is provided by the mother through the placenta, in which both fetal and maternal blood vessels are abundant, allowing for the exchange of substances between the mother and embryo. The

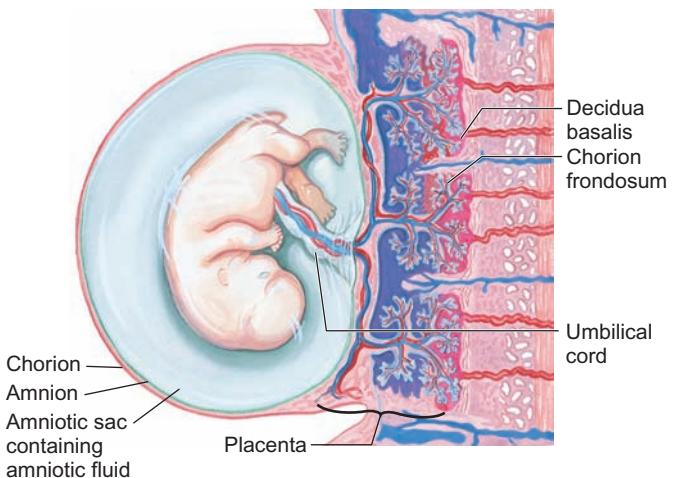


FIGURE 27.17 Placental Structure

The embryonic blood vessels that supply the developing embryo with nutrients and remove the metabolic wastes are separate from the blood vessels of the mother. Because of this separation, the placenta can selectively filter many types of incoming materials and microorganisms.



HOW SCIENCE WORKS 27.1

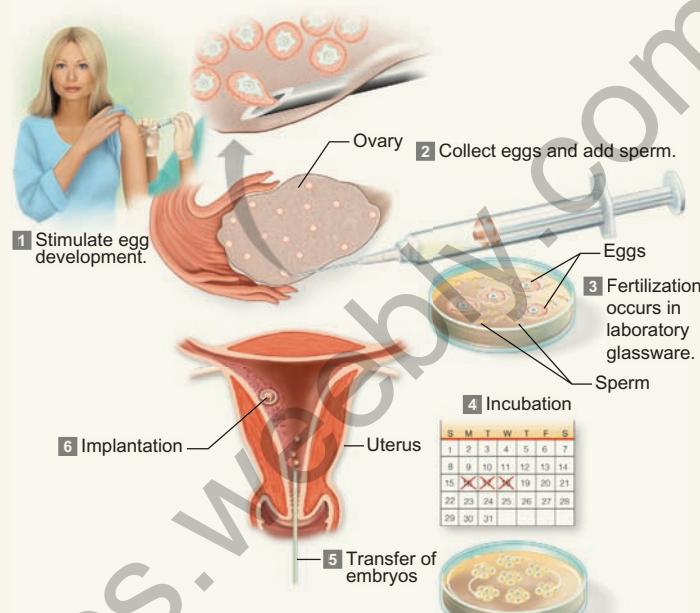
Assisted Reproductive Technology

The Centers for Disease Control and Prevention defines assisted reproductive technology (ART) as “*all fertility treatments in which both eggs and sperm are manipulated. In general, ART involves surgically removing eggs from a woman’s ovaries, combining them with sperm in the laboratory, and returning them to the woman’s body or donating them to another woman. It does NOT include procedures in which only sperm are manipulated (i.e., artificial insemination or intrauterine insemination) or procedures in which a woman takes drugs only to stimulate egg production, without the intention of having eggs retrieved.*” There are three types of ART: in vitro fertilization (IVF), gamete intra-fallopian transfer (GIFT), and zygote intra-fallopian transfer (ZIFT).

In vitro fertilization is a method that uses hormones to stimulate egg production, removing the egg or eggs from the ovary, and fertilizing it with donated sperm. The fertilized egg is incubated to stimulate cell division in a laboratory dish and then placed in the uterus. (See figure.)

GIFT relies on the same hormonal treatment as IVF to stimulate ovulation. The physician observes the transfer of unfertilized eggs and sperm into the woman’s fallopian tube through an instrument inserted through a small incision in her abdomen. Once fertilized, the zygote moves down through the fallopian tube into the uterus and implants. GIFT is only an option for women with open fallopian tubes.

In the ZIFT procedure, a woman’s mature eggs are collected and fertilized in the laboratory. Then, the zygote is inserted into



the fallopian tube through a small abdominal incision. The embryo will then travel down the fallopian tube and implant in the uterus in a normal manner.

materials diffusing across the placenta include oxygen, carbon dioxide, nutrients, and a variety of waste products. The materials entering the embryo travel through blood vessels in the umbilical cord. The diet and behavior of the mother are extremely important. Any molecules consumed by the mother can affect the embryo. Cocaine; alcohol; heroin; the chemicals in cigarette smoke; and medications, such as Phenytoin (or Dilantin) and Accutane (acne treatment), can all cross the placenta and affect the development of the embryo. Infections by such microbes as rubella virus (German measles), Varicella (chicken pox), and the protozoan *Toxoplasma* can also result in fetal abnormalities or even death.

The growth of the embryo results in the development of major parts of the body by the tenth week of pregnancy. After this time, the embryo continues to increase in size, and the structure of the body is refined.

Twins

In the United States, women giving birth have a 1 in 40 chance of delivering twins and a 1 in 650 chance of triplets or other multiple births. Twins happen in two ways. In the case of identical



Identical twins



Fraternal twins

twins (approximately one-third of all twins), the embryo splits during cleavage into two separate groups of cells. Each group develops into an independent embryo. Because they come from the same single fertilized ovum, they have the same genes and are the same sex.

Should separation be incomplete, the twins would be born attached to one another, a condition referred to as conjoined twins. Conjoined twins occur once in every 70,000 to 100,000 live births.

Fraternal twins result from the fertilization of two separate eggs by two different sperm. Therefore, they resemble each other no more than do regular brothers and sisters. They do not contain the same genes and are not necessarily the same sex.



HOW SCIENCE WORKS 27.2

History of Pregnancy Testing

The answer to the question “Am I pregnant?” once demanded a combination of guesswork, “old wives’ tales” and time. An ancient Egyptian papyrus described a test in which a woman who might be pregnant urinated on wheat and barley seeds over the course of several days: “If the barley grows, it means a male child. If the wheat grows, it means a female child. If both do not grow, she will not bear at all.”

In the Middle Ages, so-called “piss prophets” said they could tell if a woman was pregnant by the color of her urine. Urine was described as a “clear, pale lemon color leaning toward off-white, having a cloud on its surface” if she was pregnant. Some mixed wine with urine and watched for changes. In fact, alcohol reacts with certain proteins in urine, so they may have had a little help in guessing.

In 1927, a test was developed that required the injection of a woman’s urine into an immature female rat or mouse. If the woman was not pregnant, the animal showed no reaction. If she was pregnant, the animal went into heat (displayed behaviors associated with a desire to mate) despite its immaturity. This test implied that, during pregnancy, there was an increased production of certain hormones, and that they were excreted in the urine. In the 1930s, a similar test involved injecting urine into rabbits, frogs, toads, and rats. If pregnancy hormones were in the urine, they induced ovulation in the animals.

However, in 1976, advertisements proclaimed “a private little revolution,” the first home pregnancy tests. The FDA granted approval to four tests: Early Pregnancy Test, Predictor,



ACU-TEST, and Answer. All the tests identified changes in hormone levels in the urine of pregnant women.

The next generation of home pregnancy tests arrived in 2003, when the FDA approved Clearblue Easy’s digital pregnancy test. Instead of showing a thin blue line, the indicator screen now displayed the words “pregnant” or “not pregnant.”

Birth

The process of giving birth is also known as parturition, or birthing. At the end of about 9 months, hormonal changes in the mother’s body stimulate contractions of the uterine muscles during a period prior to birth called *labor*. These contractions are stimulated by the hormone oxytocin, which is released from the posterior pituitary. The contractions normally move the baby headfirst and face down through the vagina, or birth canal. One of the first effects of these contractions may be the bursting of the amnion (“bag of water”) surrounding the baby. Following this, the uterine contractions become stronger, and shortly thereafter the baby is born (figure 27.18). In some cases, the baby becomes turned in the uterus before labor. If this occurs, the feet or buttocks appear first. Such a birth is called a *breech birth*. This can be a dangerous situation, because the baby’s source of oxygen may be cut off as the placenta begins to separate from the mother’s body before the baby’s head emerges. If for any reason the baby does not begin to



FIGURE 27.18 Childbirth

What many people refer to as “natural” childbirth is really called a vaginal delivery.

breathe on its own, it will not receive enough oxygen to prevent the death of nerve cells; thus, brain damage or death can result.

Occasionally, a baby cannot be born vaginally because of its position in the uterus. Other factors include the location of the placenta on the uterine wall and the size of the birth canal. A procedure to resolve this problem is the surgical removal of the baby through the mother's abdomen. This procedure is known as a cesarean, or C-section. The procedure was apparently named after Roman Emperor Julius Caesar, who was said to have been the first child to be delivered by this method. While C-sections are known to have been performed before Caesar, the name stuck.

Following the birth of the baby, the placenta, also called the *afterbirth*, is expelled. Once born, the baby begins to function on its own. The umbilical cord collapses and the baby's lungs, kidneys, and digestive system must now support all bodily needs. Birth is quite a shock, but the baby's loud protests fill the lungs with air and stimulate breathing.

Over the next few weeks, the mother's body returns to normal, with one major exception. The breasts, which underwent changes during pregnancy, are ready to produce milk to feed the baby. Following birth, prolactin, a hormone from the pituitary gland, stimulates the production of milk, and oxytocin stimulates its release. If the baby is breast-fed, the stimulus of the baby's sucking prolongs the time during which milk is produced. This response involves both the nervous and endocrine systems. The sucking stimulates nerves in the nipples and breasts, resulting in the release of prolactin and oxytocin from the pituitary.

Recent studies have found that breast-fed babies are 20% less likely to die between the ages of 1 and 12 months than are those who are not breast-fed. In addition, the longer babies are breast-fed, the lower their risk for early death. The American Academy of Pediatrics has recommended exclusive breast-feeding (that is, only human breast milk—no formula, water, or solids) for the first 6 months of life. Breast-feeding should continue throughout the second half of the baby's first year with the introduction of solid foods.

In some cultures, breast-feeding continues for 2 to 3 years, and the continued production of milk often delays the reestablishment of the normal cycles of ovulation and menstruation. Many people believe that a woman cannot become pregnant while she is nursing a baby, a method of birth control called Lactation Amenorrhea Method (LAM). For a woman breast-feeding, the probability of becoming pregnant during the first three months is practically zero. However, because there is so much variation among women, relying on this as a natural conception-control method after the first three months is not a good choice. Many women have been surprised to find themselves pregnant again a few months after delivery.

27.9 CONCEPT REVIEW

18. What changes occur in ovulation and menstruation during pregnancy?
19. What are the functions of the placenta?
20. What causes the genetic differences between fraternal twins?

27.10 Contraception

Throughout history, people have tried various methods of conception control. In ancient times, conception control was encouraged during times of food shortage or when tribes were on the move from one area to another in search of a new home. Writings from as early as 1500 b.c. indicate that the Egyptians used a form of tampon medicated with the ground powder of a shrub to prevent fertilization. This may sound primitive, but we use the same basic principle today to destroy sperm in the vagina. As you read about the various methods of contraception, remember that no method except abstinence is 100% effective for avoiding pregnancy. Another important consideration is that only condoms are effective in preventing the spread of sexually transmitted diseases (STDs).

Barrier Methods

One way to prevent conception is to physically prevent the sperm from reaching the egg.

The male condom is probably the most popular contraceptive device. It is a thin sheath placed over the erect penis before intercourse. In addition to preventing sperm from reaching the egg, this physical barrier also helps prevent the transmission of the microbes that cause sexually transmitted diseases (STDs), such as syphilis, gonorrhea, and AIDS, from being passed from one person to another during sexual intercourse



(Outlooks 27.3). The most desirable condoms are made of a thin layer of latex that does not reduce the sensitivity of the penis. Latex condoms have also been determined to be the most effective in preventing transmission of HIV. The condom is most effective if it is prelubricated with a spermicidal material, such as nonoxynol-9. This lubricant also has the advantage of providing some protection against the spread of HIV.

Condoms for women are also available. One, called the Femidom, is a polyurethane sheath, which, once inserted, lines the contours of the woman's vagina. It has an inner ring, which sits over the cervix, and an outer ring, which lies flat against the labia. Research shows that this device protects against STDs and is as effective a contraceptive as the condom used by men.



OUTLOOKS 27.3

Sexually Transmitted Diseases

Sexually transmitted diseases (STDs) were formerly called venereal diseases (VDs). Although these kinds of illnesses are most frequently transmitted by sexual activity, many can also be spread by other methods of direct contact, such as hypodermic needles, blood transfusions, and blood-contaminated materials. Currently, the Centers for Disease Control and Prevention (CDC) in Atlanta, Georgia, recognizes over 25 diseases as being sexually transmitted (table 27.A).

The United States has the highest rate of sexually transmitted disease among the industrially developed countries. There are about 19 million new infections each year. About half of the infections occur in young adults aged 15–24 years of age. Table 27.B lists the most common STDs and estimates of the number of new cases each year. Some of the most important STDs are described here because of their high incidence in the population and the inability to bring some of them under control. For example, there is no known cure for HIV, responsible for AIDS.

Despite efforts to educate the public and the availability of effective methods for treatment, several STDs are actually increasing in frequency. In particular, *Chlamydia* infections have increased to over a million new infections per year. There has also

TABLE 27.A Sexually Transmitted Diseases

| Disease | Agent |
|---|-------------------|
| Genital herpes | Virus |
| Gonorrhea | Bacterium |
| Syphilis | Bacterium |
| Acquired immunodeficiency syndrome (AIDS) | Virus |
| Candidiasis | Yeast |
| Chancroid | Bacterium |
| Genital warts | Virus |
| <i>Gardnerella vaginalis</i> | Bacterium |
| Genital <i>Chlamydia</i> infection | Bacterium |
| Genital cytomegalovirus infection | Virus |
| Genital <i>Mycoplasma</i> infection | Bacterium |
| Group B <i>Streptococcus</i> infection | Bacterium |
| Nongonococcal urethritis | Bacterium |
| Pelvic inflammatory disease (PID) | Bacterium |
| Molluscum contagiosum | Virus |
| Crabs | Body lice |
| Scabies | Mite |
| Trichomoniasis | Protozoan |
| Hepatitis B | Virus |
| Gay bowel syndrome | Variety of agents |

TABLE 27.B Cases of Sexually Transmitted Diseases in the United States Reported in 2008

| Disease | Cases Reported in 2008 | Comments |
|--------------------------|------------------------|--|
| Chancroid | 25 | |
| Hepatitis B | 4,519 | Up to 1.4 million people may have undiagnosed disease |
| HIV/AIDS | 37,041 | About 1.1 million people infected |
| Syphilis | 46,277 | Incidence is increasing |
| Vaginal trichomoniasis | 204,000 | Probably over 7 million cases/year |
| Genital herpes | 292,000 | About 16% of population infected (about 50 million) |
| Gonorrhea | 336,742 | 700,000 cases/year estimated |
| Genital warts | 385,000 | About 1% of sexually active persons have genital warts |
| <i>Chlamydia</i> | 1,213,523 | Estimated 2.3 million infected |
| Other vaginal infections | 3,571,000 | Most common sexually transmitted disease |

been an increase in the number of cases of syphilis, especially among gay and bisexual men. In addition, a penicillin-resistant strain of *Neisseria gonorrhoeae* has led to an increase in the number of cases of gonorrhea.

The spread of STDs during sexual intercourse is significantly diminished by the use of condoms. Other types of sexual contact (e.g., hand, oral, anal) and transmission from a mother to the fetus during pregnancy help maintain some of these diseases in the population. Therefore, public health organizations, such as the U.S. Public Health Service, the CDC, and state and local public health agencies, regularly keep an eye on the number of cases of STDs. All of these agencies are involved in attempts to raise the general public health to a higher level. Their investigations have resulted in the successful control of many diseases and the identification of special problems, such as those associated with the STDs. Because the United States has an incidence rate of STDs that is 50 to 100 times higher than that of other industrially developed countries, there is still much that needs to be done.

The high-risk behaviors associated with contracting STDs include sex with multiple partners and the failure to use condoms. Whereas some STDs are simply inconvenient or annoying, others severely affect health and can result in death. As one health official stated, "We should be knowledgeable enough about our own sexuality and the STDs to answer the question, 'Is what I'm about to do worth dying for?'"



Other methods of conception control that prevent sperm from reaching the egg include the diaphragm, cervical cap, and sponge. A diaphragm is a specially fitted membranous shield that is inserted into the vagina before intercourse and positioned so that it

covers the cervix, which has the opening of the uterus. Because of anatomical differences among females, diaphragms must be fitted by a physician. The diaphragm's effectiveness is increased if spermicidal foam or jelly is also used. A cervical cap functions in a similar way. A contraceptive sponge, as the name indicates, is a small amount of absorbent material soaked in a spermicide. The sponge is placed within the vagina, where it chemically and physically prevents sperm cells from reaching the egg.

Chemical Methods

Contraceptive jellies and foams make the vaginal environment more acidic, which diminishes the sperm's chances of survival. Spermicidal (sperm-killing) foam or jelly is placed in the

vagina before intercourse. When the sperm make contact with the acidic environment, they stop swimming and soon die. These methods of contraception are often used in combination with other methods of contraception (condoms, diaphragm etc.) as additional protection in the event that the other methods fail.



Hormonal Control Methods

The first successful method of hormonal control was "the pill," or "birth-control pill," which contained a combination of the hormones estrogen and progesterone. Today there are two kinds of birth-control pills: those that contain estrogen and progesterone and those that contain progesterone only. The

combination birth-control pill works primarily by preventing ovulation, and secondarily by interfering with implantation. The quantity and balance of hormones (estrogen and progesterone) in the pill fools the ovaries into functioning as if the woman were already pregnant.

Therefore, ovulation does not occur, so conception is highly unlikely.

The combination pills are taken daily for 21 days and then stopped (some brands have 21 pills with hormones and the last 7 do not contain hormones). This allows for menstruation to occur.



The progesterone-only pill (POP, or mini pill) is taken continuously without a break. The progesterone in these pills has several effects that helps to prevent conception. Progesterone thickens the mucus at the cervix, alters the uterine lining to make implantation unlikely, and appears to interfere with the movement of sperm and egg.

Other hormone methods involve delivering the hormones by way of implants, adhesive patches, or vaginal rings that slowly release hormones and prevent the maturation and release of eggs from the follicle. The major advantage of an implant is its convenience. Once the implant has been inserted, the woman can forget about contraceptive protection for several years. If she wants to become pregnant, the implants are removed and her normal menstrual and ovulation cycles return over a period of weeks. Similarly, discontinuing the use of the patch allow normal ovulation to resume.



The vaginal ring releases a continuous low dose of estrogen and progestin for 21 days. At the end of the 21 days, the ring is removed for 7 days to allow the menstrual period to occur. A new ring is then inserted monthly.

Contraceptive hormones can also be used to stop menstrual periods, preventing the symptoms of premenstrual syndrome and improving a woman's sex life.

The emergency contraceptive pill (ECP), or "morning-after pill," uses a high dose of the same hormones found in oral contraceptives, which prevents the woman from becoming pregnant in the first place. In fact, "the pill" in higher dosages can be used as an ECP. The common medication available in the United States is known as Plan B®. These pills work by inhibiting ovulation and thickening mucus, which makes it difficult for the sperm to get to the egg.

