- **Days 6–14: Proliferative phase.** Stimulated by rising estrogen levels produced by the growing follicles of the ovaries, the basal layer of the endometrium regenerates the functional layer, glands form in it, and the endometrial blood supply increases. The endometrium once again becomes velvety, thick, and well vascularized. (Ovulation occurs in the ovary at the end of this stage, in response to the sudden surge of LH in the blood.)
- **Days 15–28: Secretory phase.** Rising levels of progesterone production by the corpus luteum of the ovary act on the estrogen-primed endometrium and increase its blood supply even more. Progesterone also causes the endometrial glands to increase in size and to begin secreting nutrients into the uterine cavity. These nutrients will sustain a developing embryo (if one is present) until it has implanted. If fertilization does occur, the embryo produces a hormone very similar to LH that causes the corpus luteum to continue producing its hormones.

  If fertilization does not occur, the corpus luteum begins to degenerate toward the end of this period as LH blood levels decline. Lack of ovarian hormones in the blood causes the blood vessels supplying the functional layer of the endometrium to go into spasms and kink. When deprived of oxygen and nutrients, those endometrial cells begin to die, which sets the stage for menses to begin again on day 28.

Although this explanation assumes a classic 28-day cycle, the length of the menstrual cycle is quite variable. It can be as short as 21 days or as long as 40 days. Only one interval is fairly constant in all females; the time from ovulation to the beginning of menses is almost always 14 or 15 days.

Hormone Production by the Ovaries

As the ovaries become active at puberty and start to produce ova, they also begin to produce ovarian hormones. The follicle cells of the growing and mature follicles produce **estrogens,*** which cause the appearance of the *secondary sex characteristics* in the young woman. Such changes include the following:

- Enlargement of the accessory organs of the female reproductive system (uterine tubes, uterus, vagina, external genitals)
- Development of the breasts
- Appearance of axillary and pubic hair
- Increased deposits of fat beneath the skin in general, and particularly in the hips and breasts
- Widening and lightening of the pelvis
- Onset of menses, or the menstrual cycle

Beyond its promotion of secondary sex characteristics, estrogen also has metabolic effects. For example, it helps maintain low total blood cholesterol levels (and high HDL levels) and facilitates calcium uptake, which sustains bone density.

The second ovarian hormone, **progesterone,** is produced by the glandular *corpus luteum* (see Figure 16.7). As mentioned earlier, after ovulation occurs the ruptured follicle is converted to the corpus luteum, which looks and acts completely different from the growing and mature follicle. Once formed, the corpus luteum produces progesterone (and some estrogen) as long as LH is still present in the blood. Generally speaking, the corpus luteum stops producing hormones by 10 to 14 days after ovulation. Except for working with estrogen to establish the menstrual cycle, progesterone does not contribute to the appearance of the secondary sex characteristics. Its other major effects are exerted during pregnancy, when it helps maintain the pregnancy by inhibiting contraction of the myometrium of the uterus, and helps prepare the breasts for milk production. (However, the source of progesterone during pregnancy is the placenta, not the ovaries.)

Mammary Glands

✓ Describe the structure and function of the mammary glands.

The **mammary glands** are present in both sexes, but they normally function only in women. Because the biological role of the mammary glands is to produce milk to nourish a newborn baby, they are actually important only when reproduction has already been accomplished. Stimulation by female sex hormones, especially estrogens, causes the female mammary glands to increase in size at puberty.

*Although the ovaries produce several different estrogens, the most important are *estradiol*, *estrone*, and *estriol*. Of these, estradiol is the most abundant and is most responsible for estrogenic effects.

Q: *Flat-chested women are perfectly able to nurse their newborn infants; hence, it is not glandular tissue that accounts for the bulk of the breast tissue. So, what does?*