The Timing Method

Not all methods of birth control require the use of physical barriers, spermicides, or hormones. Any method that prevents sperm from reaching the egg prevents conception. One method is to avoid intercourse during the times of the month when an egg may be present. This is known as the *rhythm method* of conception control. Although at first glance it appears to be the simplest and least expensive, determining when an egg is likely to be present can be very difficult. A woman with a regular 28-day menstrual cycle typically ovulates about 14 days before the onset of the next menstrual flow. To avoid pregnancy, couples need to abstain from intercourse a few days before and after this date. However, if a woman has an irregular menstrual cycle, there may be only a few days each month for intercourse without the possibility of pregnancy. In addition to calculating safe days based on the length of the menstrual

cycle, a woman can better estimate the time of ovulation by keeping a record of changes in her body temperature and vaginal pH. Both changes are tied to the menstrual cycle and can therefore help a woman predict ovulation. In particular, at about the time of ovulation, a woman has a slight rise in body temperature—less than 1°C. Thus, she should use an extremely sensitive thermometer. A digital-readout thermometer on the market spells out the word yes or no.

However, all variations of the rhythm method have high failure rates—up to 25 percent per year.

Intrauterine Devices (IUD)

The intrauterine device (IUD) is an object that must be fitted and inserted into the uterus by a physician. IUDs are very effective. This method of contraception has a failure rate of about 1%. How this device works is not completely known. There are two major kinds of IUDs: those that contain copper and those that contain the hormone progesterone. It appears that the copper interferes with the sperm's swimming ability and also alters the lining of the uterus, which makes implantation unlikely. IUDs with progesterone appear to thicken the layer of mucus around the cervix and also alter the nature of the

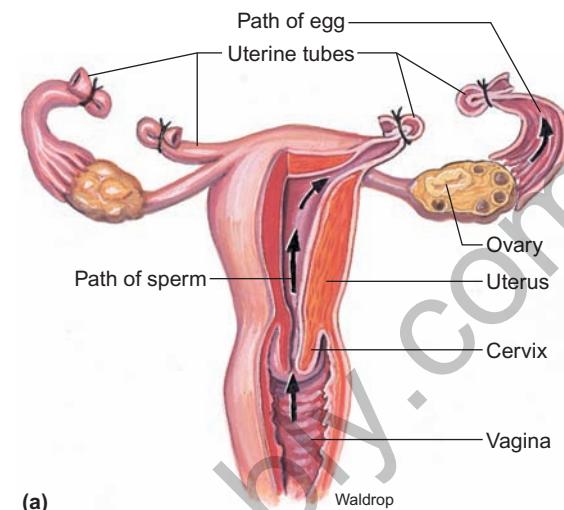
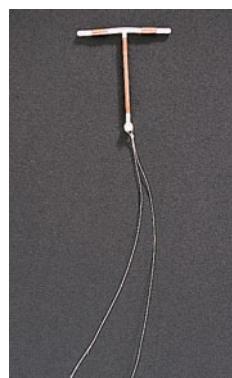
uterine lining, making implantation less likely. A major advantage of an IUD is that it can be left in place and be effective for years, but it can be removed if pregnancy is desired.

The IUD can also be used for “emergency contraception”—in cases of unprotected sex, forced sex, or the failure of a conception-control method (e.g., a broken condom). To be used for this purpose, the IUD must be inserted within 7 days of unprotected sex.

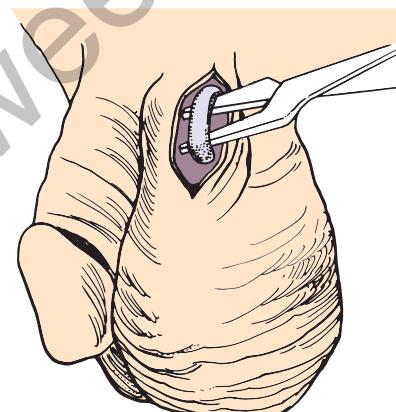
Surgical Methods

Two contraceptive methods that require surgery are tubal ligation and vasectomy (figure 27.19). Tubal ligation is the cutting and tying off of the oviducts; it can be done on an outpatient basis, in most cases. An alternative to sterilization by tubal ligation involves the insertion of small, flexible devices, called Micro-inserts, into each oviduct (fallopian tube). Once inserted, tissue grows into the inserts, blocking the tubes. Ovulation continues as usual, but the sperm and egg cannot unite.

A vasectomy can be performed in a physician’s office. A small opening is made above the scrotum, and the spermatic cord (vas deferens) is cut and tied. This prevents sperm from moving through the ducts to the outside. Because most of the semen is produced by the seminal vesicles, prostate gland, and bulbourethral glands, a vasectomy does not interfere with normal ejaculation. The sperm that are still being produced die and are reabsorbed in the testes. Vasectomy is not the same as castration. Castration is the surgical removal of testes.



(a)



(b)

FIGURE 27.19 Tubal Ligation and Vasectomy

Two very effective contraceptive methods require surgery. (a) Tubal ligation involves severing the oviducts and suturing or sealing the cut ends. This prevents the sperm cell and the egg from meeting. This procedure is generally considered ambulatory surgery; at most, it requires a short hospitalization period. (b) Vasectomy requires minor surgery, usually in a clinic under local anesthesia. Following the procedure, minor discomfort may be experienced for several days. The severing and sealing of the vas deferens prevents the release of sperm cells from the body during ejaculation.

Neither tubal ligation nor vasectomy interferes with normal sex drives. However, these medical procedures are difficult to reverse and should not be considered by those who may want to have children at a future date. These procedures are not 100% effective since, in rare instances, the tubes might reattach, allowing gametes to pass from one severed side of the duct to the other.

27.10 CONCEPT REVIEW

21. Describe hormonal methods of conception control.
22. Describe barrier methods of conception control.

27.11 Termination of Pregnancy—Abortion

Another medical procedure often associated with birth control is abortion, which has been used throughout history. Abortion is the death and removal of a developing embryo through various medical procedures. Abortion is not a method of conception control; rather, it prevents the normal development of the embryo. Abortion is a highly charged subject: Some people believe that abortion should be prohibited by law in all cases; others think that abortion should be allowed in certain situations, such as in pregnancies that endanger the mother's life or in pregnancies that are the result of rape or incest. Still others think that abortion should be available to any woman under any circumstances. Regardless of the moral and ethical issues that surround abortion, it is still a common method of terminating unwanted pregnancies.

The three most common techniques performed early in pregnancy are scraping the inside of the uterus with instruments (called *dilation and curettage*, or *D and C*), injecting a saline solution into the uterine cavity, and using a suction device to remove the embryo from the uterus. RU-486 is a drug that causes abortion and must be used under a doctor's supervision. The medication is administered orally and several days later, a hormone is administered. This usually results in the onset of contractions, which expel the fetus. A follow-up examination of the woman is made after several weeks to ensure that there are no serious side effects.

Late-term abortions are done after the *20th week of gestation*. Late-term abortion is not a medical term, and the exact point when a pregnancy becomes late term has not been defined. Nor is there exact data for the number performed. Late-term abortions performed for fetal abnormality are involved procedures called *intact dilation and extraction* (IDX or D&X), also known as partial-birth abortion.

27.11 CONCEPT REVIEW

23. What is dilation and curettage?
24. How does RU-486 work?

27.12 Changes in Sexual Function with Age

Although there is a great deal of variation, at about age 50, a woman's hormonal balance begins to change because of changes in the ovaries' production of hormones. At this time, the menstrual cycle becomes less regular and ovulation is often unpredictable. Over several years, the changes in hormone levels cause many women to experience mood swings and physical symptoms, including cramps and hot flashes. Menopause is the period when a woman's body becomes

nonreproductive, because reproductive hormones stop being produced. This causes the ovaries to stop producing eggs, and menstruation ends. Occasionally, the symptoms associated with menopause become so severe that they interfere with normal life and the enjoyment of sexual activity. A physician might recommend *hormone replacement therapy (HRT)* which involves administering either estrogen alone or estrogen and progestin together, to augment the natural production of estrogen and progesterone. Normally, the sexual enjoyment of a healthy woman continues during menopause and for many years thereafter.

Although human males do not experience a relatively abrupt change in their reproductive or sexual lives, recent evidence indicates that men also experience hormonal and emotional changes similar to those seen as women go through menopause. As men age, their production of sperm declines and they may experience a variety of problems related to their sexuality. The word *impotence* is used to describe problems that interfere with sexual intercourse and reproduction. These may include a lack of sexual desire, problems with ejaculation or orgasm, and erectile dysfunction (ED). Erectile dysfunction is the recurring inability to get or keep an erection firm enough for sexual intercourse. Most incidences of ED at any age are physical not psychological. In older men, this is usually the result of injury, disease, or the side effects of medication. Damage to nerves, arteries, smooth muscles, and other tissues associated with the penis is the most common cause of ED. Diseases linked with ED include diabetes, kidney disease, chronic alcoholism, multiple sclerosis, atherosclerosis, vascular disease, and neurologic disease. Blood pressure drugs, antihistamines, antidepressants, tranquilizers, appetite suppressants, and certain ulcer drugs have been associated with ED. Other possible causes are smoking, which reduces blood flow in veins and arteries, and lowered amounts of testosterone. ED is frequently treated with psychotherapy, behavior modification, oral or locally injected drugs, vacuum devices, and surgically implanted devices. ED is not an inevitable part of aging. Rather, sexual desires tend to wane slowly



as men age. They produce fewer sperm cells and less seminal fluid. Nevertheless, healthy individuals can experience a satisfying sex life during aging.

Human sexual behavior is quite variable. The same is true of older persons. The range of responses to sexual partners continues, but generally in a diminished form. People who were very active sexually when young continue to be active, but less so as they reach middle age. Those who were less active tend to decrease their sexual activity also. It is reasonable to state that one's sexuality continues from before birth until death.

27.12 CONCEPT REVIEW

25. What is menopause?
26. How does sexual function change with age?

Summary

The human sex drive is a powerful motivator for many activities in our lives. Although from a biological perspective it provides for reproduction and generates new gene combinations, it also has a nonbiological, sociocultural dimension. Sexuality begins before birth, as sexual anatomy is determined by the sex-determining chromosome complement received at fertilization. Females receive 2 X chromosomes. A male receives 1 X and 1 Y sex-determining chromosome. It is the presence of the Y chromosome that causes male development and the absence of a Y chromosome that allows female development.

At puberty, hormones stimulate the maturation of the ovaries and testes and the development of secondary sex characteristics. As the ovaries and testes begin to produce gametes, fertilization becomes possible. Sexual reproduction involves the production of gametes by meiosis in the ovaries and testes. The production and release of these gametes is controlled by the interaction of hormones. In males, each cell that undergoes spermatogenesis results in four sperm; in females, each cell that undergoes oogenesis results in one egg and two polar bodies. Humans have specialized structures for the support of the developing embryo, and many factors influence its development in the uterus. Sexual reproduction depends on proper hormone balance, proper meiotic division, fertilization, placenta formation, proper diet of the mother, and birth. Hormones regulate ovulation and menstruation and can be used to encourage or discourage ovulation. Fertility drugs and birth-control pills, for example, involve hormonal control. In addition to the pill, a number of contraceptive methods have been developed, including the diaphragm, condom, IUD, spermicidal jellies and foams, contraceptive implants, the sponge, tubal ligation, and vasectomy.

Hormones continue to direct our sexuality throughout our lives. Even after menopause, when fertilization and pregnancy are no longer possible for a female, normal sexual activity can continue in both men and women.

Key Terms

Use the interactive flash cards on the *Concepts in Biology*, 14/e website to help you learn the meaning of these terms.

- androgens 621
- clitoris 621
- cryptorchidism 620
- ejaculation 616
- follicles 620
- follicle-stimulating hormone (FSH) 620
- gametogenesis 622
- gonadotropin-releasing hormone (GnRH) 620
- inguinal canal 620
- luteinizing hormone (LH) 620
- masturbation 621
- menopause 636
- menstrual cycle 621
- oogenesis 623
- orgasm 616
- oviduct 625
- ovulation 621
- pituitary gland 620
- placenta 629
- polar body 625
- puberty 620
- secondary sexual characteristics 621
- semen 621
- seminiferous tubules 622
- sex 614
- sex-determining chromosomes 617
- sexuality 614
- sperm 617
- spermatogenesis 622
- X chromosome 617
- Y chromosome 617

Basic Review

1. All the factors that contribute to one's female or male nature are referred to as ____.
2. Humans have a total of ____ chromosomes, ____ of which are considered sex-determining.
 - a. 44, 2
 - b. 23, 2
 - c. 48, 4
 - d. 46, 2
3. In humans, the ____ acts as a master switch, triggering the events that convert an embryo into a male.
 - a. SRY gene
 - b. TDF gene
 - c. Y-gene
 - d. Turner's gene

4. Men with Klinefelter's syndrome may be sterile and show breast enlargement, an incomplete masculine body form, a lack of facial hair, and some minor learning problems. (T/F)
5. Semen is produced by the testes. (T/F)
6. Gonadotropin-releasing hormone (GnRH) is produced by the
 - a. hypothalamus.
 - b. pituitary.
 - c. testes.
 - d. corpus leuteum.
7. Birth control pills contain hormones. (T/F)
8. The unequal division that occurs during oogenesis results in the formation of smaller cells that do not develop into true eggs, called _____.
9. If a woman normally has a regular 21-day menstrual cycle, ovulation occurs about day ____ in the cycle.
10. If an embryo splits during cleavage into two separate groups of cells, ____ twins may develop.
11. Transgender individuals have a psychological view of themselves that is different from their physical bodies. (T/F)
12. Homosexuality appears to have a genetic basis. (T/F)
13. The cells released during ovulation
 - a. are diploid.
 - b. were present in the ovaries for several years.
 - c. contain Y chromosomes.
 - d. None of the above is correct.
14. The hormone progesterone is produced by the
 - a. corpus luteum.
 - b. pituitary.
 - c. hypothalamus.
 - d. uterus.
15. Fertilization of an egg usually takes place in the _____.

Thinking Critically

Hormones in the Environment

The practice of medicine has increasingly moved in the direction of using medications containing steroids to control disease or regulate function, as in birth-control pills. To meet these demands, the pharmaceutical industry produces enormous amounts of these drugs. However, what happens to these drugs once they enter the body? Although some of the drug is destroyed in controlling disease or regulating a function, such as ovulation, a certain amount is not and is excreted. There is some concern about the amount of medical steroids entering the environment in this way. What effects might they have on the public, who unintentionally ingest these as environmental contaminants? Consider the topics of sexual reproduction, the regulation of hormonal cycles, and fetal development, and explain (1) how you would determine "acceptable levels" of such contaminants, (2) what might happen if these levels were exceeded, and (3) what steps might be taken to control such environmental contamination.

Answers

1. sexuality
2. d
3. a
4. T
5. F
6. a
7. T
8. polar bodies
9. 7
10. identical
11. T
12. T
13. b
14. a
15. oviduct (fallopian tube)

Appendix 1

The Metric System

Standard Metric Units

| | | Abbreviation |
|-------------------------|-------|--------------|
| Standard unit of mass | gram | g |
| Standard unit of length | meter | m |
| Standard unit of volume | liter | L |

Common Prefixes

| | | Examples |
|-----------------|----------------|--|
| kilo | 1,000 | A kilogram is 1,000 grams. |
| centi | 0.01 | A centimeter is 0.01 meter. |
| milli | 0.001 | A milliliter is 0.001 liter. |
| micro (μ) | one-millionth | A micrometer is 0.000001 (one-millionth) of a meter. |
| nano (n) | one-billionth | A nanogram is 10^{-9} (one-billionth) of a gram. |
| pico (p) | one-trillionth | A picogram is 10^{-12} (one-trillionth) of a gram. |

Units of Length

| Unit | Abbreviation | Equivalent |
|------------|--------------|----------------------|
| meter | m | approximately 39 in. |
| centimeter | cm | 10^{-2} m |
| millimeter | mm | 10^{-3} m |
| micrometer | μ m | 10^{-6} m |
| nanometer | nm | 10^{-9} m |
| angstrom | \AA | 10^{-10} m |

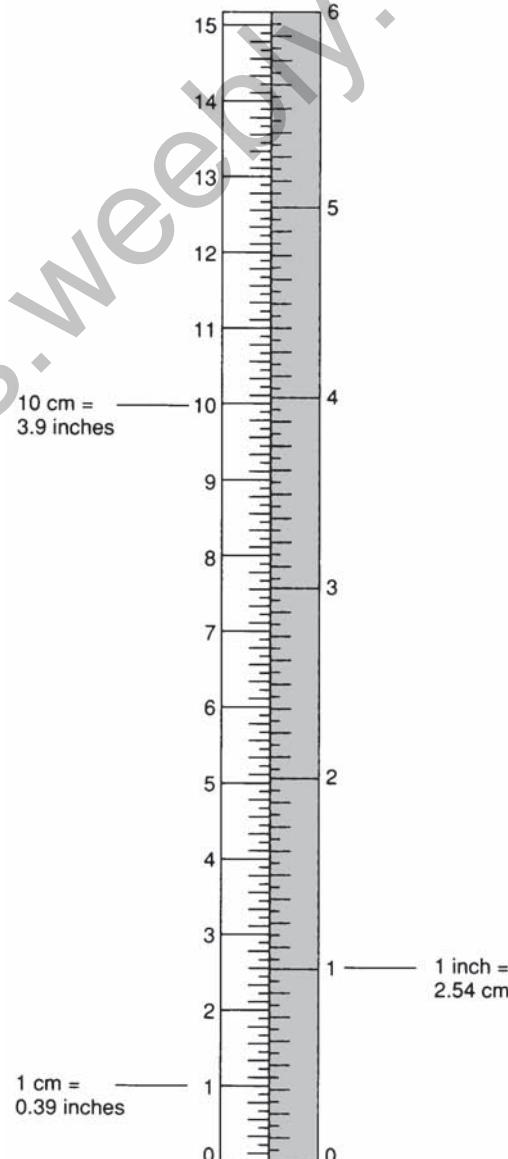
Length Conversions

| | |
|----------------|---------------------------------|
| 1 in. = 2.5 cm | 1 mm = 0.039 in |
| 1 ft = 30 cm | 1 cm = 0.39 in |
| 1 yd = 0.9 m | 1 m = 39 in |
| 1 mi = 1.6 km | 1 m = 1.094 yd 1 km = 0.6 mi |

| To Convert |
|-------------|
| inches |
| feet |
| centimeters |
| millimeters |

| Multiply By | To Obtain |
|-------------|-------------|
| 2.54 | centimeters |
| 30 | centimeters |
| 0.39 | inches |
| 0.039 | inches |

Centimeters Inches



Units of Volume

| Unit | Abbreviation | Equivalent |
|------------|--------------|---|
| liter | L | approximately 1.06 qt |
| milliliter | mL | 10^{-3} L (1 mL = 1 cm ³ = 1 cc) |
| microliter | µL | 10^{-6} L |

Volume Conversions

| | | | | | |
|---------|---|--------|------|---|------------|
| 1 tsp | = | 5 mL | 1 mL | = | 0.03 fl oz |
| 1 tbsp | = | 15 mL | 1 L | = | 2.1 pt |
| 1 fl oz | = | 30 mL | 1 L | = | 1.06 qt |
| 1 cup | = | 0.24 L | 1 L | = | 0.26 gal |
| 1 pt | = | 0.47 L | | | |
| 1 qt | = | 0.95 L | | | |
| 1 gal | = | 3.8 L | | | |

| To Convert | Multiply By | To Obtain |
|--------------|-------------|--------------|
| fluid ounces | 30 | milliliters |
| quarts | 0.95 | liters |
| milliliters | 0.03 | fluid ounces |
| liters | 1.06 | quarts |

Units of Weight

| Unit | Abbreviation | Equivalent |
|-----------|--------------|---------------------------------|
| kilogram | kg | 10^3 g (approximately 2.2 lb) |
| gram | g | approximately 0.035 oz |
| milligram | mg | 10^{-3} g |
| microgram | µg | 10^{-6} g |
| nanogram | ng | 10^{-9} g |
| pictogram | pg | 10^{-12} g |