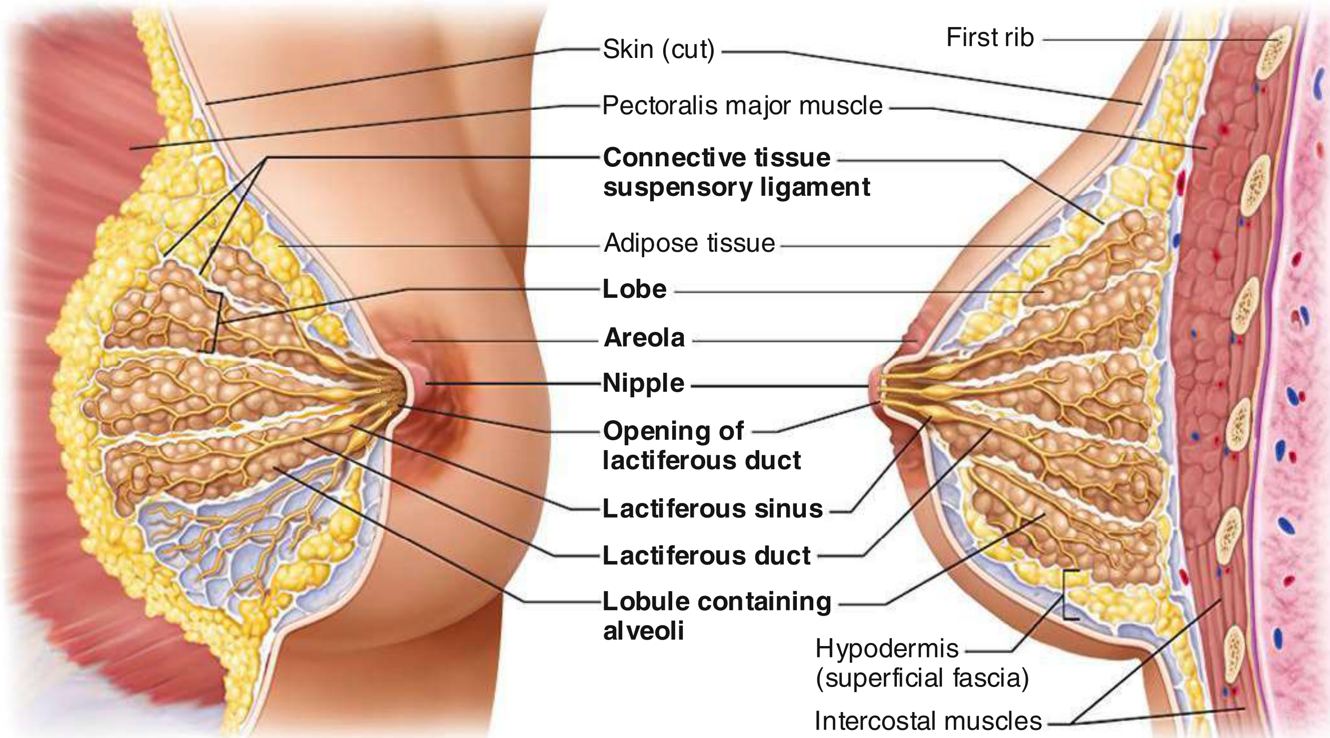


Figure 16.13 Female mammary glands. (a) Anterior view. **(b)** Sagittal section.

Developmentally, the mammary glands are modified *sweat glands* that are part of the skin. Each mammary gland is contained within a rounded skin-covered breast anterior to the pectoral muscles. Slightly below the center of each breast is a pigmented area, the **areola** (ah-re′o-lah), which surrounds a central protruding **nipple** (**Figure 16.13**).

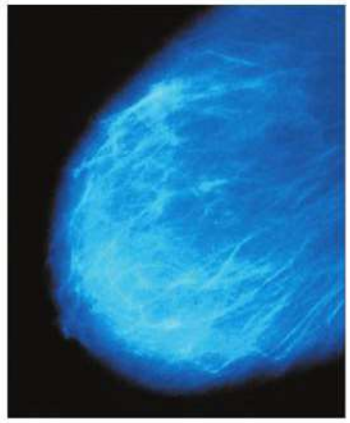
Internally, each mammary gland consists of 15 to 25 *lobes* that radiate around the nipple. The lobes are padded and separated from one another by connective tissue and fat. Within each lobe are smaller chambers called *lobules,* which contain clusters of **alveolar glands** that produce the milk when a woman is **lactating** (producing milk). The alveolar glands of each lobule pass the milk into the **lactiferous** (lak-tif′er-us) **ducts,** which open to the outside at the nipple. Just deep to the areola, each duct has a dilated region called a **lactiferous sinus** where milk accumulates during nursing.

HOMEOSTATIC IMBALANCE

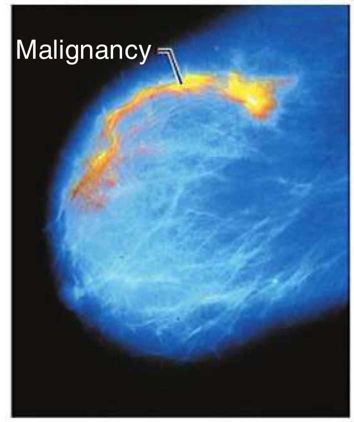
Cancer of the breast is the second most common cause of death in American women. One woman in eight will develop this condition. Some 10 percent of breast cancers stem from hereditary defects, and half of these can be traced to dangerous mutations in a pair of genes (*BRCA1* and *2*). Eighty percent of women who carry the altered gene develop breast cancer. With the possible exception of family history, most risk factors reflect lifelong exposure to estrogen (early menses, late menopause, estrogen replacement therapy, and others).

A: Adipose tissue.

(a) Mammogram procedure



(b) Film of normal breast



(c) Film of breast with tumor

Figure 16.14 Mammograms.

Breast cancer is often signaled by a change in skin texture, puckering, or leakage from the nipple. Early detection by breast self-examination and mammography is unquestionably the best way to increase a woman's chances of surviving breast cancer. Because most breast lumps are discovered by women themselves in routine monthly breast exams, this simple examination should be a priority in every woman's life. Currently the American Cancer Society recommends scheduling **mammography**—X-ray examination that detects breast cancers too small to feel (less than 1 cm)—every 2 years for women between 40 and 49 years old and yearly thereafter (Figure 16.14).

DID YOU GET IT?

17. Which ovarian hormone can be called a feminizing hormone because it promotes the formation of female secondary sex characteristics?
18. What happens during the proliferative stage of the uterine cycle?
19. What are three important functions of progesterone in women?
20. Why do mutations of the *BRCA* genes cause problems?

For answers, see Appendix D.

Pregnancy and Embryonic Development

- ✓ Define *fertilization* and *zygote*.
- ✓ Describe implantation.
- ✓ Distinguish between an embryo and a fetus.
- ✓ List the major functions of the placenta.

Because the birth of a baby is such a familiar event, we tend to lose sight of the wonder of this accomplishment. In every instance it begins with a single cell, the fertilized egg, and ends with an extremely complex human being consisting of trillions of cells. The development of an embryo is very complex, and the details of this process can fill a good-sized book. Our intention here is simply to outline the important events of pregnancy and embryonic development.

Let's get started by defining some terms. The term **pregnancy** refers to events that occur from the time of fertilization (conception) until the infant is born. The pregnant woman's developing offspring is called the **conceptus** (kon-sep-tus; "that which is conceived"). Development occurs during the **gestation period** (*gestare* = to carry), which extends by convention from the last menstrual period (a date the woman is likely to remember) until birth, approximately 280 days. So, at the moment of fertilization, the mother is officially (but illogically) two weeks pregnant!

From fertilization through week 8, the *embryonic period*, the conceptus is called an **embryo,** and from week 9 through birth, the *fetal period*, the conceptus is called a **fetus** ("the young in the womb"). At birth, it is an infant. Figure 16.15 shows the changing size and shape of the conceptus as it progresses from fertilization to the early fetal stage.