Weight Conversions

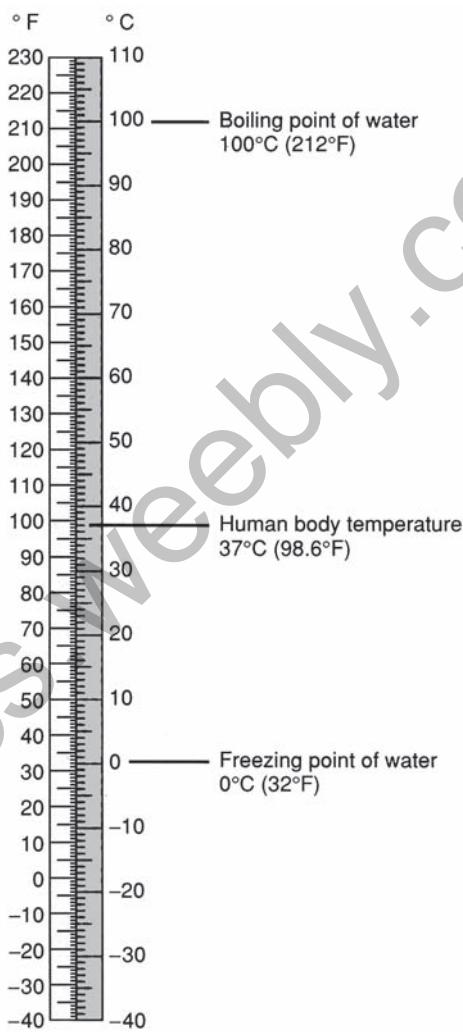
| | |
|----------------|----------------|
| 1 oz = 28.3 g | 1 g = 0.035 oz |
| 1 lb = 453.6 g | 1 kg = 2.2 lb |
| 1 lb = 0.45 kg | |

| To Convert | Multiply By | To Obtain |
|------------|-------------|-----------|
| ounces | 28.3 | grams |
| pounds | 453.6 | grams |
| pounds | 0.45 | kilograms |
| grams | 0.035 | ounces |
| kilograms | 2.2 | pounds |

Apothecary System of Weight and Volume*

| Metric Weight | Apothecary Weight | Metric Volume | Apothecary Volume |
|---------------|---------------------------|---------------|-------------------|
| 30 g | = 1 ounce | 1,000 mL | = 1 quart |
| 15 g | = 4 drams | 500 mL | = 1 pint |
| 10 g | = 2.5 drams | 250 mL | = 8 fl ounces |
| 4 g | = 60 grains (= 1 dram) | 90 mL | = 3 fl ounces |
| 2 g | = 30 grains | 30 mL | = 1 fl ounce |
| 1 g | = 15 grains | | |

Temperature



Temperature Conversions

$$^{\circ}\text{C} = \frac{(^{\circ}\text{F} - 32) \times 5}{9}$$

$$^{\circ}\text{F} = \frac{(^{\circ}\text{C} \times 9)}{5} + 32$$

Some Equivalents

$$\begin{aligned} 0^{\circ}\text{C} &= 32^{\circ}\text{F} \\ 37^{\circ}\text{C} &= 98.6^{\circ}\text{F} \\ 100^{\circ}\text{C} &= 212^{\circ}\text{F} \end{aligned}$$

*Used by pharmacists in preparing medications.

Appendix 2

Acronyms

| | | | |
|------|---|----------|---|
| ADH | antidiuretic hormone | LDL | low-density lipoprotein |
| AIDS | acquired immunodeficiency syndrome | LH | luteinizing hormone |
| AMU | atomic mass unit | Lp(a) | lipoprotein a |
| ATP | adenosine triphosphate | NAD | nicotinamide adenine dinucleotide |
| BMI | body mass index | NADP | nicotinamide adenine dinucleotide phosphate |
| BMR | basal metabolic rate | PCB | polychlorinated biphenyl |
| CAM | crassulacean acid metabolism | pH | hydrogen ion concentration |
| DDT | dichlorodiphenyltrichloroethane | PKU | phenylketone urea |
| DNA | deoxyribonucleic acid | RBC | red blood cell |
| DRI | dietary reference intakes | RNA | ribonucleic acid |
| EGF | epidermal growth factor | RuBisCo | ribulose bisphosphate carboxylase |
| ER | endoplasmic reticulum | SARS | severe acute respiratory syndrome |
| ETS | electron-transport system | SDA | specific dynamic action |
| FAD | flavin adenine dinucleotide | STD | sexually transmitted disease |
| FAS | fetal alcohol system | TCA | tricarboxylic acid cycle |
| FSH | follicle-stimulating hormone | TSH | thyroid-stimulating hormone |
| GnRH | gonadotropin-releasing hormone | UNAIDS | United Nations Joint HIV/AIDS Program |
| GSH | growth-stimulating hormone | USAMRIID | U.S. Army Medical Research Institute of Infectious Diseases |
| HDL | high-density lipoprotein | VLDL | very-low-density lipoprotein |
| HIV | human immunodeficiency virus | WBC | white blood cell |
| HLA | human leukocyte antigens | | |
| ICSH | interstitial cell-stimulating hormone | | |
| IPCC | Intergovernmental Panel on Climate Change | | |

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Glossary

A

abiotic factors (ə-bīt'ä-tik fak-tōrz) Nonliving parts of an organism's environment.

absorption (əb'-sorp-shən) The movement of simple molecules from the digestive system to the circulatory system for dispersal throughout the body.

abyssal ecosystem (ə-bi-səl eco-sis-təm) A benthic ecosystem that occurs at great depths in the ocean.

accessory pigments (ak-ses-uh-ree pig-mənt) Photosynthetic pigments other than the chlorophylls that enable an organism to use more colors of the visible light spectrum for photosynthesis (e.g., carotenoids [yellow, red, and orange]; phycoerythrins [red]; and phycocyanin [blue]).

acetyl (ə'-sē-təl) The 2-carbon remainder of the carbon skeleton of pyruvic acid ($\text{CH}_3\text{CO}-$) that is able to enter the mitochondrion for oxidation in the Krebs cycle.

acetyl-CoA (ə'-sē-təl kō'-ā) The 2-carbon remainder of the carbon skeleton of pyruvic attached to a coenzyme A molecule.

acetylcholine (ə-se-təl-kō-lēn) A neurotransmitter secreted into the synapse by many axons and received by dendrites.

acetylcholinesterase (uh-seet-kō-lə'-nes-tə'-rās) An enzyme present in the synapse that destroys acetylcholine.

acid-base reactions (a-sēd bās rē'-ak-shən) When the ions of one compound (acid) interact with the ions of another compound (base), forming a salt and water.

acids (a-sēds) Compounds that release a hydrogen ion in a solution.

acoelomate (ā'-sē-lə-māt) Without a coelom; the internal organs have no spaces between them.

acquired characteristics (ə'-kwī(-ə)r ker-ik-tō'-ris-tik) Characteristics of an organism

gained during its lifetime, not determined genetically and therefore not transmitted to the offspring.

actin (ak-tən) A protein found in the thin myofilaments of muscle fibers that binds to myosin.

actin filaments (ak-tən fi-lə-mənts) Filaments composed of the protein actin that are part of a cell's cytoskeleton.

activation energy (ak-ti-vā'shun e-nər-jē) Energy required to start a reaction.

active site (ak-tiv sīt) The place on the enzyme that causes the substrate to change.

active transport (ak-tiv trans-'port) The use of a carrier molecule to move molecules across a plasma membrane in a direction opposite that of the concentration gradient. The carrier requires an input of energy other than the kinetic energy of the molecules.

adaptive radiation (ə'-dap-tiv rā-dē'-ä-shən) A specific evolutionary pattern in which there is a rapid increase in the number of kinds of closely related species.

adenine (a-dē-nēn) A double-ring nitrogenous-base molecule in DNA and RNA; the complementary base of thymine or uracil.

adenosine triphosphate (ATP) (ə'-de-nō-sēn trī'-făs-făt) A molecule formed from the building blocks of adenine, ribose, and phosphates; it functions as the primary energy carrier in the cell.

aerobic cellular respiration (er'-ō-bik 'sel-yə-lər res-pō'-rā-shən) The biochemical pathway that requires oxygen and converts food, such as carbohydrates, to carbon dioxide and water. During this conversion, it releases the chemical-bond energy as ATP molecules.

aerobic exercise (er'-ō-bik ek-sər-sīz) The level of exercise at which the level of exertion allows the heart and lungs to keep up with the oxygen needs of the muscles.

age distribution (āj dis-trō'-byü-shən) The number of organisms of each age in the population.

alcoholic fermentation (al-kō'-ho-lik fər-mən'-tā-shən) The anaerobic respiration pathway in yeast cells; during this process, pyruvic acid from glycolysis is converted to ethanol and carbon dioxide.

algae (al-gā) Protists that have cell walls and chlorophyll and can therefore carry on photosynthesis.

allele (ə'-lēl) An alternative form of a gene for a particular characteristic (e.g., attached earlobe and free earlobe are alternative alleles for ear shape).

allele frequency (ə'-lēl frē-kwən(t)-sē) A measure of how common a specific allele is, compared with other alleles for the same characteristic.

allergy ('a-lər-jē) An abnormal immune reaction to an antigen. Possibly the most familiar are allergies to foods, pollens, and drugs.

alternation of generations (ol-tōr'-nā-shən əv je-nō'-rā-shən) The aspect of the life cycle in which there are two distinctly different forms of an organism; each form is involved in the production of the other and only one form is involved in producing gametes; the cycling of a diploid sporophyte generation and a haploid gametophyte generation in plants.

alternative splicing (ol'-tōr-nō-tiv splī-sij) A process that selects which exons will be retained as part of the mature mRNA that will be used during translation. Alternative splicing allows for the possibility that a single gene can produce more than one type of protein.

altruism ('al-trū-i-zəm) Behavior in which an individual animal gives up an advantage or puts itself in danger to aid others.

alveoli (al'-vē-əlē) Tiny sacs found in the lungs; where gas exchange takes place.

amino acid (ə-'mē-nō 'a-sōd) A basic subunit of protein consisting of a short carbon skeleton that contains an amino group, a carboxylic acid group, and one of various side groups.

anabolism (ə-'na-bə-li-zəm) Metabolic pathways that result in the synthesis of new, larger compounds (e.g., protein synthesis).

anaerobic cellular respiration (a-nə-'rō-bik 'sel-yə-lər res-pə-'rā-shən) A biochemical pathway that does not require oxygen for the production of ATP and does not use O₂ as its ultimate hydrogen ion acceptor.

anaerobic exercise (a-nə-'rō-bik 'ek-sər-sīz) Bouts of exercise that are so intense that the muscles cannot get oxygen as fast as they need it.

analogous structures (ə-'na-lə-gəs 'strək-chər) Structures that have the same function (ex., the wing of a butterfly and the wing of a bird) but different evolutionary backgrounds.

anaphase ('a-nə-fāz) The third stage of mitosis, characterized by division of the centromeres and movement of the chromosomes to the poles.

androgens ('an-drō-jən) Male sex hormones, produced by the testes, that cause the differentiation of typical internal and external genital male anatomy.

angiosperms ('an-jē-ə-spərmz) Plants that produce flowers, seeds, and fruits.

anorexia nervosa (a-nō-'rek-sē-ə nōr-'vō-sə) A nutritional deficiency disease characterized by severe, prolonged weight loss for fear of becoming obese; this eating disorder is thought to stem from sociocultural factors.

anther ('an-thər) The sex organ in plants that produces the pollen that contains the sperm.

antheridium (an-thə-'ri-dē-əm) The structure in lower plants that bears sperm.

anthropomorphism ('an-thrō-pə-mor-fī-zəm) The ascribing of human feelings, emotions, or meanings to the behavior of animals.

antibiotics (an-tē-bī-'ä-tiks) Drugs that selectively kill or inhibit the growth of a particular cell type.

antibody ('an-ti-bā-dē) A protein made by B-cells in response to a molecule known as the antigen.

anticodon (an-ti-'kō-dān) The trio of bases in the tRNA that is involved in base-pairing.

antidiuretic hormone (ADH) (an-ti-dī-yu'-re-tik 'hōr-mōn) The hormone produced by the pituitary gland that stimulates the kidney to reabsorb water.

antigen ('an-ti-jēn) A large organic molecule, usually a protein, which is able to stimulate the production of a specific defense response and becomes neutralized or destroyed by that response.

aorta (ä-'ör-tə) The large blood vessel that carries blood from the left ventricle to the majority of the body.

apoptosis (a-pōp-'tō-sēs) Death that has a genetic basis and not the result of injury.

Archaea (är-kē-ə) One of two domains of prokaryotic organisms: Archaea and Bacteria. Distinguished from the domain Bacteria by differences in the nature of the DNA, cell wall, and cell membrane.

archegonium (är-ki-'gō-nē-əm) The structure in lower plants that bears eggs.

arteries ('är-tē-rēz) The blood vessels that carry blood away from the heart.

arterioles (är-'tir-ē-'ölz) Small arteries, located just before capillaries, that can expand and contract to regulate the flow of blood to parts of the body.

asexual reproduction (ä-'sek-shwəl rē-prō-'dk-shən) A form of duplication that requires only one parent and results in two organisms that are genetically identical to the parent.

assimilation (ə-si-mā-'lā-shən) The physiological process that takes place in a living cell as it converts nutrients in food into specific molecules required by the organism.

association (ə-sō-sē-'ā-shən) An animal learns that a particular outcome is associated with a particular stimulus.

aster ('as-tər) Microtubules that extend from the centrioles to the plasma membrane of an animal cell.

asymmetry (ä-'si-mā-trē) The characteristic of animals with no particular body shape.

atomic mass unit (ə-'tā-mik 'mas 'yü-nət) A unit of measure used to describe the mass of atoms and is equal to 1.67×10^{-24} grams, approximately the mass of 1 proton.

atomic nucleus (ə-'tā-mik 'nū-klē-əs) The central region of an atom.

atomic number (ə-'tā-mik 'nōm-bər) The number of protons in an atom.

atomic weight (ə-'tā-mik 'wāt) The weight of an atomic nucleus, expressed in atomic mass units (the sum of the protons and neutrons).

atoms ('a-tōmz) The fundamental units of matter; the smallest parts of an element that still act like that element.

atria ('ā-trē-ə) Thin-walled sacs of the heart that receive blood from the veins of the body and empty into the ventricles.

atrioventricular valves (ä-trē-ō-ven-'tri-kyō-lər 'valvz) Valves, located between the atria and ventricles of the heart, that prevent the blood from flowing backwards from the ventricles into the atria.

attachment site (ə-'tach-mənt 'sīt) A specific point on the surface of the enzyme where it can physically attach itself to the substrate; also called binding site.

autoimmune diseases ('ō-tō-i-'myūn di-'zēz) Disorders that result from the immune system turning against normal chemicals and cells of the body.

autosomes ('ō-tō-sōmz) Chromosomes that typically carry genetic information used by an organism for characteristics other than the primary determination of sex.

autotrophs ('ō-tō-trōfs) Organisms that are able to make their food molecules from inorganic raw materials by using basic energy sources, such as sunlight.

axon ('ak-sän) A neuronal fiber that carries information away from the nerve cell body.

B

bacteria (bak-'tir-ē-ə) Noneukaryotic, unicellular organisms of the Domain Bacteria; formerly used to refer to members of both the Domain Bacteria and the Domain Archaea.

basal metabolic rate (BMR) ('bā-säl me-tō-'bā-lik 'rāt) The amount of energy required to maintain normal body activity while at rest.

bases ('bā-sez) Compounds that release hydroxide ions or accept hydrogen ions in a solution.

basilar membrane ('ba-zə-lər 'mem-brān) A membrane in the cochlea containing sensory cells that are stimulated by the vibrations caused by sound waves.

behavior (bi-'hā-vyōr) How an organism acts, what it does, and how it does it.

| | | |
|---|---|---|
| behavioral isolating mechanisms (bi-'hā-vyōr-rēl 'ī-sō-lāt-ing 'me-kō-ni-zōmz) Reproductive isolating mechanisms that prevent interbreeding between species because of differences in behavior. | how living entities interact with things around them. | the light-independent reactions stage of photosynthesis. |
| benign tumor (bi-'nīn 'tū-mōr) A cell mass that does not fragment and spread beyond its original area of growth. | biomagnification (bī-ō-mag-nā-fā-'kā-shōn) The accumulation of a compound in increasing concentrations in organisms at successively higher trophic levels. | capillary ('ka-pō-ler-ē) The thinnest blood vessel that exchanges materials between the blood and tissues that surround these vessels. |
| benthic ('ben-thik) A term used to describe organisms that live in bodies of water, attached to the bottom or to objects in the water. | biomass ('bī-ō-mas) The dry weight of a collection of designated organisms. | carbohydrates (kär-bō-'hī-drāts) One class of organic molecules composed of carbon, hydrogen, and oxygen in a ratio of 1:2:1; the basic building block of carbohydrates is a simple sugar (monosaccharide). |
| benthic ecosystem ('ben-thik 'ē-kō-sis-təm) An aquatic ecosystem that exists on the bottom of a body of water. | biomes ('bī-ōmz) Large, regional communities primarily determined by climate. | carbon cycle ('kär-bōn 'sī-kēl) The processes and pathways involved in capturing inorganic carbon-containing molecules, converting them into organic molecules that are used by organisms, and the ultimate release of inorganic carbon molecules back to the abiotic environment. |
| bilateral symmetry (bī-'la-tō-rēl 'si-mō-trē) The characteristic of animals that are constructed along a plane running from a head to a tail region, so that only a cut along one plane of this axis results in two mirror halves. | bioremediation ('bī-ō-ri-mē-dē-'ā-shōn) The use of living organisms to remove toxic agents from the environment. | carbon skeleton ('kär-bōn 'ske-lə-tōn) The central portion of an organic molecule composed of rings or chains of carbon atoms. |
| bile ('bīl) The product of the liver, stored in the gallbladder, that is responsible for the emulsification of fats. | biosphere ('bī-ō-sfīr) The worldwide ecosystem. | carcinogens (kär-'si-nā-jōnz) Agents that cause cancer. |
| binary fission ('bī-nō-rē 'fi-shōn) A method of asexual cell division used by non-eukaryotic cells. | biotechnology (bī-ō-tek-'nā-lō-jē) The science of gene manipulation. | cardiovascular system ('kär-dē-ō-'vas-kyō-lōr 'sis-təm) The organ system of all vertebrates including humans that pumps blood around the body and consists of blood, the heart, and vessels. |
| binding site (attachment site) ('bīn-dīj 'sīt) A specific point on the surface of the enzyme where it can physically attach itself to the substrate. | blood ('blōd) The fluid medium, consisting of cells and plasma, that assists in the transport of materials and heat. | carnivores ('kär-nō-vōrz) Animals that eat other animals. |
| binomial system of nomenclature (bī-'nō-mē-əl 'sis-təm 'ōv 'nō-mēn-klā-chōr) A naming system that uses two Latin names, genus and specific epithet, for each species of organism. | bloom ('blūm) A rapid increase in the number of microorganisms in a body of water. | carrier proteins ('ker-ē-ər 'prō-tēnz) A category of proteins that pick up molecules at one place and transport them to another. |
| biochemical isolating mechanisms (bī-ō-'ke-mi-kōl 'ī-sō-lāt-ing 'me-kō-ni-zōmz) Differences in biochemical activities that prevent mating between individuals of different species. | body mass index (BMI) ('bā-dē 'mas 'in-deks) The weight of a person in kilograms divided by the person's height in meters squared. | carrying capacity ('ka-rē-ing kā-'pa-sə-tē) The maximum sustainable population for an area. |
| biochemical pathway (metabolic pathway) (bī-ō-'ke-mi-kōl 'path-wā) A major series of enzyme-controlled reactions linked together. | Bowman's capsule ('bō-mōnз- 'kap-səl) The saclike structure at the end of a nephron that surrounds the glomerulus. | catabolism (kā-'ta-bō-li-zōm) Metabolic pathways that result in the breakdown of compounds (e.g., glycolysis). |
| biochemistry (bī-ō-'ke-mō-strē) The chemistry of living things, often called biological chemistry. | breathing ('brē-thīng) The process of pumping air into and out of the lungs. | catalyst ('ka-tō-lōst) A chemical that speeds up a reaction but is not used up in the reaction. |
| biogenesis (bī-ō-'je-nā-səs) The concept that life originates only from preexisting life. | bronchi ('brāj-kī) Major branches of the trachea that ultimately deliver air to bronchioles in the lungs. | cell cycle ('sel 'sī-kēl) All the stages of growth and division for a eukaryotic cell. |
| biological species concept (bī-ō-'lä-ji-kōl 'spē-shēz 'kān-sept) The concept that species are distinguished from one another by their inability to interbreed. | bronchioles ('brāj-kē-ōlz) Small tubes that deliver air to the alveoli in the lungs. | cell division ('sel dō-'vi-zhən) The process in which a cell becomes two new cells. |
| biology (bī-'ä-lō-jē) The science that deals with the study of living things and | budding ('bō-dīng) A type of asexual reproduction in which the new organism is an outgrowth of the parent. | cell plate ('sel 'plāt) A plant-cell structure that begins to form in the center of the cell and proceeds to the cell membrane, resulting in cytokinesis. |
| | bulimia (bū-'lē-mē-ō) A nutritional deficiency disease characterized by a binge-and-purge cycle of eating; it is thought to stem from psychological disorders. | cells ('selz) The basic structural units of all living things; the smallest units that display the characteristics of life. |
| | calorie ('ka-lō-rē) The amount of heat energy necessary to raise the temperature of 1 gram of water 1°C. | |
| | Calvin cycle ('kal-vōn- 'sī-kēl) A cyclic sequence of reactions that make up | |