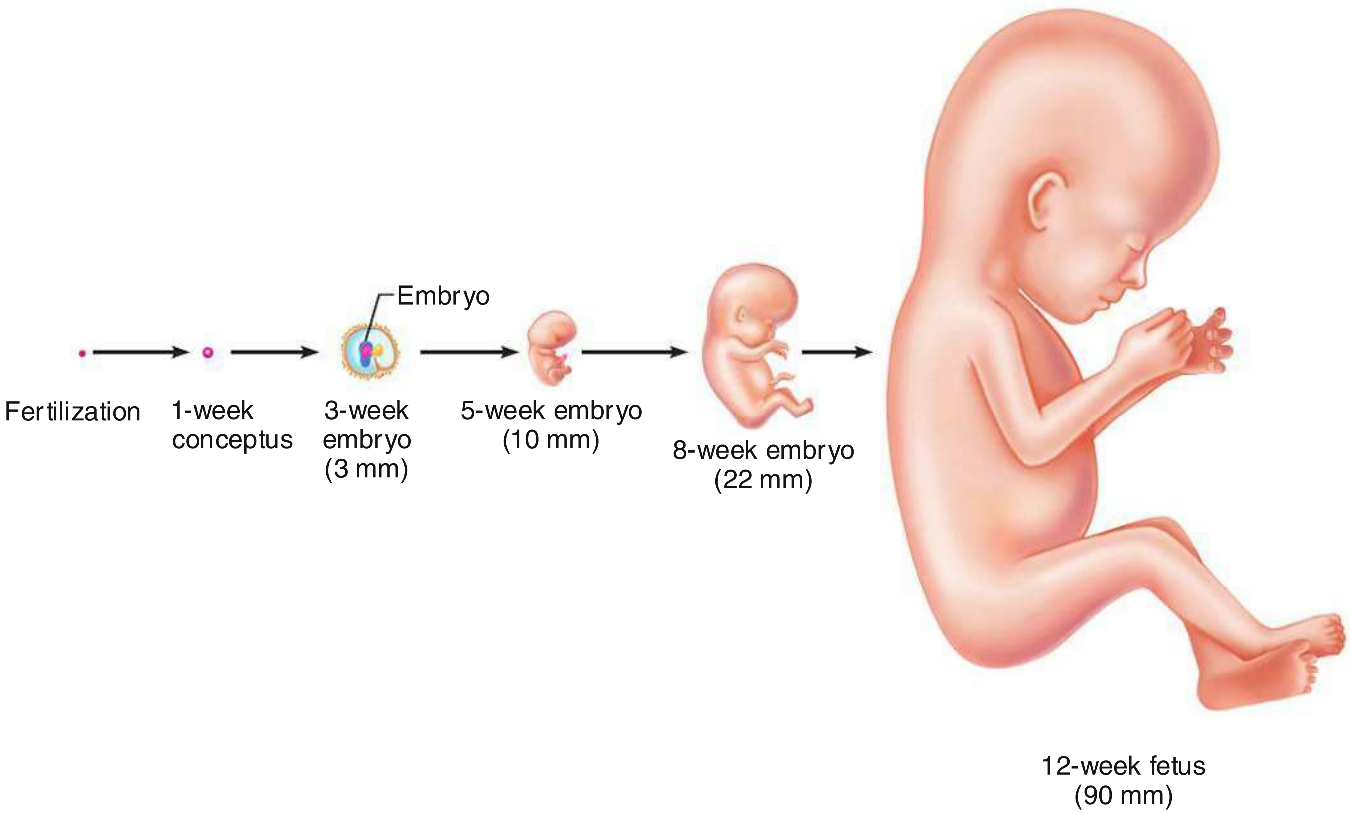


Figure 16.15 Diagrams showing the approximate size of a human conceptus from fertilization to the early fetal stage. Measurements are crown to rump length.

Accomplishing Fertilization

Before fertilization can occur, the sperm must reach the ovulated secondary oocyte. The oocyte is viable for 12 to 24 hours after it is cast out of the ovary, and sperm generally retain their fertilizing power within the female reproductive tract for 24 to 48 hours after ejaculation. Consequently, for fertilization to occur, sexual intercourse must occur no more than 2 days before ovulation and no later than 24 hours after, at which point the oocyte is approximately one-third of the way down the length of the uterine tube. Remember that sperm are motile cells that can propel themselves by lashing movements of their tails. If sperm are deposited in a female's vagina at the approximate time of ovulation, they are attracted to the oocyte by chemicals that act as "homing devices," allowing them to locate the oocyte. It takes 1 to 2 hours for sperm to complete the journey up the female duct system into the uterine tubes even through they are only about 12 cm (5 inches) away. However, millions of sperm leak from the vagina, and of those remaining, millions more are destroyed by the vagina's acidic environment. Only a few hundred to a few thousand sperm finally make it to the egg's vicinity.