C

- calorie** ('ka-lō-rē) The amount of heat energy necessary to raise the temperature of 1 gram of water 1°C.
- Calvin cycle** ('kal-vōn- 'sī-kēl) A cyclic sequence of reactions that make up

cell theory ('sel 'thē-ə-rē) The concept that all living things are made of cells.

cellular membranes ('sel-yə-lər 'mem-brānz) Thin sheets of material composed of phospholipids and proteins; some of the proteins have attached carbohydrates or fats.

cellular respiration ('sel-yə-lər res-pə-'rā-shən) A major biochemical pathway by which cells release the chemical-bond energy from food and convert it into a usable form (ATP).

cell wall ('sel 'wól) An outer covering on some cells; may be composed of cellulose, chitin, or peptidoglycan, depending on the kind of organism.

central nervous system ('sen-trəl 'nær-vəs-sis-təm) The portion of the nervous system consisting of the brain and spinal cord.

centriole ('sen-trē-ōl) Two sets of nine short microtubules; each set of tubules is arranged in a cylinder.

centromere ('sen-trə-mir) The sequence of bases at the site where the sister chromatids are attached.

cerebellum (ser-ə-'be-ləm) The region of the brain, connected to the medulla oblongata, that receives many kinds of sensory stimuli and coordinates muscle movement.

cerebrum (so-'rē-brəm) The region of the brain that surrounds most of the other parts of the brain and is involved in consciousness and thought.

chemical bonds ('ke-mi-kəl 'bändz) Forces that combine atoms or ions and hold them together.

chemical equation ('ke-mi-kəl i-'kwā-zhən) A way of describing what happens in a chemical reaction.

chemical reaction ('ke-mi-kəl rē-'ak-shən) The formation or rearrangement of chemical bonds, usually indicated in an equation by an arrow from the reactants to the products.

chemicals ('ke-mi-kəlz) Substances used or produced in processes that involve changes in matter.

chemistry ('ke-mə-strē) The science concerned with the study of the composition, structure, and properties of matter and the changes it undergoes.

chemosynthesis ('kē-mō-'sin-thə-səs) The use of inorganic chemical reactions as a source of energy to make larger, organic molecules.

chlorophyll ('klör-ə-fil) The green pigment located in the chloroplasts of plant cells associated with trapping light energy.

chloroplasts ('klör-ə-plasts) Energy-converting, membranous, saclike organelles in plant cells containing the green pigment chlorophyll.

chromatid ('krō-mə-təd) One of two component parts of a chromosome formed by replication and attached at the centromere.

chromatin ('krō-mə-tən) An area or a structure within the nucleus of a cell composed of long molecules of deoxyribonucleic acid (DNA) in association with proteins.

chromosomal aberration ('krō-mə-sōm-al a-bə-'rā-shən) A change in the structure of chromosomes that can affect the expression of genes (e.g., translocation, duplication mutations).

chromosomes (krō-mə-'sōmz) Double-stranded DNA molecules with attached protein (nucleoprotein) coiled into a short, compact unit.

cilia ('si-lē-ə) Numerous short, hairlike structures projecting from the cell surface that enable locomotion.

class ('klas) A group of closely related families within a phylum.

classical conditioning ('kla-si-kəl kən-'di-shin) Learning that occurs when an involuntary, natural, reflexive response to a natural stimulus is transferred from the natural stimulus to a new stimulus.

cleavage furrow ('klē-vij 'fōr-ō) An indentation of the cell membrane of an animal cell that pinches the cytoplasm into two parts during cell division.

climax community ('klī-maks kə-'myü-nə-tē) A relatively stable, long-lasting community.

clitoris ('kli-tō-rəs) A small, elongated erectile structure located between and at the head of the labia; it is equivalent to the penis.

clone ('klōn) Exact copies of biological entities such as genes, organisms, or cells.

cochlea ('kō-klē-ə) The part of the ear that converts sound into nerve impulses.

coding strand ('kō-ding 'strand) One of the two DNA strands that serves as a template, or pattern, for the synthesis of RNA.

codominance (kō-'dä-mə-nəns) A situation in which both alleles in a heterozygous organism express themselves.

codon ('kō-dän) A sequence of three nucleotides of an mRNA molecule that directs the placement of a particular amino acid during translation.

coelom ('sē-lōm) A body cavity in which internal organs are suspended.

coenzyme (kō-'en-zīm) A molecule that works with an enzyme to enable the enzyme to function as a catalyst.

cofactor ('kō-fak-tər) Inorganic ions or organic molecules that serve as enzyme helpers.

commensalism (kə-'men-sə-li-zəm) A relationship between two organisms in which one organism is helped and the other is not affected.

communication (kə-myü-nə-'kā-shən) The use of signals to convey information from one animal to another.

community (kə-'myü-nə-tē) Populations of different kinds of organisms that interact with one another in a particular place.

competition (käm-pə-'ti-shən) A relationship between two organisms in which both organisms are harmed.

competitive exclusion principle (käm-'pe-tə-tiv iks-'klü-zhən 'prin-sə-pəl) No two species can occupy the same niche at the same time.

competitive inhibition (käm-'pe-tə-tiv in-hib-ə-shən) The formation of a temporary enzyme-inhibitor complex that interferes with the normal formation of enzyme-substrate complexes, resulting in a decreased turnover.

complete proteins (käm-'plēt 'prō-tēnz) Protein molecules that provide all the essential amino acids.

complex carbohydrates ('käm-pleks kär-bō-'hī-drāts) Macromolecules composed of simple sugars combined by dehydration synthesis to form a polymer.

compound (käm-'paünd) A kind of matter that consists of a specific number of atoms (or ions) joined to each other in a particular way and held together by chemical bonds.

concentration gradient (diffusion gradient) (kän-sən-'trā-shən 'grā-dē-ənt)

(di-'fyū-zhən 'grā-dē-ənt) The gradual change in the number of molecules per unit of volume over distance.

conditioned response (kən-'di-shənd ri-'späns) The modified behavior displayed in which a new response is associated with a natural stimulus.

cones ('kōnz) Reproductive structures of gymnosperms that produce pollen in males or eggs in females.

consumers (kən-'sü-mərs) Organisms that must obtain energy in the form of organic matter.

control group (kən-'trōl 'grüp) The situation used as the basis for comparison in a controlled experiment. The group in which there are no manipulated variables.

controlled experiment (kən-'trōld ik-'sper-ə-mənt) An experiment that includes two groups, one in which the variable is manipulated in a particular way and one in which there is no manipulation.

control processes (kən-'trl 'prä-se-səz) Mechanisms that ensure an organism will carry out all life activities in the proper sequence (coordination) and at the proper rate (regulation).

convergent evolution (kən-'vör-jənt e-və-'lüshən) An evolutionary pattern in which widely different organisms show similar characteristics.

coral reef ecosystem ('kōr-əl 'rēf ē-kō-sis-təm) A benthic ecosystem in shallow water produced by coral animals that build cup-shaped external skeletons around themselves. A symbiotic relationship between corals and algae provides the organic matter that supports other kinds of organisms.

cotyledons (kä-tə-'lē-dən) Embryonic leaves that have food stored in them; also known as seed leaves.

covalent bond (kō-'vā-lənt 'bänd) The attractive force formed between two atoms that share a pair of electrons.

cristae ('kris-tə) Folded surfaces of the inner membranes of mitochondria.

critical period ('kri-ti-kəl 'pir-ē-əd) The period of time during the life of an animal when imprinting can take place.

crossing-over ('krō-sinj 'ō-vər) The exchange of a part of a chromatid from 1 chromosome with an equivalent part of a chromatid from a homologous chromosome.

cryptorchidism (krip-'tōr-kə-di-zəm) A developmental condition in which

the testes do not migrate from the abdomen through the inguinal canal to the scrotum.

cytokinesis (sī-tō-kə-'nē-səs) The division of the cytoplasm of one cell into two new cells.

cytoplasm ('sī-tō-pla-zəm) The portion of the protoplasm that surrounds the nucleus.

cytosine ('sī-tō-sēn) A single-ring nitrogenous-base molecule in DNA and RNA; it is complementary to guanine.

cytoskeleton (sī-tō-'ske-lə-tən) The internal framework of eukaryotic cells composed of intermediate filaments, microtubules, and microfilaments; provides the cell with a flexible shape, and the ability to move through the environment, to move molecules internally, and to respond to environmental changes.

D

death phase ('deth 'fāz) The portion of some population growth curves in which the size of the population declines.

deceleration phase (dē-se-lə-'rā-shen 'fāz) A phase in the population growth curve during which the population growth rate begins to slow.

deciduous (di-'si-jə-wəs) A type of tree that loses its leaves at the end of the growing season.

decomposers (dē-kəm-'pō-zərs) Organisms that use dead organic matter as a source of energy.

deductive reasoning (deduction) (di-'dək-tiv 'rēz-nij) (di-'dək-shən) The mental process of using accepted generalizations to predict the outcome of specific events; from the general to the specific.

dehydration synthesis reaction (dē-hī-'drā-shən 'sin-thə-səs rē-'ak-shən) A reaction that results in the formation of a macromolecule when water is removed from between the two smaller component parts.

deletion aberration (di-'lē-shən a-bō-'rā-shən) A major change in DNA that can be observed at the level of the chromosome.

deletion mutation (di-'lē-shən myū-'tā-shən) A change in the DNA that has resulted from the removal of one or more nucleotides.

denatured (dē-'nā-chərd) Altered so that some of the protein's original

properties are diminished or eliminated.

dendrites ('den-drīts) Neuronal fibers that receive information from axons and carry it toward the nerve-cell body.

denitrifying bacteria (dē-'nī-trō-fī-ing bak-'tir-ē-ə) Several kinds of bacteria capable of converting nitrite to nitrogen gas.

density-dependent limiting factors ('den-sə-tē di-'pen-dənt 'li-mə-tij 'fak-tərz) Population-limiting factors that become more effective as the size of the population increases.

density-independent limiting factors ('den-sə-tē in-də-'pen-dənt 'li-mə-tij 'fak-tərz) Population-controlling factors that are not related to the size of the population.

deoxyribonucleic acid (DNA) (dē-'äk-si-rī-bō-nü-klē-ik 'a-səd) A polymer of nucleotides that serves as genetic information. In noneukaryotic cells, it is a double-stranded loop and contains attached HU proteins. In eukaryotic cells, it is found in strands with attached histone proteins. When tightly coiled, the DNA and histone structure is known as a chromosome.

dependent variable (di-'pen-dənt 'ver-ē-ə-bəl) A variable that changes in direct response to (depends on) how another variable (independent variable) is manipulated.

depolarized (dē-'pō-lə-rīzd) Having lost the electrical difference existing between two points or objects.

determination (di-tər-mə-'nā-shən) The process a cell goes through to select which genes it will eventually express on a more or less permanent basis.

diaphragm ('dī-ə-frām) The muscle separating the lung cavity from the abdominal cavity; it is involved in exchanging the air in the lungs.

diastolic blood pressure (di-ə-'stā-līk 'blōd 'pre-shər) The pressure present in a large artery when the heart is not contracting.

dicot ('dī-kät) An angiosperm whose embryo has two seed leaves.

diet ('dī-ət) The food and drink consumed by a person from day to day.

dietary fiber ('dī-ə-ter-ē 'fī-bər) Natural (plant) or industrially produced polysaccharides that are resistant to hydrolysis by human digestive enzymes.

Dietary Reference Intakes ('dī-ə-ter-ē 're-fôrns 'in-täks) Published by the USDA, these guidelines provide information on the amounts of certain nutrients various members of the public should receive.

differentiation (dif-ə-'ren-shē-'ā-shən) The process of forming specialized cells within a multicellular organism.

diffusion (di-'fyü-zhən) The net movement of a kind of molecule from an area of higher concentration to an area of lesser concentration.

digestion (dī-'jes-chən) The breakdown of complex food molecules to simpler molecules; the chemical reaction of hydrolysis.

digestive system (dī-'jes-tiv 'sis-təm) The organ system responsible for the processing and distribution of nutrients and consists of a muscular tube and glands that secrete digestive juices into the tube.

diploblastic (dip-lō-'blas-tik) A condition in which some simple animals consist of only two layers of cells.

diploid ('di-plöid) Having two sets of chromosomes: one set from the maternal parent and one set from the paternal parent.

directional selection (də-'rek-shnal sə-'lek-shən) Selection that occurs when individuals at one extreme of the range of a characteristic are consistently selected for.

disruptive selection (dis-'rəp-tiv sə-'lek-shən) Selection that occurs when both extremes of a range for a characteristic are selected for and the intermediate condition is selected against.

distal convoluted tubule ('dis-təl 'kän-və-lü-təd 'tü-byüł) The downstream end of the nephron of the kidney, primarily responsible for regulating the amount of hydrogen and potassium ions in the blood.

divergent evolution (də-'vər-jənt e-və-'lü-shən) A basic evolutionary pattern in which individual speciation events cause many branches in the evolution of a group of organisms.

DNA fingerprinting (DNA 'fin-gər-print-ing) A laboratory technique that detects differences in DNA to identify a unique individual; the differences in DNA are detected by using variable number tandem repeats, restriction enzymes, and electrophoresis.

DNA library (DNA 'lī-brer-ē) A collection of cloned DNA fragments that represent all the genetic information of an organism.

DNA replication (re-plə-'kā-shən) The process by which the genetic material (DNA) of the cell reproduces itself prior to its distribution to the next generation of cells.

domain (dō-'mān) The first (broadest) classification unit of organisms; there are three domains: Bacteria, Archaea, and Eucarya.

dominance hierarchy ('dä-mə-nəns 'hī-rär-kē) A relatively stable, mutually understood order of priority within a group.

dominant allele ('dä-mə-nənt ə-'lēł) An allele that expresses itself and masks the effects of other alleles for the trait.

double bond ('də-bəł 'bänd) A pair of covalent bonds formed between two atoms when they share two pairs of electrons.

double-factor cross ('də-bal 'fak-tər 'krōs) A genetic study in which two pairs of alleles are followed from the parental generation to the offspring.

Down syndrome ('daūn 'sin-drōm) A genetic disorder resulting from the presence of an extra chromosome 21. Symptoms include slightly slanted eyes, flattened facial features, a large tongue, and a tendency toward short stature and fingers. Individuals usually display mental retardation.

duodenum (dü-ə-'dē-nəm) The first part of the small intestine, which receives food from the stomach and secretions from the liver and pancreas.

duplications (dü-pli-'kā-shənз) A form of chromosomal aberration in which a portion of a chromosome is replicated and attached to the original section in sequence.

dynamic equilibrium (dī-'na-mik ē-kwə-'li-brē-əm) The condition in which molecules are equally dispersed; therefore, movement is equal in all directions.

E

ecology (i-'kä-lə-jē) The branch of biology that studies the relationships between organisms and their environment.

ecosystem ('ē-kō-sis-təm) A unit consisting of a community of organisms (populations) and its interactions with the physical surroundings.

ectoderm ('ek-tə-dərm) The outer embryonic layer.

ectotherms ('ek-tə-thərmz) Animals that are unable to regulate their body temperature by automatic physiological processes but can regulate their temperature by moving to places where they can be most comfortable.

ejaculation (i-ja-kyə-'lä-shən) The release of sperm cells and seminal fluid through the penis of a male.

electron (i-'lek-trän) A negatively charged particle moving at a distance from the nucleus of an atom; it balances the positive charges of the protons.

electron-transport system (ETS) (i-'lek-trän trans-'pōrt 'sis-təm) The series of oxidation-reduction reactions in aerobic cellular respiration in which the energy is removed from hydrogens and transferred to ATP.

electrophoresis (i-lek-trə-fə-'rē-səs) A technique that separates DNA fragments, proteins, or other molecules on the basis of size.

elements ('e-lə-mənts) Fundamental chemical substances that are made up of collections of only one kind of atom.

emergent properties (i-'mər-jənt 'prä-pər-tēz) Never-before-seen features that result from the interaction of simple components when they form much more complex substances.

endocrine glands ('en-də-krən 'glandz) Glands that secrete into the circulatory system.

endocrine system ('en-də-krən 'sis-təm) A number of glands that communicate with one another and other tissues through chemical messengers transported throughout the body by the circulatory system.

endocytosis (en-dō-sī-'tō-səs) The process cells use to wrap membrane around a particle (usually food) and engulf it.

endoderm ('en-də-dərm) The inner embryonic layer.

endoplasmic reticulum (ER) (en-də-plaz-mik ri-'ti-kyə-ləm) Folded membranes and tubes throughout the eukaryotic cell that provide a large surface on which chemical activities take place.

endoskeletons (en-dō-'ske-lə-tənз) Skeletons typical of vertebrates in which the skeleton is surrounded by muscles and other organs.

endospore ('en-dō-spór) A unique bacterial structure with a low metabolic rate that germinates under favorable conditions to grow into a new cell.

endosymbiotic theory (en-dō-sim-bī-'ä-tik 'thè-ə-rē) A theory suggesting that some organelles found in eukaryotic cells may have originated as free-living cells.

endotherms ('en-dō-thərmz) Animals that have internal temperature-regulating mechanisms and can maintain a relatively constant body temperature in spite of wide variations in the temperature of their environment.

energy ('e-nər-jē) The ability to do work or cause things to move.

energy level ('e-nər-jē 'le-vəl) A region surrounding an atomic nucleus that contains electrons moving at approximately the same speed and having approximately the same amount of kinetic energy.

enhancer sequence (in-hān-sər 'sē-kwəns) A DNA sequence that regulates gene expression by acting as a binding site for proteins that increase the ability of RNA polymerase to transcribe a specific protein.

environment (in-vī-rō-mēnt) Anything that affects an organism during its lifetime.

environmental resistance (in-vī-rō-mēn-təl ri-zis-təns) The collective factors that limit population growth.

enzymatic competition (en-zō-'ma-tik käm-pə-'ti-shən) Competition among several different available enzymes to combine with a given substrate material.

enzymes ('en-zīmz) Molecules, produced by organisms, that are able to control the rate at which chemical reactions occur.

enzyme-substrate complex ('en-zīm 'səb-strāt 'käm-pleks) A temporary molecule formed when an enzyme attaches itself to a substrate molecule.

epigenetics (e-pi-jē-'ne-tiks) The study of changes in gene expression caused by factors other than alterations in a cell's DNA.

epinephrine (e-pē-'ne-frīn) A hormone produced by the adrenal medulla and certain nerve cells that increases heart rate, blood pressure, and breathing rate.

epiphytes ('e-pē-fīts) Plants that live on the surface of other plants without doing harm.

essential amino acids (i-'sen-shəl ə-'mē-nō 'a-səds) Amino acids that cannot be synthesized by the human body and must be part of the diet (e.g., lysine, tryptophan, and valine).

essential fatty acids (i-'sen-shəl 'fa-tē 'a-səds) The fatty acids linoleic and linolenic, which cannot be synthesized by the human body and must be part of the diet.

estrogen ('es-trō-jēn) One of the female sex hormones responsible for the growth and development of female sexual anatomy.

estuary ('es-chō-wer-ē) A special category of aquatic ecosystem that consists of shallow, partially enclosed areas where freshwater enters the ocean; intermediate in saltiness between freshwater and the ocean.

Eucarya (yu'ka-re-ah) The domain of life that includes all organisms that have eukaryotic cells (plants, animals, fungi, protozoa, and algae).

eukaryotic cells (yū-ker-ē-'ä-tik 'sels) One of the two major types of cells; cells that have a true nucleus, as in plants, fungi, protists, and animals.

euphotic zone (yü-'fō-tik 'zōn) The upper layer of the ocean, where the sun's rays penetrate.

evolution (e-vō-'lü-shən) A change in the frequency of genetically determined characteristics within a population over time.

excretory system ('ek-skrō-tōr-ē 'sis-təm) The organ system responsible for the processing and elimination of metabolic waste products and consists of the kidneys, ureters, urinary bladder, and urethra.

exocrine glands ('ek-sō-krēn 'glandz) Glands that secrete through ducts to the surface of the body or into hollow organs of the body.

exocytosis (ek-sō-sī-'tō-səs) The process cells use to wrap membrane around a particle (usually cell products or wastes) and eliminate it from a cell.

exon ('ek-sän) Sequences of mRNA that are used to code for proteins.

exoskeletons (ek-sō-'ske-lə-tənz) Skeletons typical of many invertebrates, in which the skeleton is on the outside of the animal.

experiment (ik-'sper-ə-mēnt) A re-creation of an event that enables a scientist to gain valid and reliable empirical evidence.

experimental group (ik-sper-ə-'men-təl 'grüp) The group in a controlled experiment that has a variable manipulated.

exponential growth phase (ek-spo-'nen-chəl 'grōth 'fāz) The period of time during population growth when the population increases at an accelerating rate.

expressivity (ek-spre-'si-və-tē) A term used to describe situations in which the gene expresses itself but not equally in all individuals that have it.

external parasites (ek-'stăr-nəl 'per-ə-sīts) Parasites that live on the outside of their hosts.

extinction (ik-'stīn-shən) The loss of a species.

extrinsic limiting factors (ik-'stīn-shən 'li-mā-tin 'fak-tərz) Population-controlling factors that arise outside the population.

F

facilitated diffusion (fə-'si-lə-tät-ed di-'fyü-zhən) Diffusion assisted by carrier molecules.

family ('fam-lē) A group of closely related genera within an order.

fats ('fats) A class of water-insoluble macromolecules composed of a glycerol and fatty acids.

fatty acid ('fa-tē 'a-səd) One of the building blocks of a fat, composed of a long-chain carbon skeleton with a carboxylic acid functional group.

fermentation (fər-mən-'tā-shən) Pathways that oxidize glucose to generate ATP energy using something other than O₂ as the ultimate hydrogen acceptor.

fertilization (fər-tə-lə-'zā-shən) The joining of haploid nuclei, usually from an egg and a sperm cell, resulting in a diploid cell called a zygote.

filter feeders ('fil-tər 'fē-dərz) Animals that use cilia or other appendages to create water currents and filter food out of the water.

fitness ('fit-nəs) The concept that those who are best adapted to their environment produce the most offspring. Nutritionally, a measure of how efficiently a person can function both physically and mentally.

flagella (flə-'je-lə) Long, hairlike structures, projecting from the cell surface, that enable locomotion.

flavin adenine dinucleotide (FAD) ('flā-vən 'a-də-nēn dī-'nū-klē-ə-tid) A hydrogen carrier used in respiration.

flower ('flaur) A complex plant reproductive structure made from modified stems and leaves that produces pollen and eggs.

fluid-mosaic model ('flü-əd mō-'zā-ik 'mä-dəl) The concept that the cellular membrane is composed primarily of protein and phospholipid molecules that are able to shift and flow past one another.

follicles ('fă-li-kĕlz) Saclike structures near the surface of the ovary, which encases the soon-to-be-released secondary oocyte.

follicle-stimulating hormone (FSH) ('fă-li-kĕl 'stim-yə-lā-tiŋ 'hōr-mōn) The pituitary secretion that causes the ovaries to begin to produce larger quantities of estrogen and to develop the follicle and prepare the egg for ovulation.

food chain ('fūd 'chān) A sequence of organisms that feed on one another, resulting in a flow of energy from a producer through a series of consumers.

Food Guide Pyramid ('fūd 'gī d 'pir-ə-mid) A tool developed by the U.S. Department of Agriculture to help the general public plan for good nutrition; it contains guidelines for required daily intake from each of the six food groups.

food web ('fūd 'web) A system of interlocking food chains.

formed elements ('fōrm'd e-lə-mənts) Red, white blood cells and platelets suspended in a watery matrix called plasma.

formula ('fōr-myə-lə) Pertains to a chemical compound; describes what elements it contains (as indicated by a chemical symbol) and in what proportions they occur (as indicated by the subscript number).

fossil ('fă-səl) Physical evidence of former life.

founder effect ('faün-dər i-'fekt) The concept that small, newly established populations are likely to have reduced genetic diversity because of the small number of individuals in the founding population.

fovea centralis ('fō-vē-ə sen-'tra-ləs) The area of sharpest vision on the retina,

containing only cones, where light is sharply focused.

frameshift mutation ('frām-shift myü-'tā-shən) A form of mutation that occurs when insertions or deletions cause the ribosome to read the wrong sets of three nucleotides.

free-living nitrogen-fixing bacteria

('nī-trā-jən 'fiks-siŋ bak-'tir-ē-ə) Soil bacteria that convert nitrogen gas molecules into nitrogen compounds plants can use.

fruit ('früt) The structure (mature ovary) in angiosperms that contains seeds.

functional groups ('fōn-shnəl 'grüpəs)

Specific combinations of atoms attached to the carbon skeleton that determine specific chemical properties.

fungus ('fōn-gəs) The common name for members of the kingdom Fungi.

of structural and regulatory proteins.

gene expression ('jēn ik-'spre-shən) The cellular process of transcribing and translating genetic information.

gene flow ('jēn 'flō) The movement of genes within a population because of migration or the movement of genes from one generation to the next by gene replication and reproduction.

gene frequency ('jēn 'frē-kwən-sē) A measure of how often a specific gene shows up in the gametes of a population.

gene pool ('jēn 'pūl) All the genes of all the individuals of a species.

generative processes ('jen-rə-tiv 'prä-ses-es) Actions that increase the size of an individual organism (growth) or increase the number of individuals in a population (reproduction).

gene-regulator proteins ('jēn 're-gyə-lā-tər 'prō-tēns) Chemical messengers within a cell that inform the genes as to whether protein-producing genes should be turned on or off or whether they should have their protein-producing activities increased or decreased (e.g., gene-repressor proteins and gene-activator proteins).

gene therapy ('jēn 'ther-ə-pē) A technique that introduces new genetic material into an organism to correct a genetic deficiency.

genetically modified (GM) (jə-'ne-tik-lē 'mä-də-fid) Engineered to contain genes from at least one other species.

genetic bottleneck (jə-'ne-tik 'bä-təl-nek) The concept that, when populations are severely reduced in size, they may lose some of their genetic diversity.

genetic cross (jə-'ne-tik 'krōs) A planned breeding or mating between two organisms.

genetic diversity (jə-'ne-tik də-'vər-sə-tē) The degree to which individuals in a population possess alternative alleles for characteristics.

genetic drift (jə-'ne-tik 'drift) A change in gene frequency that is not the result of natural selection; this typically occurs in a small population.

genetic recombination (jə-'ne-tik rē-käm-bō-'nā-shən) The gene mixing that occurs during sexual reproduction.

genetics (jə-'ne-tiks) The study of genes, how genes produce characteristics, and how the characteristics are inherited.

G

gallbladder ('gōl-bla-dər) The organ, attached to the liver, that stores bile.

gametes ('ga-mēts) Haploid sex cells.

gametogenesis (gə-mē-tō-'je-nə-sēs) The generating of gametes; the meiotic cell-division process that produces sex cells; oogenesis and spermatogenesis.

gametophyte (gə-'mē-tō-fīt) A haploid plant that produces gametes; it alternates with the sporophyte through the life cycle.

gametophyte generation (gə-'mē-tō-fīt je-nə-rā-shən) A life cycle stage in plants in which a haploid sex cell is produced by mitosis.

gas ('gas) The phase of matter in which the molecules are more energetic than the molecules of a liquid, resulting in only a slight attraction for each other.

gastric juice ('gas-trik 'jüs) The secretions of the stomach; they contain enzymes and hydrochloric acid.

gene ('jēn) Any molecule usually segments of DNA, able to (1) replicate by directing the manufacture of copies of themselves; (2) mutate, or chemically change, and transmit these changes to future generations; (3) store information that determines the characteristics of cells and organisms; and (4) use this information to direct the synthesis

genome ('jē-nōm) A set of all the genes necessary to specify an organism's complete list of characteristics.

genomics (jē-'nō-miks) A new field of science that has developed since the sequencing of the human genome; the field looks at how genomes are organized and compares them with genomes of other organisms.

genotype ('jē-nō-tip) The catalog of genes of an organism, whether or not these genes are expressed.

genus ('jē-nəs) A group of closely related species within a family.

geographic isolation (jē-ə-'gra-fik ɪ-sə-'lā-shən) A condition in which part of the gene pool is separated by geographic barriers from the rest of the population.

glands ('glandz) Organs that manufacture and secrete a material either through ducts or directly into the circulatory system.

glomerulus (glo-'mer-ə-ləs) A cluster of blood vessels, surrounded by Bowman's capsule in the kidney.

glyceraldehyde-3-phosphate (gli-sə-'ral-də-hīd 3 'fās-fāt) A 3-carbon compound, produced during glycolysis and photosynthesis, that can be converted to other organic molecules.

glycerol ('gli-sə-rōl) One of the building blocks of a fat, composed of a carbon skeleton that has three alcohol groups (OH) attached to it.

glycolysis (glī-'kä-lë-sës) The anaerobic first stage of cellular respiration, consisting of the enzymatic breakdown of a sugar into two molecules of pyruvic acid.

Golgi apparatus ('gōl-jē a-pō-'ra-təs) A stack of flattened, smooth, membranous sacs; the site of synthesis and packaging of certain molecules in eukaryotic cells.

gonads ('gō-nads) Organs in which meiosis occurs to produce gametes; ovaries or testes.

gonadotropin-releasing hormone (GnRH) ('gō-nā-də-'trō-pōn ri-'lē-siñ 'hōr-mōn) A hormone released from the hypothalamus that stimulates the release of follicle-stimulating hormone (FSH) and luteinizing hormone (LH).

gradualism ('gra-jē-wə-li-zəm) A model for evolutionary change that assumes that evolution occurred slowly by accumulating small changes over a long period of time.

grana ('grā-nə) Stacks of sacs of the chloroplast membrane (thylakoids) where chlorophyll molecules are concentrated.

granules ('gran-yüł) Materials whose structure is not as well defined as that of other organelles.

growth-stimulating hormone (GSH) ('grōth stim-yō-lā-tin 'hōr-mōn) The hormone produced by the anterior pituitary gland that stimulates tissues to grow.

guanine ('gwā-nēn) A double-ring nitrogenous-base molecule in DNA and RNA; it is the complementary base of cytosine.

gymnosperms ('jim-nə-spōrmz) Plants that produce their seeds in cones.

H

habitat ('ha-bə-tat) The place or part of a community occupied by an organism.

habitat preference (ecological isolating mechanisms) ('ha-bə-tat 'pre-färns) Reproductive isolating mechanisms that prevent interbreeding between species because they live in different areas.

habituation (ha-bi-chō-'wā-shən) A change in behavior in which an animal ignores a stimulus after repeated exposure to it.

haploid ('ha-plōid) Having a single set of chromosomes, resulting from the reduction division of meiosis.

Hardy-Weinberg concept ('här-dē 'wīn-bōrg 'kän-sept) Populations of organisms will maintain constant gene frequencies from generation to generation as long as mating is random, the population is large, mutation does not occur, migration does not occur, and no genes provide more advantageous characteristics than others.

heart ('härt) The muscular pump that forces blood through the blood vessels of the body.

heat (hēt) The total internal kinetic energy of molecules.

hemoglobin ('hē-mō-glō-bōn) An iron-containing molecule found in red blood cells, to which oxygen molecules bind.

hepatic portal vein (hi-'pa-tik 'pōr-təl 'vān) A blood vessel that collects blood from capillaries in the intestine and delivers it to a second set of capillaries in the liver.

herbivores ('ər-bə-vōrz) Animals that feed directly on plants.

heterotrophs ('he-tə-rə-trōfs) Organisms that require a source of organic material from their environment; they cannot produce food on their own.

heterozygous ('he-tə-rə-ō-zī-güs) Describes a diploid organism that has 2 different alleles for a particular characteristic.

high-energy phosphate bond ('hī 'e-nər-jē 'fās-fāt 'bänd) The bond between two phosphates in an ADP or ATP molecule that readily releases its energy for cellular processes.

homeostasis (hō-mē-ō-'stā-sēs) The maintenance of a constant internal environment.

homeotherms (hō-mē-ō-'thōrmz) Animals that maintain a constant body temperature.

homologous chromosomes (hō-'mä-lə-gōz 'krō-mä-sōmz) A pair of chromosomes in a diploid cell that contain similar genes at corresponding loci throughout their length.

homologous structures (hō-'mä-lə-gōz 'sträk-chörz) Structures in different species that have been derived from a common ancestral structure.

homozygous (hō-mō-'zī-gōs) Describes a diploid organism that has 2 identical alleles for a particular characteristic.

hormone ('hōr-mōn) A chemical messenger secreted by an endocrine gland to regulate other parts of the body.

host ('hōst) An organism that a parasite lives in or on and uses as a source of food.

hybrid inviability ('hī-brōd in-vī-ə-'bi-lə-tē) Mechanisms that prevent the offspring of two different species from continuing to reproduce.

hydrogen bonds ('hī-drə-jēn 'bändz) Weak attractive forces between molecules; important in determining how groups of molecules are arranged.

hydrolysis reactions (hī-'drä-lə-sēs rē-'ak-shəns) Processes that occur when large molecules are broken down into smaller parts by the addition of water.

hydrophilic (hī-drə-'fi-lik) Readily absorbing or dissolving in water.

hydrophobic (hī-drə-'fō-bik) Tending not to combine with, or incapable of dissolving in, water.

hydroxide ions (hī-'dräk-sīd 'ī-ənz) Negatively charged particles (OH^-) composed of oxygen and hydrogen atoms released from a base when dissolved in water.

hypertonic (hī-pōr-'tā-nik) A comparative term describing one of two solutions; a hypertonic solution is one with higher amount of dissolved material.

hypothalamus (hī-pō-'tha-lō-məs) The region of the brain located in the floor of the thalamus and connected to the pituitary gland; it is involved in sleep and arousal; emotions, such as anger, fear, pleasure, hunger, sexual response, and pain; and automatic functions, such as temperature, blood pressure, and water balance.

hypothesis (hī-'pā-thē-sēs) A possible answer to or explanation for a question that accounts for all the observed facts and that is testable.

hypotonic (hī-pō-'tā-nik) A comparative term describing one of two solutions; a hypotonic solution is one with a lower amount of dissolved material.

immune system (ī-'myūn 'sis-tēm) The system of white blood cells specialized to provide the body with resistance to disease.

immunity (ī-'myü-nə-tē) The ability to maintain homeostasis by resisting or defending against potentially harmful agents including microbes, toxins, and abnormal cells such as tumor cells.

immunization ('i-myō-nā-zā-shōn) The technique used to induce the immune system to develop an acquired immunity to a specific disease by the use of a vaccine.

immunodeficiency diseases (i-myō-nō-di-'fi-shēn-sē di-'zēz) Disorders that result from the immune system not having one or more component cells or chemicals.

imperfect flower (im-'pōr-fikt 'flār) A flower that contains either male (stamens) or female (pistil) reproductive structures, but not both.

imprinting ('im-prin-tij) A form of learning that occurs in a very young animal that is genetically primed to learn a specific behavior in a very short period.

inclusions (in-'klü-zhōns) Materials inside a cell that are usually not readily identifiable; stored materials.

incomplete dominance (in-kōm-'plēt 'dā-mā-nōns) Occurs when the phenotype of a heterozygote is intermediate between the two homozygotes on a phenotypic gradient; that is, the phenotypes appear to be “blended” in heterozygotes.

incomplete proteins (in-kōm-'plēt 'prō-tēnз) Protein molecules that do not provide all the essential amino acids.

incus ('inj-kōs) The ear bone that is located between the malleus and the stapes.

independent assortment (in-dē-'pen-dənt ē-sōrt-mənt) The segregation, or assortment, of one pair of homologous chromosomes independently of the segregation, or assortment, of any other pair of chromosomes.

independent variable (in-dē-'pen-dənt 'ver-ē-ə-bəl) A variable that is purposely manipulated to determine how it will affect the outcome of an event.

inductive reasoning (induction) (in-'dēk-tiv 'rē-za-nij) (in-'dēk-shōn) The mental process of examining many sets of facts and developing generalizations; from the specific to the general.

inflammation (in-flā-'mā-shōn) A non-specific defense method that is a series of events that clear an area of harmful agents and damaged tissue.

ingestion (in-'jes-chōn) The process of taking food into the body through eating.

inguinal canal ('in-gwā-nəl kā-'nal) The opening in the floor of the abdominal cavity through which the testes in a human male fetus descend into the scrotum.

inhibitor (in-'hi-bō-tōr) A molecule that temporarily attaches itself to an enzyme, thereby interfering with the enzyme's ability to form an enzyme-substrate complex.

inorganic molecules (in-or-'ga-nik 'mä-li-yülz) Molecules that do not contain carbon atoms in rings or chains.

insertion mutation (in-'sōr-shōn myü-'tā-shōn) A change in DNA resulting from the addition of one or more nucleotides to the normal DNA sequence.

insight ('in-sit) Learning in which past experiences are reorganized to solve new problems.

instinctive behavior (in-'stiñ-tiv bi-'hā-vyōr) Automatic, preprogrammed, genetically determined behavior.

intermediate filaments (in-tär-'mē-dē-ət 'fi-lə-mənts) Protein fibers that connect microtubules and microfilaments as part of the cytoskeleton.

internal parasites (in-'tōr-nəl 'per-ə-sīt) Parasites that live inside their hosts.

interphase ('in-tär-fāz) The stage between cell divisions in which the cell is engaged in metabolic activities.

interspecific competition (in-tär-spi-'si-fik käm-pə-'ti-shōn) Interaction between two members of *different* species that is harmful to both organisms.

interspecific hybrids (in-tär-spi-'si-fik 'hī-brādz) Hybrids between two different species.

intraspecific competition (in-trä-spi-'si-fik käm-pə-'ti-shōn) Interaction between two members of the *same* species that is harmful to both organisms.

intraspecific hybrids (in-trä-spi-'si-fik 'hī-brādz) Organisms that are produced by the controlled breeding of separate varieties of the same species.

intrinsic limiting factors (in-'trin-zik 'li-mā-tiij 'fak-tōrz) Population-controlling factors that arise from within the population.

intron ('in-trän) Sequences of mRNA that do not code for protein.

inversion (in-'vər-zhōn) A chromosomal aberration in which a chromosome is broken and a piece becomes reattached to its original chromosome, but in a flipped orientation.

invertebrates (in-'vər-tə-brāts) Animals without backbones.

ion ('ī-ən) Electrically unbalanced or charged atoms.

ionic bonds (ī-'ä-nik 'bändz) The attractive forces between ions of opposite charge.

isotonic (ī-sō-'tā-nik) A term used to describe two solutions that have the same concentration of dissolved material.

isotope ('ī-sō-tōp) An atom of the same element that differs only in the number of neutrons.