When the swarming sperm reach the oocyte, their cell surface hyaluronidase enzymes break down the "cement" that holds the follicle cells of the corona radiata together around the oocyte. Once a path has been cleared through the corona, thousands of sperm undergo the **acrosomal reaction** in which the acrosome membranes break down, releasing enzymes that digest holes in the oocyte membrane. Then, when the membrane is adequately weakened and a single sperm makes contact with the oocyte's membrane receptors, the head (nucleus) of the sperm is pulled into the oocyte cytoplasm. This is one case that does not bear out the adage "The early bird catches the worm" because sperm that are in the best position to be *the* fertilizing sperm are the ones that come along after hundreds of sperm have undergone acrosomal reactions to expose the oocyte

Q: *Why is the multicellular blastocyst only slightly larger than the single-cell zygote?*

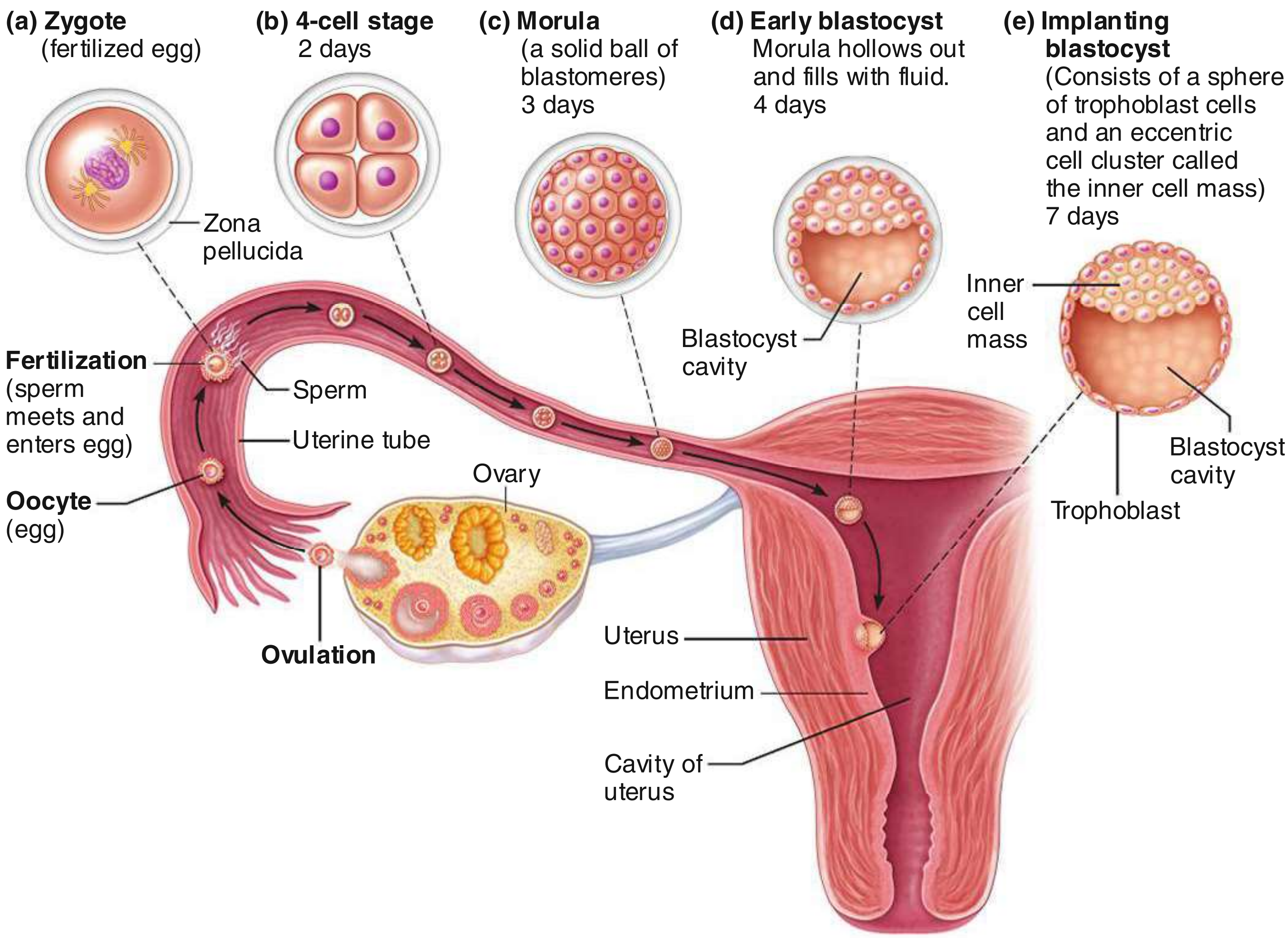


Figure 16.16 Cleavage is a rapid series of mitotic divisions that begins with the zygote and ends with the blastocyst. The zygote begins to divide about 24 hours after fertilization and continues to divide rapidly (undergo cleavage) as it travels down the uterine tube. The embryo reaches the uterus 3 to 4 days after ovulation and floats freely for another 2 to 3 days, nourished by secretions of the endometrial glands. At the late blastocyst stage, the embryo is implanting into the endometrium; this begins at about day 7 after ovulation.

membrane. Once a single sperm has penetrated the oocyte, the oocyte nucleus completes the second meiotic division, forming the ovum and a polar body.