K

kidneys ('kid-nēz) The primary organs involved in regulating blood levels of water, hydrogen ions, salts, and urea.

kilocalorie (kcal) ('kē-lō-ka-lē-rē) A measure of heat energy 1,000 times larger than a calorie; food Calories are kilocalories.

kinetic energy (kə-'ne-tik 'e-nər-jē) Energy of motion.

kinetic molecular theory (kə-'ne-tik mə-'le-kyə-lar 'thē-ə-rē) All matter is made up of tiny particles that are in constant motion.

kinetochore (kə-'ne-tō-kōr) A multi-protein complex attached to each chromatid at the centromere.

kingdom ('kjō-dəm) A classification category larger than a phylum and smaller than a domain.

Krebs cycle ('krebs 'sī-kəl) The series of reactions in aerobic cellular respiration that results in the production of two carbon dioxides, the release of four pairs of hydrogens, and the formation of an ATP molecule.

kwashiorkor (kwā-shē-'ör-kōr) A protein-deficiency disease, common in malnourished children, caused by prolonged protein starvation leading to reduced body size, lethargy, and low mental ability.

L

lacteal ('lak-tē-əl) A tiny lymphatic vessel located in a villus.

lactic acid fermentation ('lak-tik 'a-sēd fər-mən-'tā-shən) A process during which the pyruvic acid (CH_3COCOOH) that results from glycolysis is converted to lactic acid ($\text{CH}_3\text{CHOHCOOH}$) by the transfer of electrons that had been removed from the original glucose.

lag phase ('lag 'fāz) The period of time following colonization when a population remains small or increases slowly.

large intestine (also colon) ('lärg in-'tes-tən) The last portion of the food tube; it is primarily involved in reabsorbing water.

law of conservation of energy ('lō əv kän-sər-'vā-shən əv 'e-nər-jē) The law that states that energy is never created or destroyed.

Law of Dominance ('lō əv 'dä-mə-nəns) When an organism has 2 different alleles for a trait, the allele that is expressed and overshadows the expression of the other allele is said to be dominant; the allele whose

expression is overshadowed is said to be recessive.

Law of Independent Assortment ('lō əv in-de-'pen-dənt ə-'sōrt-mənt) Members of one allelic pair will separate from each other independently of the members of other allele pairs.

Law of Segregation ('lō əv se-gri-'gā-shən) When haploid gametes are formed by a diploid organism, the 2 alleles that control a trait separate from one another into different gametes, retaining their individuality.

leaf ('lēf) Plant structure specialized for carrying out the process of photosynthesis.

learned behavior ('lərn'd bi-'hā-vyör) A change in behavior as a result of experience.

learning ('lərn-inj) A change in behavior as a result of experience.

lichen ('li-chən) An organism comprised of a fungus and an alga protist or cyanobacterium existing in a mutualistic relationship.

light-capturing events ('lit 'kap-chər-in i'-vent) The first stage in photosynthesis; involves photosynthetic pigments capturing light energy in the form of excited electrons.

light-dependent reactions ('lit di-'pen-dənt rē-'ak-shəns) The second stage in photosynthesis, during which excited electrons from the light-capturing events are used to make ATP, and water is broken down to hydrogen and oxygen. The hydrogens are transferred to electron carrier coenzymes, NADP⁺.

light-independent reactions ('lit in-di-'pen-dənt rē-'ak-shəns) The third stage of photosynthesis; involves cells using ATP and NADPH from the light-dependent reactions to attach CO₂ to 5-carbon starter molecules to manufacture organic molecules (e.g., glucose [$\text{C}_6\text{H}_{12}\text{O}_6$]).

limiting factors ('li-mə-tin 'fak-tərz) Environmental influences that limit population growth.

limnetic zone (lim-'ne-tik 'zōn) In freshwater ecosystems, the portion of a lake that does not have rooted vegetation.

linkage ('lin-kij) A situation in which the genes for different characteristics are inherited together more frequently than would be predicted by probability.

linkage group ('lin-kij 'grüp) A group of genes located on the same chro-

mosome that tend to be inherited together.

lipids ('li-pədz) Large organic molecules that do not easily dissolve in water; classes include true (neutral) fats, phospholipids, and steroids.

liquid ('li-kwəd) The phase of matter in which the molecules are strongly attracted to each other, but, because they have more energy and are farther apart than in a solid, they move past each other more freely.

littoral zone ('li-tō-räl 'zōn) In freshwater ecosystems, the region with rooted vegetation.

locus ('lō-küs) The spot on a chromosome where an allele is located.

loop of Henle ('lüp 'əv 'hen-lē) The middle portion of the nephron; primarily involved in regulating the amount of water lost from the kidney.

lung ('lōŋ) Organs of the body that allow gas exchange to take place between the air and blood.

luteinizing hormone (LH) (lü-tē-ən-ī-zin 'hōr-mōn) A hormone produced by the anterior pituitary gland, which stimulates ovulation.

lymph ('limf) Liquid material that leaves the circulatory system to surround cells.

lymphatic system (lim-'fa-tik 'sis-təm) A collection of thin-walled tubes that collect, filter, and return lymph from the body to the circulatory system.

lymph nodes ('limf 'nōdz) Small encapsulated bodies found along the lymph vessels that contain large numbers of white blood cells (WBCs), macrophages, and lymphocytes that remove microorganisms and foreign particles from the lymph.

lysosomes ('li-sə-sōmz) Specialized, submicroscopic organelles that hold a mixture of hydrolytic enzymes.

M

macromolecules (ma-krō-'mä-li-kyüls) Very large molecules, many of which are composed of many smaller, similar monomers that are chemically bonded together.

malignant tumors (mə-'lig-nənt 'tü-mərz) Nonencapsulated growths of tumor cells that are harmful; they may spread to or invade other parts of the body.

- malleus** ('ma-lē-əs) The ear bone that is attached to the tympanum.
- mass number** ('mas 'nəm-bər) The weight of an atomic nucleus expressed in atomic mass units (the sum of the protons and neutrons).
- masturbation** (mas-tər-'bā-shən) Stimulation of one's own sex organs.
- matter** ('ma-tər) Anything that has weight (mass) and takes up space (volume).
- mechanical (morphological) isolating mechanisms** (mi'-ka-ni-kəl [mōr'-fā-lā-jī-kəl] 'i-sə-lā-tij 'me-kə-ni-zəm) Structural differences that prevent mating between members of different species.
- medulla oblongata** (mə-'də-lə ə-blōng'-gā-tə) The region of the more primitive portion of the brain, connected to the spinal cord, that controls such automatic functions as blood pressure, breathing, and heart rate.
- medusa** (mi'-dū-sə) A free-swimming adult stage in the phylum Cnidaria that reproduces sexually.
- meiosis** (mī'-ō-sēs) The specialized pair of cell divisions that reduces the chromosome number from diploid ($2n$) to haploid (n).
- meiosis I** (mī'-ō-sēs 'wən) The first stage in a form of cell division involved in the production of gametes; results in the reduction of the number of chromosomes from $2n$ (diploid) to n (haploid).
- meiosis II** (mī'-ō-sēs 'tū) The second stage in a form of cell division involved in the production of gametes; results in the doubling of the number of newly produced haploid cells from meiosis I.
- Mendelian genetics** (men'-dē-lē-ən jē'-ne-tiks) The pattern of inheriting characteristics that follows the laws formulated by Gregor Mendel.
- menopause** ('me-nə-pōz) The period beginning at about age 50 when the ovaries stop producing viable secondary oocytes and ovarian hormones.
- menstrual cycle** ('men-strü-əl 'sī-kəl) The repeated building up and shedding of the lining of the uterus.
- mesenteries** ('me-zən-ter-ēz) Connective tissues that hold the organs in place and serve as support for blood vessels connecting the various organs.
- mesoderm** ('me-zə-dərm) The middle embryonic layer.
- messenger RNA (mRNA)** ('me-sən-jər) A molecule composed of ribonucleotides that functions as a copy of the gene and is used in the cytoplasm of the cell during protein synthesis.
- metabolism** (mə-'ta-bə-li-zəm) The total of all the chemical reactions and energy changes that take place in an organism.
- metaphase** ('me-tə-fāz) The second stage in mitosis, characterized by alignment of the chromosomes at the equatorial plane.
- metastasize** (mə-'tas-tə-sīz) The process by which cells of tumors move from the original site and establish new colonies in other regions of the body.
- microfilaments** (mī-krō-'fi-lə-mənts) Long, fiberlike, submicroscopic structures made of protein and found in cells, often in close association with the microtubules; provide structural support and enable movement.
- microorganism (microbe)** (mī-krō-'ör-gə-nizmə) A small organism that cannot be seen without magnification.
- microtubules** (mī-krō-'tü-byüls) Submicroscopic, hollow tubes of protein that function throughout the cytoplasm to provide structural support and enable movement.
- minerals** ('min-rəlz) Inorganic elements that cannot be manufactured by the body but are required in low concentrations; essential to metabolism.
- missense mutation** ('mīs-sens myü-'tā-shən) A change in the DNA at a single point that causes the wrong amino acid to be used in making a protein.
- mitochondria** (mī-tə-'kān-drē-ə) Membranous organelles resembling small bags with a larger bag inside that is folded back on itself; serve as the site of aerobic cellular respiration.
- mitosis** (mī-'tō-sēs) A process that results in equal and identical distribution of replicated chromosomes into two newly formed nuclei.
- mixture** ('miks-chər) Matter that contains two or more substances *not* in set proportions.
- molecules** ('mä-li-kyüł) The smallest particles of a chemical compound; the smallest naturally occurring parts of an element or a compound.
- monocot** ('mä-nə-kät) An angiosperm whose embryo has one seed leaf (cotyledon).
- monoculture** ('mä-nə-kəl-chər) The agricultural practice of planting the same varieties of a species over large expanses of land.
- monohybrid cross** (mä-nō-'hī-brəd 'krōs) A mating between two organisms that are both heterozygous for the one observed gene.
- monosomy** (mä-nō-'sō-mē) A cell with only 1 of the 2 chromosomes of a homologous pair.
- mortality** (mōr'-ta-lə-tē) The number of individuals leaving the population by death per thousand individuals in the population.
- motor neurons** ('mō-tər 'nū-rənz) Neurons that carry information from the central nervous system to muscles or glands.
- motor unit** ('mō-tər 'yü-nət) All the muscle cells stimulated by a single neuron.
- multigene families** ('məl-tə-jēn 'fam-lēz) A type of variation in an organism's DNA sequence; this variation consists of several different genes that produce different proteins that are related in function.
- multiple alleles** ('məl-tə-pəl ə-'lēlz) Several different alleles for a particular characteristic within a population, not just 2.
- multiregional hypothesis** ('məl-tə-rēj-nəl hī-'pä-thə-səs) The concept that *Homo erectus* migrated to Europe and Asia from Africa and evolved into *Homo sapiens*.
- mutagens** ('myü-tə-jən) Agents that mutate, or chemically damage, DNA.
- mutation** (myü-'tā-shən) Any change in the genetic information of a cell.
- mutualism** ('myü-chə-wə-li-zəm) A relationship between two organisms in which both organisms benefit.
- mycorrhizae** (mī-kə-'rī-zē) Symbiotic relationships between fungi and plant roots.
- mycotoxins** (mī-kə-'täk-sənz) Deadly poisons produced by fungi.
- myosin** ('mī-ə-sən) The protein molecule, found in the thick filaments of muscle fibers, that attaches to actin, bends, and moves actin molecules along its length, causing the muscle fiber to shorten.
- N**
- natality** (nā-'ta-lə-tē) The number of individuals entering the population by reproduction per thousand individuals in the population.
- negative-feedback inhibition** ('ne-gə-tiv 'fēd-bak in-hə-'bi-shən) A regulatory

mechanism in which an increase in the stimulus causes a decrease of the response and results in homeostasis.

nekton ('nek-tən) Many kinds of aquatic animals that are large enough and strong enough to be able to swim against currents and tides and go where they want to.

nephrons ('ne-fräñz) Tiny tubules that are the functional units of kidneys.

nerve cell ('nərv 'sel) The basic unit of the nervous system that consists of a central body and several long fibrous extensions.

nerve impulse ('nərv 'im-pəls) A series of changes that take place in the neuron, resulting in a wave of depolarization, which passes from one end of the neuron to the other.

nerves ('nərvz) Bundles of neuronal fibers.

nervous system ('nər-vəs 'sis-təm) A network of neurons that carry information from sense organs to the central nervous system and from the central nervous system to muscles and glands.

net movement ('net 'müv-mənt) Movement in one direction minus the movement in the other.

neuron (nerve cell) ('nü-rän) The cellular unit consisting of a cell body and fibers that makes up the nervous system.

neurotransmitter (nür-ō-trans-'mi-tər) A molecule released by the axons of neurons that stimulates other cells.

neutron ('nü-trän) A particle in the nucleus of an atom that has no electrical charge; named *neutron* to reflect this lack of electrical charge.

niche ('nich) An organism's specific functional role in its community.

nicotinamide adenine dinucleotide (NAD⁺) (ni-kə-'tē-nə-mīd 'a-də-nēn dī-'nü-klē-ə-tīd) An electron acceptor and hydrogen carrier used in respiration.

nitrifying bacteria ('nī-trī-fī-ij bak-'tir-ē-ə) Several kinds of bacteria capable of converting ammonia to nitrite, or nitrite to nitrate.

nitrogen cycle ('nī-trə-jən 'sī-kəl) The cycling of nitrogen atoms between the abiotic and biotic components and among the organisms in an ecosystem.

nitrogen-fixing bacteria ('nī-trə-jən 'fik-sij bak-'tir-ē-ə) Bacteria that are able to

convert the nitrogen gas (N₂) that enters the soil into ammonia that plants can use.

non-coding strand (nän-'kō-dīg 'strand) The strand of DNA that is not read directly by the enzymes.

nondeciduous (nän-di-'si-jə-wəs) A type of tree that does not lose its leaves all at once.

nondisjunction (nän-dis-'jən-shən) An abnormal meiotic division that results in sex cells with too many or too few chromosomes.

noneukaryotic (nän-ker-ē-'ä-tik) One of two general types of living cells: eukaryotic and noneukaryotic. Two forms of noneukaryotic organisms are recognized: Bacteria and Archaea.

non-homologous chromosomes (nän-hō-'mä-lə-gəs 'krō-mə-sōmz)

Chromosomes that have different genes on their DNA.

nonsense mutation ('nän-sens myü-'tā-shən)

A type of point mutation that causes a ribosome to stop protein synthesis by introducing a stop codon too early.

norepinephrine (nór-e-pä-'ne-frēn) The hormone produced by the adrenal medulla and certain nerve cells that increases heart rate, blood pressure, and breathing rate.

nuclear membrane ('nü-klē-ər 'mem-brān) The structure surrounding the nucleus that separates the nucleoplasm from the cytoplasm.

nucleic acids (nū-'klē-ik 'a-sədz) Complex molecules that store and transfer information within a cell. They are constructed of fundamental monomers known as nucleotides.

nucleolus (nū-'klē-ə-lüs) A nuclear structure composed of completed or partially completed ribosomes and the specific parts of chromosomes that contain the information for their construction.

nucleoplasm ('nü-klē-ə-pla-zəm) The liquid matrix of the nucleus, composed of a mixture of water and the molecules used in the construction of the rest of the nuclear structures.

nucleoprotein (nū-klē-ō-'prō-tēn) DNA strands with attached proteins that become visible during cell division.

nucleosome (nū-klē-ō-sōm) Histone protein with their encircling DNA.

nucleotides ('nū-klē-ə-tīdz) Fundamental subunits of nucleic acid constructed

of a phosphate group, a sugar, and an organic nitrogenous base.

nucleus ('nü-klē-əs) The central body that contains the information system for the cell; also the central part of an atom, containing protons and neutrons.

nutrients ('nü-trē-ənts) Molecules required by organisms for growth, reproduction, or repair.

nutrition (nū-'tri-shən) Collectively, the processes involved in taking in, assimilating, and utilizing nutrients.

obesity (ō-'bē-sə-tē) The condition of being overweight to the extent that a person's health, quality of life, and life span are adversely affected.

observation (äb-sər-'vā-shən) The process of using the senses or extensions of the senses to record events.

observational learning (imitation) (äb-sər-'vā-shən-əl 'lōrn-ij) A form of association that involves a complex set of associations used in watching another animal being rewarded for performing a particular behavior and then performing the same behavior oneself.

offspring ('öf-sprinj) Descendants of a set of parents.

olfactory epithelium (äl-'fak-trē e-pə-'thē-əm) The cells of the nasal cavity that respond to chemicals.

omnivores ('äm-ni-vörz) Animals that are carnivores at some times and herbivores at others.

oogenesis (ō-ə-'je-nə-sēs) The gametogenesis process that leads to the formation of eggs.

operant (instrumental) conditioning ('ä-pə-rənt kən-'di-shnij) A change in behavior that results from associating a stimulus with a response by either rewarding or punishing the behavior after it has occurred.

order ('ör-dər) A group of closely related classes within a phylum.

organ ('ör-gən) A structure composed of groups of tissues that perform particular functions.

organelles (ör-gə-'nelz) Cellular structures that perform specific functions in the cell; the function of organelles is directly related to their structure.

organic molecules (ó'r'-gá-nik 'mä-li-kyü'lz) Complex molecules whose basic building blocks are carbon atoms in chains or rings.

organism ('ór-gó-ni-zóm) An independent living unit.

organ system ('ór-gén 'sis-tém) A structure composed of groups of organs that perform particular functions.

orgasm ('ór-gá-zóm) The complex series of responses to sexual stimulation that results in an intense frenzy of sexual excitement.

osmosis (äz-'mō-sës) The net movement of water molecules through a selectively permeable membrane.

osteoporosis (äs-té-ö-pö-'rō-sës) A disease condition resulting from the demineralization of the bone, resulting in pain, deformities, and fractures; related to a loss of calcium.

out-of-Africa hypothesis ('aut əv 'a-fri-kə hī-'pä-thë-sës) The concept that modern humans (*Homo sapiens*) originated in Africa and migrated from Africa to Europe and Asia and displaced existing hominins.

oval window ('ō-väl 'win-dö) The membrane-covered opening of the cochlea, to which the stapes is attached.

ovaries ('ō-vä-rëz) Female sex organs, which produce haploid sex cells, called eggs.

oviduct ('ō-vë-dëkt) The tube (*fallopian tube*) that carries the egg to the uterus.

ovulation (äv-yë-'lä-shëñ) The release of a secondary oocyte from the surface of the ovary.

oxidation-reduction reaction (äk-së-'dä-shëñ ri-'dëk-shëñ rë-'ak-shëñ) An electron-transport reaction in which the molecules losing electrons become oxidized and those gaining electrons become reduced.

oxidizing atmosphere ('äk-së-dëz-ëj 'at-mësfir) An atmosphere that contains molecular oxygen.

oxytocin (äk-së-'tö-sëñ) The hormone, released from the posterior pituitary, that causes contraction of the uterus.