After sperm entry, changes occur in the fertilized egg to prevent other sperm from gaining entry. In humans, of the millions of sperm ejaculated, only *one* can penetrate an oocyte. **Fertilization** occurs at the moment the genetic material of a sperm combines with that of an ovum to form a fertilized egg, or **zygote** (zi′gōt). The zygote represents the first cell of the new individual.

A: *Because as the zygote and then its descendants divide, little or no time is provided for growth between subsequent division cycles. As a result, the cells get smaller and smaller and the size of the cell mass stays approximately the same size as the initial zygote.*

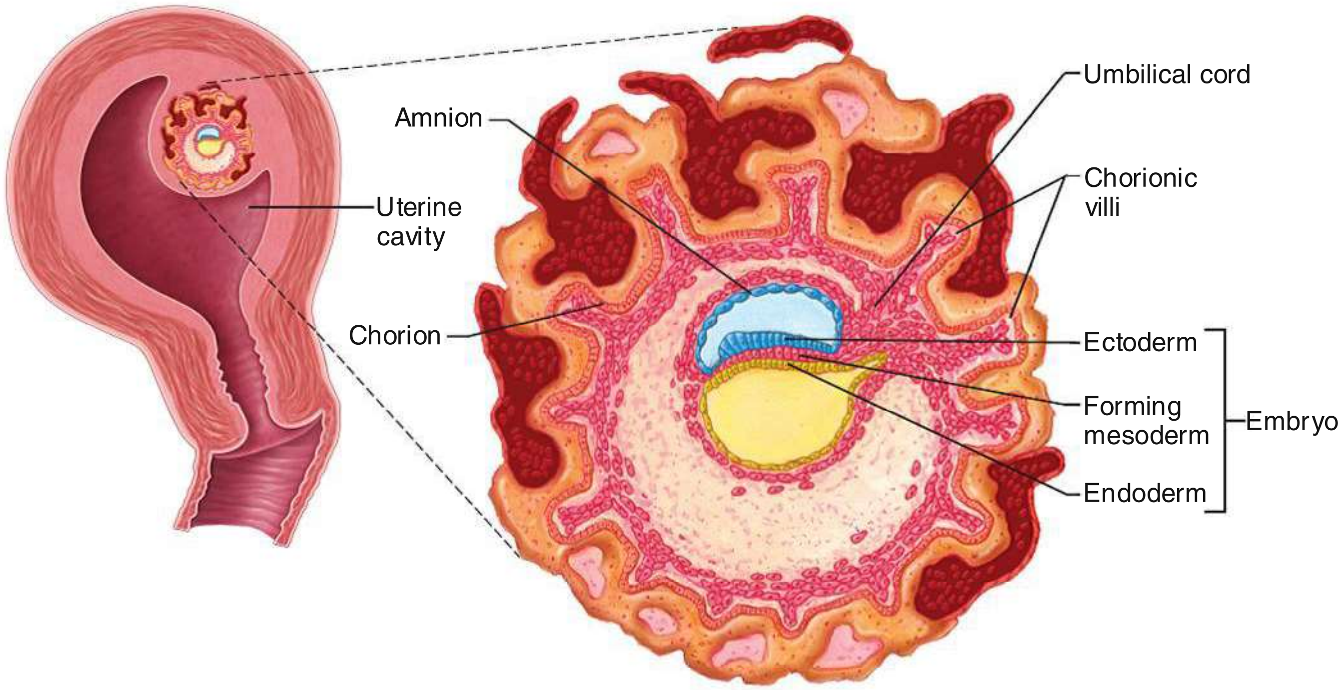


Figure 16.17 **Embryo of approximately 18 days.** Embryonic membranes present.