P

pancreas ('pan-kré-ës) The organ of the body that secretes many kinds of digestive enzymes into the duodenum.

panspermia ('pan-spër-më-ë) A hypothesis by Svante Arrhenius in the early 1900s

that life arose outside the Earth and that living things were transported to Earth to seed the planet with life.

parasite ('per-ä-sít) An organism that lives in or on another organism and derives nourishment from it.

parasitism ('per-ä-sö-ti-züm) A relationship between two organisms that involves one organism living in or on another organism and deriving nourishment from it.

pathogens ('pa-thë-jënz) Agents that cause specific diseases.

pelagic (pë-'la-jik) Aquatic organisms that are not attached to the bottom.

pelagic ecosystem (pë-'la-jik 'ë-kö-sis-tém) An aquatic ecosystem which exists in open water in which the organisms are not attached to the bottom.

penetrance ('pe-në-trans) A term used to describe how often an allele expresses itself when present.

pepsin ('pep-sëñ) The enzyme, produced by the stomach, that is responsible for beginning the digestion of proteins.

perception (për-'sep-shëñ) Recognition by the brain that a stimulus has been received.

perfect flower ('për-fikt 'flair) A flower that contains both male (stamen) and female (pistil) reproductive structures.

peripheral nervous system (pë-'ri-frö'l nör-vüs 'sis-tém) The fibers that communicate between the central nervous system and other parts of the body.

peroxisomes (pë-'räk-së-sömz) Membrane-bound, submicroscopic organelles that hold enzymes capable of producing hydrogen peroxide that aids in the control of infections and other dangerous compounds.

petals ('pe-töls) Modified leaves of angiosperms; accessory structures of a flower.

pH A scale used to indicate the concentration of an acid or a base.

phagocytosis (fa-gë-së-'tö-sës) The process by which the cell wraps around a particle and engulfs it.

pharynx ('fa-riëjs) The region at the back of the mouth cavity; the throat.

phases of matter ('fázëz əv 'ma-tér) Physical conditions of matter (solid, liquid, and gas) determined by the relative amounts of energy of the molecules.

phenotype ('fë-nö-típ) The physical, chemical, and behavioral expression of the genes possessed by an organism.

pheromones ('fer-ä-möñz) Chemicals produced by an animal and released into the environment to trigger behavioral or developmental processes in another animal of the same species.

phloem ('flö-em) One kind of vascular tissue found in higher plants; it transports food materials from the leaves to other parts of the plant.

phospholipids (fäs-fö-'li-pödz) A class of water-insoluble molecules that resembles fats but contains a phosphate group (PO_4) in its structure.

phosphorylation reaction (fäs-för-ä-'lă-shëñ rë-'ak-shëñ) The reaction that takes place when a cluster of atoms, known as a phosphate group, is added to another molecule.

photoperiod (fö-tö-'pir-ë-öd) The length of the light part of the day.

photosynthesis (fö-tö-'sin-thë-sës) A series of reactions that take place in chloroplasts and results in the storage of sunlight energy in the form of chemical-bond energy.

photosystems (fö-tö-'sis-témz) Clusters of photosynthetic pigments (e.g., chlorophyll) that serve as energy-gathering or energy-concentrating mechanisms; used during the light-capturing events of photosynthesis.

phylogeny (fë-'lä-jë-në) The science that explores the evolutionary relationships among organisms and seeks to reconstruct evolutionary history.

phylum ('fë-lëm) A subdivision of a kingdom.

phytoplankton (fë-tö-'plän-tön) Microscopic, photosynthetic species that form the basis for most aquatic food chains.

pinocytosis (pi-nä-së-'tö-sës) The process by which a cell engulfs some molecules dissolved in water.

pioneer community (pí-ä-'nir kë-'myü-nä-të) The first community of organisms in the successional process established in a previously uninhabited area.

pioneer organisms (pí-ä-'nir 'ór-gë-ni-zëms) The first organisms in the successional process.

pistil ('pis-töl) The female reproductive structure in flowers; contains the ovary, which produces eggs.

pituitary gland (pə-tü-ə-ter-ē 'gland) The gland at the base of the brain that controls the functioning of other glands throughout the organism.

placenta (pla-sen-tə) An organ made up of tissues from the embryo and the uterus of the mother; allows for the exchange of materials between the mother's bloodstream and the embryo's bloodstream; also produces hormones.

plankton ('plān-ktōn) Small, floating or weakly swimming organisms.

plasma ('plaz-mə) The watery matrix that contains the molecules and cells of the blood.

plasma membrane (cell membrane) ('plaz-mə 'mem-brān) The outer boundary membrane of the cell.

plasmid ('plaz-məd) A plasmid is a circular piece of DNA that is found free in the cytoplasm of some bacteria.

platelets ('plat-ləts) Fragments of specific kinds of white blood cells; important in blood clotting.

pleiotropy ('plī-ä-trö-pē) The multiple effects that a gene may have on the phenotype of an organism.

poikilotherms (poi'-kē-lō-thərmz) Animals with a variable body temperature that changes with the external environment.

point mutation ('point myü-'tā-shən) A change in the DNA of a cell as a result of a loss or change in a nitrogenous-base sequence.

polar body ('pō-lər 'bä-dē) The smaller of two cells formed by unequal meiotic division during oogenesis.

pollen ('pä-lən) The male gametophyte in gymnosperms and angiosperms.

pollination (pä-la-'nā-shən) The transfer of pollen in gymnosperms and angiosperms.

polygenic inheritance ('pä-lē-jēn in-'her-ə-təns) The concept that a number of different pairs of alleles may combine their efforts to determine a characteristic.

polymerase chain reaction (PCR) (pə-'lim-ə-rās 'chān rē-'ak-shən) A laboratory technique that is able to generate useful quantities of DNA from very small amounts of DNA.

polymers ('pä-lə-mərs) Combinations of many smaller, similar building blocks called monomers (mono = single) bonded together.

polyp ('pä-ləp) A sessile larval stage in the phylum Cnidaria that reproduces asexually.

polypeptide (pä-lē-'pep-tīd) A macromolecule composed of a specific sequence of amino acids.

polyploidy ('pä-lē-plōid) A condition in which cells contain multiple sets of chromosomes.

pons ('pānz) The region of the brain, immediately anterior to the medulla oblongata, that connects to the cerebellum and higher regions of the brain and controls several sensory and motor functions of the head and face.

population (pä-pyə-'lā-shən) A group of organisms of the same species located in the same place at the same time.

population density (pä-pyə-'lā-shən 'den-sə-tē) The number of organisms of a species per unit area.

population distribution (pä-pyə-'lā-shən dis-trə-'byü-shən) The way individuals within a population are arranged with respect to one another.

population genetics (pä-pyə-'lā-shən jē-'ne-tiks) The study of the kinds of genes within a population, their relative numbers, and how these numbers change over time.

population growth curve (pä-pyə-'lā-shən 'grōth 'kərv) A graph of the change in population size over time.

population pressure (pä-pyə-'lā-shən 'pre-shər) Intense competition as a result of high population density that leads to changes in the environment and the dispersal of organisms.

positive feedback ('pä-zə-tiv 'fēd-bak) A regulatory mechanism in which an increase in the stimulus causes an increase of the response and does not result in homeostasis.

potential energy (pə-'ten-shəl 'e-nər-jē) The energy an object has because of its position.

predation (pri-'dā-shən) A relationship between two organisms that involves the capturing, killing, and eating of one by the other.

predator ('pre-də-tər) An organism that captures, kills, and eats another animal.

prey ('prā) An organism captured, killed, and eaten by a predator.

primary carnivores ('prī-mer-ē 'kär-nə-vörz) Carnivores that eat herbivores and are therefore on the third trophic level.

primary consumers ('prī-mer-ē kən-'sü-mərs) Organisms that feed directly on plants—herbivores.

primary succession ('prī-mer-ē sək-'səshən) The orderly series of changes that begins in a previously uninhabited area and leads to a climax community.

prions ('prī-äñz) Infectious protein particles responsible for diseases such as Creutzfeldt-Jakob disease and bovine spongiform encephalitis.

probability (prä-bə-'bi-lə-tē) The chance that an event will happen, expressed as a percentage or fraction.

producers (prə-'dū-sərz) Organisms that produce new organic material from inorganic material with the aid of sunlight.

productivity (prō-dək-'ti-və-tē) The rate at which an ecosystem can accumulate new organic matter.

products ('prä-dəkt̄s) New molecules resulting from a chemical reaction.

prokaryotes (prō-'ka-rē-ōts) Organisms that do not have a nucleus in their cells; Bacteria and Archaea.

prokaryotic cells (prō-ka-rē-'ä-tik 'səls) One of the two major types of cells; now referred to as noneukaryotic cells. They do not have a typical nucleus bound by a nuclear membrane and lack many of the other membranous cellular organelles—for example, members of Bacteria and Archaea.

promoter sequences (prə-'mō-tər 'sē-kwəns) Specific sequences of DNA nucleotides that RNA polymerase uses to find a protein-coding region of DNA and to identify which of the two DNA strands is the coding strand.

prophase ('prō-fāz) The first phase of mitosis, during which individual chromosomes become visible.

proteins ('prō-tēn̄s) Macromolecules made up of one or more polypeptides attached to each other by bonds.

protein-sparing ('prō-tēn̄ 'spe-riŋ) The conservation of proteins by first oxidizing carbohydrates and fats as a source of ATP energy.

proteomics (prō-tē-'ō-miks) A new field of science that has developed since the sequencing of the human genome; it groups proteins by similarities to help explain their function and how they may have evolved.

proton ('prō-tān̄) The particle in the nucleus of an atom that has a positive electrical charge.

proto-oncogene (prō-tō-'äj-kō-jēn) Genes that code for proteins that provide signals to the cell that encourage cell division.

protoplasm ('prō-tō-pla-zəm) The living portion of a cell, as distinguished from the nonliving cell wall.

protozoa (prō-tō-'zō-ä) Heterotrophic, eukaryotic, unicellular organisms.

proximal convoluted tubule ('präk-sə-məl 'kän-və-lü-təd 'tü-byüł) The upstream end of the nephron of the kidney; is responsible for reabsorbing most of the valuable molecules filtered from the glomerulus into Bowman's capsule.

pseudocoelom (sü-dō-'sē-ləm) A body cavity located between the lining of the gut and the outer body wall and does not have muscles around the digestive system; the word means false body cavity.

pseudoscience (sü-dō-'sī-əns) An activity that uses the appearance or language of science to convince or mislead people into thinking that something has scientific validity.

puberty ('pyü-bər-tē) A time in the life of a developing individual characterized by the increasing production of sex hormones, which cause it to reach sexual maturity.

pulmonary artery ('pūl-mə-när-ē 'är-tə-rē) The major blood vessel that carries blood from the right ventricle to the lungs.

pulmonary circulation ('pūl-mə-när-ē sər-kyə-'lā-shən) The flow of blood through certain chambers of the heart and blood vessels to the lungs and back to the heart.

punctuated equilibrium ('pənj-chə-wā-təd ē-kwə-'li-brē-əm) The theory stating that evolution occurs in spurts, between which there are long periods with little evolutionary change.

Punnett square ('pə-nət 'skwer) A method used to determine the probabilities of allele combinations in a zygote.

pyloric sphincter (pī-'lōr-ik 'sfīñ-tər) The valve located at the end of the stomach that regulates the flow of food from the stomach to the duodenum.

R

radial symmetry ('rā-dē-əl 'si-mə-trē) The characteristic of an animal with a body constructed around a central axis; any division of the body along this axis results in two similar halves.

reactants (rē-'aktənts) Materials that will be changed in a chemical reaction.

receptor mediated endocytosis (ri-'sep-tər 'mē-dē-ä-təd en-dō-sī-'tō-səs) The process in which molecules from the cell's surroundings bind to receptor molecules on the plasma membrane, followed by the membrane folding into the cell so that the cell engulfs these molecules.

recessive allele (ri-'se-siv ə-'lēl) An allele that, when present with its homolog, does not express itself and is masked by the effect of the other allele.

recombinant DNA (rē-'käm-bə-nənt) DNA that has been constructed by inserting new pieces of DNA into the DNA of an organism.

red blood cells (rbcs) ('red 'blōd 'sels) Small, disk-shaped cells that lack a nucleus and contain the iron-containing pigment hemoglobin.

reducing atmosphere (ri-'düs-ihj 'at-mə-sfir) An atmosphere that does not contain molecular oxygen (O_2).

reduction division (ri-'dək-shən də-'vīzhən) A type of cell division in which daughter cells get only half the chromosomes from the parent cell.

regulator proteins ('re-gyə-lā-tər 'prō-tēnз) Proteins that influence the activities that occur in an organism—for example, enzymes and some hormones.

reproductive capacity (biotic potential) (rē-prō-'dək-tiv kə-'pa-sə-tē) The theoretical maximum rate of reproduction.

reproductive (genetic) isolating mechanisms (rē-prō-'dək-tiv 'i-sə-lā-tiij 'me-kə-nizəmz) Mechanisms that prevent interbreeding between species.

respiratory system ('res-prō-tōr-ē 'sis-təm) The organ system that moves air into and out of the body and consists of lungs, trachea, the air-transport pathway, and diaphragm.

response (ri-'späns) The reaction of an organism to a stimulus.

responsive processes (ri-'spän-siv 'prä-se-səs) Abilities to react to external and internal changes in the environment—for example, irritability, individual adaptation, and evolution.

restriction enzymes (ri-'strik-shən 'en-zīmz) Proteins that catalyze the cutting of the DNA helix; these proteins cut the DNA helix into two pieces at specific DNA sequences.

restriction fragments (ri-'strik-shən 'frag-mənts) Pieces of DNA that are created by cutting DNA with restriction enzymes; restriction fragments are used in cloning and characterizing DNA.

restriction sites (ri-'strik-shən 'sīts) The DNA sequence that is recognized by a restriction enzyme; the restriction enzyme cuts at this sequence, generating two DNA fragments.

retina ('re-tə-nə) The light-sensitive region of the eye.

rhodopsin (rō-'däp-sən) A light-sensitive pigment found in the rods of the retina.

ribonucleic acid (RNA) (rī-bō-nū-'klē-ik 'a-sad) A polymer of nucleotides formed on the template surface of DNA by transcription; three forms are mRNA, rRNA, and tRNA.

ribosomal RNA (rRNA) (rī-bə-'sō-məl) A globular form of RNA; a part of ribosomes.

ribosomes ('rī-bə-sōmz) Small structures composed of two protein and ribonucleic acid subunits, involved in the assembly of proteins from amino acids.

ribulose ('rī-byə-lōs) A 5-carbon sugar molecule used in photosynthesis.

ribulose-1,5-bisphosphate carboxylase/oxygenase (RuBisCO) ('rī-byə-lōs bī-'fäs-fät kär-'bák-sə-lās 'āk-si-jə-nās) An enzyme found in the stroma of chloroplast that speeds the combining of the CO_2 with an already present 5-carbon carbohydrate, ribulose.

RNA polymerase (rō-'lim-ə-rās) An enzyme that bonds RNA nucleotides together during transcription after they have aligned on the DNA.

rods ('rädz) Light-sensitive cells in the retina of the eye that respond to low-intensity light but do not respond to different colors of light.

root ('rüt) Underground structures that anchor the plant and absorb water and minerals.

root hairs ('rüt 'hers) Tiny cellular outgrowths of roots that improve the ability of plants to absorb water and minerals.

S

salivary glands ('sa-lə-ver-ē 'glandz) Glands that produce saliva.

salts ('sôltz) Ionic compounds formed from a reaction between an acid and a base.

saprophytes ('sa-prə-fīts) Organisms that obtain energy by the decomposition of dead organic material.

saturated ('sa-chə-rā-təd) A term used to describe the carbon skeleton of a fatty acid that contains no double bonds between carbons.

science ('sī-əns) A process used to solve problems or develop an understanding of natural events.

scientific law (sī-ən-'ti-fik 'lō) A uniform or constant fact that describes what happens in nature.

scientific method (sī-ən-'ti-fik 'me-thəd) A way of gaining information (facts) about the world around you that involves observation, hypothesis formation, testing of hypotheses, theory formation, and law formation.

seasonal isolating mechanisms ('sēz-nəl 'ī-sə-lā-tīng 'me-kə-ni-zəmz) Reproductive isolating mechanisms that prevent interbreeding between species because they reproduce at different times of the year.

secondary carnivores ('se-kən-der-ē 'kär-nō-vörz) Carnivores that feed on primary carnivores and are therefore at the fourth trophic level.

secondary consumers ('se-kən-der-ē kən-'sü-mərз) Animals that eat other animals—carnivores.

secondary sexual characteristics ('se-kən-der-ē 'sek-shwəl ker-ik-tō-'ris-tiks) Characteristics of the adult male or female, including the typical shape that develops at puberty: broader shoulders; heavier long-bone muscles; development of facial hair, axillary hair, and chest hair; and changes in the shape of the larynx in the male; rounding of the pelvis and breasts and changes in deposition of fat in the female.

secondary succession ('se-kən-der-ē sek-'seshən) The orderly series of changes that begins with the disturbance of an existing community and leads to a climax community.

seed ('sēd) A specialized structure that contains an embryo along with stored food enclosed in a protective covering called the seed coat.

seed leaves ('sēd 'lēvz) Cotyledons; embryonic leaves in seeds.

segmental duplications (seg-'men-təl dü-pli-'kā-shənz) A type of variation in an organism's DNA sequence; this variation occurs when a segment of

DNA, which may contain several genes, occurs twice in the genome.

segmentation (seg-mən-'tā-shən) The separation of the body of an animal into a number of recognizable units from the anterior to the posterior end of the animal.

segregation (se-gri-'gā-shən) The separation and movement of homologous chromosomes to the opposite poles of the cell.

selecting agents (sə-'lek-tīng 'ā-jənts) Factors that affect the probability that a gene will be passed on to the next generation.

selectively permeable (sə-'lek-tiv-lē 'pər-mē-ə-bəl) The property of a membrane that allows certain molecules to pass through it but interferes with the passage of others.

semen ('sē-mən) The sperm-carrying fluid produced by the seminal vesicles, prostate gland, and bulbourethral glands of males.

semicircular canals (se-mē-'sər-kyo-lər kə-'nalz) A set of tubular organs, associated with the cochlea, that sense changes in the movement or position of the head.

semilunar valves (se-mē-'lū-nər 'valvz) Valves, located in the pulmonary artery and aorta, that prevent the flow of blood backwards, into the ventricles.

seminiferous tubules (se-mə-'ni-frəs 'tü-byülz) Sperm-producing tubes in the testes.

sensory neurons ('sens-rē 'nū-rānz) Neurons that send information from sense organs to the central nervous system.

sepals ('sē-pəls) Accessory structures of flowers.

sessile ('sē-sil) Firmly attached.

sex ('seks) The nature of the biological differences between males and females.

sex chromosomes ('seks 'krō-mə-sōmz) Chromosomes that carry genes that determine the sex of an individual (X and Y in humans).

sex-determining chromosomes ('seks di-'tōr-mə-niŋ 'krō-mə-sōmz) The chromosomes X and Y, which are primarily responsible for determining if an individual will develop as a male or a female.

sex linkage ('seks 'lip-kij) Refers to genes that are located on the chromosomes that determine the sex of an individual.

sex ratio ('seks 'rā-shō) The number of males in a population compared with the number of females.

sexual reproduction ('sek-shwəl rē-prō-'dék-shən) The propagation of organisms involving the union of gametes from two parents.

sexual selection ('sek-shwəl sə-'lek-shən) Selection that is the result of specific individuals being chosen by members of the opposite sex for mating purposes.

sexuality (sek-shō-'wa-lə-tē) All the factors that contribute to one's female or male nature.

signal transduction ('sig-nəl trans-'dék-shən) The process by which cells detect specific signals and transmit those signals to the cell's interior.

silencer sequence ('sī-lən-sor 'sē-kwəns) A DNA sequence that regulates gene expression by acting as a binding site for proteins that decrease the ability of RNA polymerase to transcribe a specific protein.

silent mutation ('sī-lənt myü-'tā-shən) A change of a single nucleotide that does not cause a change in the amino acids used to build a protein.

single-factor cross ('sing-gəl 'fak-tər 'krōs) A genetic study in which a single characteristic is followed from the parental generation to the offspring.

sister chromatids ('sis-tər 'krō-mə-tədz) The 2 chromatids of a chromosome that were produced by replication and that contain the identical DNA.