Events of Embryonic and Fetal Development

As the zygote journeys down the uterine tube (propelled by peristalsis and cilia), it begins to undergo rapid mitotic cell divisions—forming first two cells, then four, and so on. This early stage of embryonic development, called **cleavage,** is shown in **Figure 16.16**. Because there is not much time for cell growth between divisions, the daughter cells become smaller and smaller. Cleavage provides a large number of cells to serve as building blocks for constructing the embryo. Consider for a moment how difficult it would be to construct a building from one huge block of granite. If you now consider how much easier your task would be if you could use hundreds of brick-size granite blocks, you will quickly grasp the importance of cleavage.

By the time the developing embryo reaches the uterus (about 3 days after ovulation, or on day 17 of the woman's cycle), it is a *morula,* a tiny ball of 16 cells that looks like a microscopic raspberry. The uterine endometrium is still not fully prepared to receive the embryo at this point, so the embryo floats free in the uterine cavity, temporarily using the uterine secretions for nutrition. While still unattached, the embryo continues to develop until it has about 100 cells, and then it hollows out to form a ball-like structure called either a **blastocyst** (blas′to-sist) or a **chorionic** (ko″re-on′ik) **vesicle.** At the same time, it secretes an LH-like hormone called **human chorionic gonadotropin (hCG),** which prods the corpus luteum of the ovary to continue producing its hormones. (If this were not the case, the functional layer of the endometrium would be sloughing off shortly in menses.) Many home pregnancy tests assay for hCG in a woman's urine.

The blastocyst has two important functional areas: the **trophoblast,** which forms the large fluid-filled sphere, and the **inner cell mass,** a small cluster of cells on one side (see Figure 16.16e). By day 7 after ovulation, the blastocyst has attached to the endometrium and has eroded away the lining in a small area, embedding itself in the thick velvety mucosa. All of this is occurring even while development is continuing and the three primary germ layers are being formed from the inner cell mass (**Figure 16.17**). The *primary germ layers* are the **ectoderm** (which gives rise to the nervous system and the epidermis of the skin), the **endoderm** (which forms mucosae and associated glands), and the

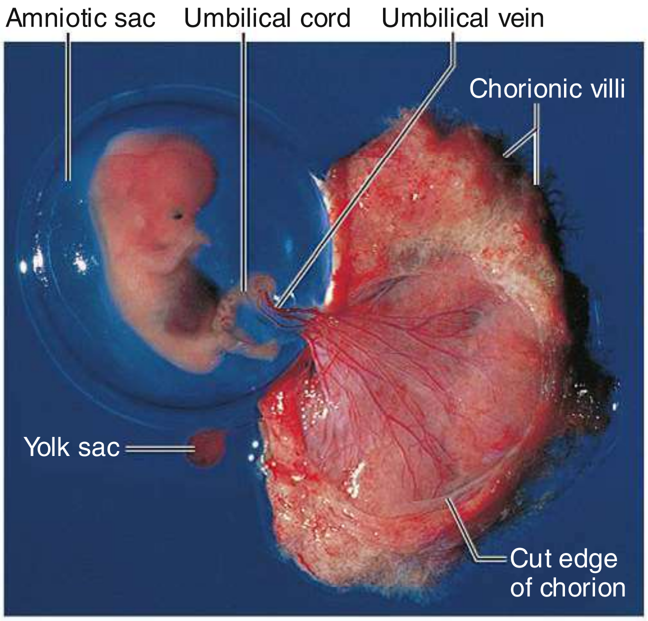


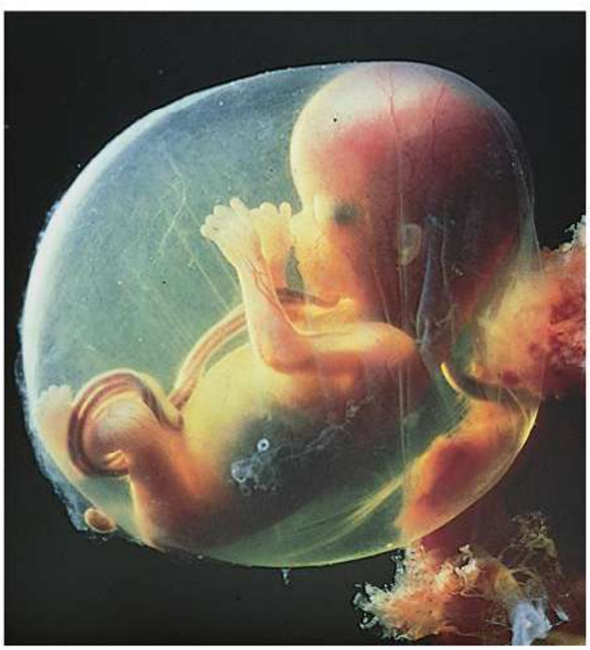
Figure 16.18 **The 7-week embryo.** A 7-week embryo, encased in its amniotic sac, and the chorionic villi (to the right), which cooperate with maternal uterine tissues to form the placenta.

mesoderm (which gives rise to virtually everything else). Implantation has usually been completed and the uterine mucosa has grown over the burrowed-in embryo by day 14 after ovulation—the day the woman would ordinarily be expecting to start menses.