skeleton ('ske-lə-tən) The part of an organism that provides structural support.

small intestine ('smōl in-'tes-tən) The portion of the digestive system immediately following the stomach; it is responsible for digestion and absorption.

society (sə-'sī-ə-tē) Interacting groups of animals of the same species that show division of labor.

sociobiology (sō-sē-ō-bi-'ä-lə-jē) The systematic study of all forms of social behavior, both human and nonhuman.

solid ('sä-ləd) The phase of matter in which the molecules are packed tightly together; they vibrate in place.

solute ('säl-yüt) The component that dissolves in a solvent.

solution (sə-'lü-shən) A homogeneous mixture of ions or molecules of two or more substances.

solvent ('säl-vənt) The component present in the larger amount.

soma ('sō-mə) The cell body of a neuron, which contains the nucleus.

somatic cell nuclear transfer (sō-'ma-tik 'sel 'nū-klē-ər trans-'fər) A laboratory technique in which the nucleus of a cell is placed into an unfertilized egg cell; the cell may then be stimulated to grow; cells that are generated from this growth will have the same genetic information as the cell that donated the nucleus.

speciation (spē-shē-'ā-shən) The process of generating new species.

species ('spē-shēz) A population of organisms potentially capable of breeding naturally among themselves and having offspring that also interbreed. Also, the smallest irreversible unit of evolution; a group of organisms that shares a common ancestor with other species, but is set off from those others by having newer, genetically unique traits.

specific dynamic action (SDA) (spi-'si-fik dī-'na-mik 'ak-shən) The amount of energy required to digest and assimilate food. SDA is equal to approximately 10% of total daily kilocalorie intake.

specific epithet (spi-'si-fik 'e-pə-thət) A word added to the genus name to identify which one of several species within the genus is being identified (i.e., *Homo sapiens*: *Homo* is the genus name and *sapiens* is the specific epithet).

sperm ('spərm) The haploid sex cells produced by sexually mature males.

spermatogenesis (spər-ma-tə-'je-nə-səs) The gametogenesis process that leads to the formation of sperm.

spinal cord ('spī-nəl 'kōrd) A collection of nerve fibers surrounded by the vertebrae that conveys information to and from the brain.

spindle ('spin-dəl) An array of microtubules extending from pole to pole; used in the movement of chromosomes.

spindle fiber ('spin-dəl 'fī-bərs) Microtubules that are individual strands of the spindle.

spontaneous generation (spän-'tā-nē-əs je-nə-'rā-shən) The idea that living organisms arose from nonliving material.

spontaneous mutations (spän-'tā-nē-əs myü-'tā-shənz) Natural changes in the

DNA caused by unidentified environmental factors.

spore ('spór) In the kingdom Fungi, a cell with a tough protective cell wall that can resist extreme conditions.

sporophyte generation (or stage) ('spór-ə-fit je-nə-'rā-shən) A stage in the life cycle of plants in which this diploid ($2n$) plant, which has special plant parts where meiosis takes place, produces haploid (n) spores.

sporophyte stage ('spór-ə-fit 'stāj) A life cycle stage in plants in which a haploid spore is produced by meiosis.

stabilizing selection ('stā-bə-lī-zij sə-'lek-shən) Selection that occurs when individuals at the extremes of the range of a characteristic are consistently selected against.

stable equilibrium phase ('stā-bal ē-kwə-'li-brē-əm 'fāz) The period of time during population growth when the number of individuals entering a population and the number leaving the population are equal, resulting in a stable population size.

stamens ('stā-mənz) Male reproductive structures of a flower.

stapes ('stā-pēz) The ear bone that is attached to the oval window.

stem ('stem) Plant structures that connect the roots with the leaves and position the leaves so that they receive sunlight.

stem cells ('stem 'selz) Cells that can differentiate into any type of cell, including liver cells, skin cells, and brain cells; embryonic and hematopoietic cells.

steroids ('stir-oidz) One of the three kinds of lipid molecules characterized by their arrangement of interlocking rings of carbon.

stimulus ('stim-yə-ləs) Any change in the internal or external environment of an organism that it can detect.

stroma ('strō-mə) The region within a chloroplast that has no chlorophyll.

structural proteins ('strək-chə-rəl 'prō-tēnəz) Proteins that are important for holding cells and organisms together, such as the proteins that make up the cell membrane, muscles, tendons, and blood.

subspecies (breeds, varieties, strains, races) ('səb-spē-shēz) Regional groups within a species that are significantly different structurally, physiologically,

or behaviorally yet are capable of exchanging genes by interbreeding.

substrate ('səb-strāt) A reactant molecule with which the enzyme combines.

succession (sək-'se-shən) The process of changing one type of community to another.

successional (stage) (successional community) (sək-'se-shə-nəl 'stāj) An intermediate stage in succession.

symbiosis (sim-bē-'ō-səs) A close physical relationship between two kinds of organisms; parasitism, commensalism, and mutualism are examples of symbiosis.

symbiotic nitrogen-fixing bacteria (sim-bē-'ō-tik 'nī-trā-jən 'fik-sin bak-'tir-ē-ə) Bacteria that live in the roots of certain kinds of plants, where they convert nitrogen gas molecules into compounds that plants can use.

synapse ('si-naps) The space between the axon of one neuron and the dendrite of the next, where chemicals are secreted to cause an impulse to be initiated in the second neuron.

synapsis (sə-'nap-səs) The condition in which the two members of a pair of homologous chromosomes come to lie close to one another.

systemic circulation (sis-'te-mik sər-kyə-'lā-shən) The flow of blood through certain chambers of the heart and blood vessels to the general body and back to the heart.

systolic blood pressure ('sis-tō-lik 'blēd 'pre-shər) The pressure generated in a large artery when the ventricles of the heart are contracting.

T

tandem clusters ('tan-dəm 'kləs-tərs) A type of variation in an organism's DNA sequence; this variation occurs when a gene is duplicated several times in the same region of DNA.

taxonomy (tak-'sä-nə-mē) The science of classifying and naming organisms.

telomere ('te-lə-mir) A chromosome cap composed of repeated, specific sequences of nucleotide pairs; its activity or inactivity is associated with cell aging and cancer.

telophase ('te-lə-fāz) The last phase in mitosis, characterized by the formation of daughter nuclei.

temperature ('tem-pə-chür) A measure of molecular energy of motion.

termination sequences (tər-mə-'nā-shən 'sē-kwəns) DNA nucleotide sequences that indicate when RNA polymerase should finish making an RNA molecule.

territorial behavior (ter-ə-'tór-ē-əl bi-'hā-vyər) Behavior involved in establishing, defending, and maintaining a territory for food, mating, or other purposes.

territory ('ter-ə-tör-ē) A space that an animal defends against others of the same species.

testes ('tes-təz) The male sex organs, which produce haploid cells—sperm.

testosterone (tes-'täs-tə-rōn) The male sex hormone, produced in the testes, that controls male sexual development.

thalamus ('tha-lə-məs) The region of the brain that relays information between the cerebrum and lower portions of the brain; it also provides some level of awareness in that it determines pleasant and unpleasant stimuli and is involved in sleep and arousal.

theory ('thē-ə-rē) A widely accepted, plausible generalization about fundamental concepts in science that is supported by many experiments and explains why things happen in nature.

theory of natural selection ('thē-ə-rē əv 'na-chə-rəl sə-'lek-shən) In a species of genetically differing organisms, the organisms with the genes that enable them to survive better in the environment and thus reproduce more offspring than others will transmit more of their genes to the next generation.

thinking ('thinj-kinj) A mental process that involves memory, a concept of self, and an ability to reorganize information.

thylakoid ('thī-lə-koid) A membranous sac found within chloroplasts of plant cells that contains chlorophyll and is the site of the light-capturing events and the light-dependent reactions of photosynthesis; a stack of thylakoids is known as a grana.

thymine ('thī-mēn) A single-ring, nitrogenous-base molecule in DNA but not in RNA; it is complementary to adenine.

tissue ('ti-shü) A group of specialized cells that work together to perform a specific function.

tissue fluid ('ti-shü 'flü-əd) The liquid that bathes the body's cells and contains

the same chemicals as plasma but smaller amounts of the blood protein albumin.

trachea ('trā-kē-ə) The major tube, supported by cartilage rings, that carries air to the bronchi; also known as the windpipe.

transcription (tran-'skrip-shən) The process of manufacturing RNA from the template surface of DNA; three forms of RNA that can be produced are mRNA, rRNA, and tRNA.

transcription factors (tran-'skrip-shən 'fak-tōrz) Proteins that help control the transcription process by binding DNA or other transcription factors and regulating when RNA polymerase begins transcription.

transcriptomics (tran-skript-'tä-miks) A new field of science developed since the sequencing of the human genome; it looks at when and how much of a particular transcript is made by an organism.

transfer RNA (tRNA) (trans-'fər) A molecule composed of ribonucleic acid. It is responsible for transporting a specific amino acid into a ribosome for assembly into a protein.

transformation (trans-fər-'mā-shən) A technique or process in which an organism gains new genetic information from its environment; this is known to happen to bacteria and is used to introduce DNA fragments to bacteria during the DNA cloning process.

translation (trans-'lā-shən) A chromosomal aberration in which one broken segment of DNA becomes integrated into a different chromosome.

translocation (trans-lō-'kā-shən) The process whereby tRNA uses mRNA as a guide to arrange the amino acids in their proper sequence according to the genetic information in the chemical code of DNA.

transpiration (trans-pə-'rā-shən) In plants, the transportation of water from the soil by way of the roots to the leaves, where it evaporates.

triploblastic (tri-plō-'blas-tik) A condition typical of most animals in which their bodies consist of three layers of cells.

trisomy ('trī-sō-mē) The presence of 3 chromosomes instead of the normal 2, resulting from the nondisjunction of homologous

chromosomes during meiosis—as in Down syndrome.

trophic level ('trō-fik 'le-vəl) A step in the flow of energy through an ecosystem.

tropism ('trō-pi-zəm) Any reaction to a particular stimulus in which the organism orients toward or away from the stimulus.

tropomyosin (trä-pō-'mī-ə-sən) A molecule, found in thin myofilaments of muscle, that helps regulate when muscle cells contract.

troponin ('trō-pō-nən) A molecule, found in thin myofilaments of muscle, that helps regulate when muscle cells contract.

true (neutral) fats ('trü 'fats) Important organic molecules composed of glycerol and fatty acids that are used to provide energy.

tumor ('tü-mər) A mass of undifferentiated cells not normally found in a certain portion of the body.

tumor-suppressor gene ('tü-mər sə-'pre-sər 'jēn) Code for proteins that provide signals that discourage cell division.

turnover number ('tərn-ō-vər 'nəm-bər) The number of molecules of substrate with which a single molecule of enzyme can react in a given time.

tympanum ('tim-pə-nəm) The eardrum.

U

unique structural organization (yū-'nēk 'strək-chə-rəl ör-gə-nə-'zā-shən) One of five traits displayed by living things and not shown by nonliving things; can be seen at the molecular, cellular, and organism levels.

unsaturated (ən-'sa-chə-rā-təd) A term used to describe the carbon skeleton of a fatty acid containing carbons that are double-bonded to each other at one or more points.

uracil ('yür-ə-sil) A single-ring nitrogenous-base molecule in RNA but not in DNA; it is complementary to adenine.

V

vaccines (vak-'sēns) Antigens made so they can start an active immunity without causing disease.

vacuoles ('va-kyō-wōlz) Large sacs within the cytoplasm of a cell, composed of a single membrane.

variable number tandem repeats (VNTRs)

('ver-ĕ-ə-bĕl 'nōm-bĕr 'tan-dĕm ri'-pĕtz) A type of variation in an organism's DNA sequence that is a repeated sequence; different individuals may have the sequence repeated a different number of times; this variation can occur in regions of the DNA that do not code for genes.

variables ('ver-ĕ-ə-bĕlz) Factors in an experimental situation or other circumstance that are changeable.

vascular cambium ('vas-kyă-lĕr 'kam-bĕ-əm) A layer of cells between the xylem and phloem in trees that is responsible for the increase in diameter of a stem.

vascular tissue ('vas-kyă-lĕr 'ti-shü) Consists of tube-like cells that allow plants to efficiently transport water and nutrients about the plant.

vector ('vek-tĕr) An organism that carries a disease or parasite from one host to the next.

veins ('vānz) The blood vessels that return blood to the heart.

ventricles ('ven-tri-kĕlz) The powerful muscular chambers of the heart whose contractions force blood to flow through the arteries to all parts of the body.

vertebrates ('vĕr-tă-brĕts) Animals with backbones.

vesicles ('ve-si-kĕls) Small, intracellular, membrane-bound sacs in which various substances are stored.

villi ('vi-lĭ) Tiny, fingerlike projections in the lining of the small intestine that increase the surface area for absorption.

viroid ('vī-rōid) An infectious particle composed solely of single-stranded RNA.

virus ('vī-rĕs) A nucleic acid particle coated with protein that functions as an obligate intracellular parasite.

vitamin-deficiency disease ('vī-tă-mĕn di-fishĕn-sē di-zĕz) Poor health caused by the lack of a certain vitamin in the diet—for example, scurvy from lack of vitamin C.

vitamins ('vī-tă-mĕnz) Organic molecules that cannot be manufactured by the body but are required in very low concentrations for good health.

voltage ('vōl-tij) A measure of the electrical difference between two points or objects.

W

white blood cells (wbc's) ('hwīt 'blĕd 'selz) Formed elements in the blood that lack hemoglobin, are larger than RBCs, and have a nucleus; also called leukocytes.

wood ('wūd) The accumulation of the xylem in the trunk of gymnosperms.

X

X chromosome ('eks 'krō-mĕ-sōm) The chromosome in a human female egg (and in one-half of sperm cells) that is associated with the determination of sexual characteristics.

X-linked genes ('eks-'lĕkt jĕnz) Genes located on the sex-determining X chromosome.

xylem ('zī-lĕm) A kind of vascular tissue that transports water from the roots to other parts of the plant.

Y

Y chromosome ('wī 'krō-mĕ-sōm) The sex-determining chromosome in one-half the sperm cells of human males responsible for determining maleness.

Y-linked genes ('wī-'lĕkt jĕnz) Genes found only on the Y chromosome.

Z

zooplankton (zō-ə-'plănk-tōn) Nonphotosynthetic aquatic protozoa and tiny animals.

zygote ('zī-gōt) A diploid cell that results from the union of an egg and a sperm.

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Prefixes and Suffixes

a-, ab-, abs- away from; abductor
a-, an- not, without; amitosis
ad- to, toward; adductor
adeno- gland; adenovirus
aer- air; aerobic
albus- white; *Staphylococcus albus*
allelon- of one another; allele
amb- both, on both sides; ambivalent
amoeba- change; *Amoeba*, amoeboid
amyl- starch; amylase
ana- back, anew; anabolism, anaphase
andr- man; androgen
anti- opposite, against; antibody
aortic- artery; aorta
apex- tip, point; apical
aqua- water; aquarium, aquatic
arthro- joined; arthrosore
-ase denotes an enzyme; oxidase
-ate denotes the salt of an acid ending in -ic; succinate
atrium- entrance; atrial
aur- ear; auricle
auto- self; autonomic, autotomy

bacterio- bacteria; bacteriocin
basis- bottom; basilar
bi-, bin- double or two; binomial
bio- living; bioluminescence
bronchus- air tubes; bronchial

capill- hair; capillary
cardio- heart; cardiovascular
cata- down; catabolism, catalyst
cephale- head; cephalic, encephalon
cerebrum- brain; cerebral
cervix- neck; cervical
cardia- heart; cardiac
chemo- chemical; chemostat
chlor- green; chloroplast
chole- bile; cholesterol
chondrus- cartilage; chondrocranium
chrom- color; chromosome
-cide kill; germicide
cilium- eyelid; ciliata, ciliary
coel- hollow; coelom
con- with; connection
contra- against; contralateral
corona- crown; coronary
crypto- hidden; cryptorchidism
cyt- cell; leukocyte, cytoplasm
cyte- state of the blood; leukocyte

de- from; deoxyribose
di- two; disaccharide
dia- through; diaphragm, diarrhea
diplo- double; diploid
dis- apart, away; disinfect

-emia state of the blood; toxemia
en- in; encysted
encephalo- brain; encephalitis
endo- within; endospore
entero- intestine; enteritis, enterotoxin
epi- upon, above; epidermis, epidemic
erythro- red; erythrocyte

eu- good; eukaryote
ex- out of, from, through; excretion
extra- outside; extracellular
-form shape; vermiform

gam- marriage; gamete
gaster- belly; gastroenteritis
gen-, geny-, geno-, -genesis bring to life, create; gene, genetics, parthenogenesis
genic- producing; carcinogenic
gest- carry; gestation, ingest, digest
glyco- sweet, sugar; glycolysis
gram- writing; diagram
gyn-, gynec- woman; gynecology

halo- salt; halophile
haplo- single; haploid
hepat- liver; hepatic
hetero- other; heterozygote
histo- web; histology
homo- alike; homozygote
humor- fluid; aqueous humor
hydr- water; hydrophobia
hyper- above; hypertonic, hypertrophy
hypo- under; hypotonic, hypodermic

inferior- beneath
inter- between, among; interface
intra- within; intracellular
iso- equal; isotonic
-itis inflammation of; myelitis

karyo- nucleus; karyotype

lacto- milk; lactose, *Lactobacillus*
leuco- white; leucocyte
-logy study; biology, bacteriology
lys- loosening, decomposition; lysosome
-lysis breaking down, loosening; hemolysis, glycolysis

macro- large; macroscopic, macronucleus
mal- bad; malfunction
mega- great; megasporangium, acromegaly
melan- black; melanin, melanoma
meta- after; metabolism, metaphase
meter- measure; thermometer
micro- small; micronucleus, microscope
morph- form; morphology
multi- many; multinucleate
mut- change; mutant, mutation
myco- fungus; mycology
myxo- mucus, slime; myxobacterium, myxovirus

necro- dead; necrosis
neo- new; neoplasm
nom- law; taxonomy, autonomic
nomen- name; nomenclature
non- not; nondisjunction

oec- house; ecology, economy
-oid like; neuroid, amoeboid
-oma tumor; carcinoma

ortho- straight; orthodontist
-ose denotes a sugar or carbohydrate; glucose
-osis action of or condition of; tuberculosis
osteо- bone; osteitis
ovum- egg; oviduct, ovarian

peri- around; pericardium
-phag devour; phagocyte
-phage eating; macrophage
phago- to eat; phagocyte
-phase appearance; metathase
-phil loving; hemophilia, thermophilic
-phile lover; thermophile
phob- hating; hydrophobia
-phobia fear; hydrophobia
photo- light; photosynthesis
phyco- seaweed, alga; phycochrome
phyl- tribe; phylum, phylogeny
phyto- plant; phytopathology
pleur- side; pleural
pneuma- breath; pneumatic, pneumon
pod- foot; pseudopod
poly- many; polymorphic
pre- before; prenatal
pro- before; prokaryote
proto- first; protoplasm, protozoa
pseud- false; pseudopod
pulmo- lung; pulmonary

quadr- four-fold; quadruped

re- back; regenerate, react
-rhag burst; hemorrhage
rhodo- rose; rhodopsin

scler- hard; sclera, sclerosis
sect- cut; section, insect, dissect
semi- half; semilunar
sepsis- putrefaction, infection; aseptic
-soma body; chromosome
-some body; chromosome
spiro- coil, spiral; spirochete
spor- seed; spore
strepto- twined, chainlike; streptococcus
sub- under; subconscious
sym-, syn- together; symbiosis

-taxis movement in response to stimulus; phototaxis
telo- end; telophase
tetra- four; tetrad
therm- heat; thermometer, homothermal
trans- across, beyond, through; transformation
tropho- nourishment; trophozoite
-trophy nourishment; heterotrophic

uni- one; unicellular

zoo- living being, animal; zoospore
zyg- yoke; zygote, homozygous