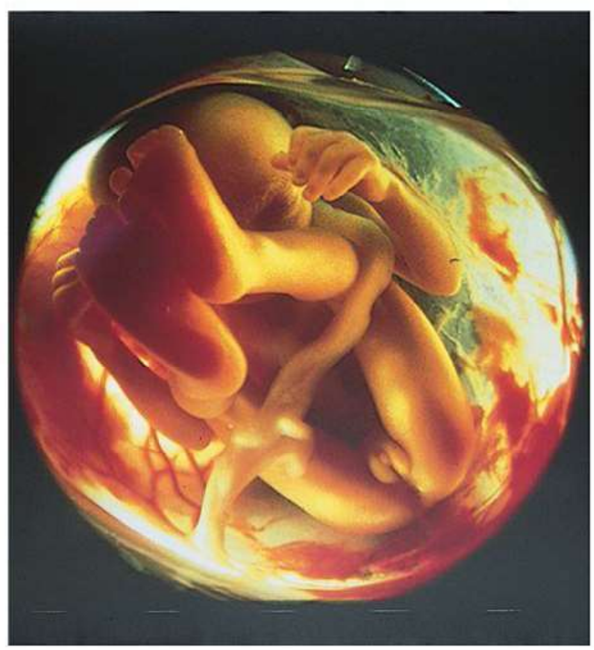
After it is securely implanted, the trophoblast part of the blastocyst develops elaborate projections, called **chorionic villi,** which combine with the tissues of the mother's uterus to form the **placenta** (plah-sen′tah) (**Figure 16.18**). Once the placenta has formed, the platelike embryonic body, now surrounded by a fluid-filled sac called the **amnion** (am′ne-on), is attached to the placenta by a blood vessel–containing stalk of tissue, the **umbilical cord** (Figures 16.17 and 16.18). (We discussed the special features of the umbilical blood vessels and fetal circulation in Chapter 11.)

Generally by the third week, the placenta is functioning to deliver nutrients and oxygen to and remove wastes from the embryonic blood. All exchanges are made through the placental barrier. By the end of the second month of pregnancy, the placenta has also become an endocrine organ and is producing estrogen, progesterone, and other hormones that help to maintain the pregnancy. At this time, the corpus luteum of the ovary becomes inactive.

By the eighth week of embryonic development, all the groundwork has been completed.



(a)



(b)

Figure 16.19 **Photographs of a developing fetus.** **(a)** Fetus in month 3, about 6 cm (2.5 inches) long. **(b)** Fetus late in month 5, about 19 cm (8 inches) long.

All the organ systems have been laid down, at least in rudimentary form, and the embryo looks distinctly human. Beginning in the ninth week of development, we refer to the embryo as a fetus. From this point on, the major activities are growth and organ specialization, accompanied by changes in body proportions. During the fetal period, the developing fetus grows from a crown-to-rump length of about 3 cm (slightly more than 1 inch) and a weight of approximately 1 g (0.03 ounce) to about 36 cm (14 inches) and 2.7 to 4.1 kg (6 to 10 pounds) or more. (Total body length at birth is about 55 cm, or 22 inches.) As you might expect with such tremendous growth, the changes in fetal appearance are quite dramatic (**Figure 16.19**). The most significant of these changes are summarized in **Table 16.1** (pp. 565–566). By approximately 270 days after fertilization (the end of the tenth lunar month), the fetus is said to be "full-term" and is ready to be born.

DID YOU GET IT?

21. How does cleavage differ from cell divisions occurring after birth?

22. What are three roles of the placenta?

For answers, see Appendix D.

Effects of Pregnancy on the Mother

✓ Indicate several ways that pregnancy alters or modifies the functioning of the mother's body.

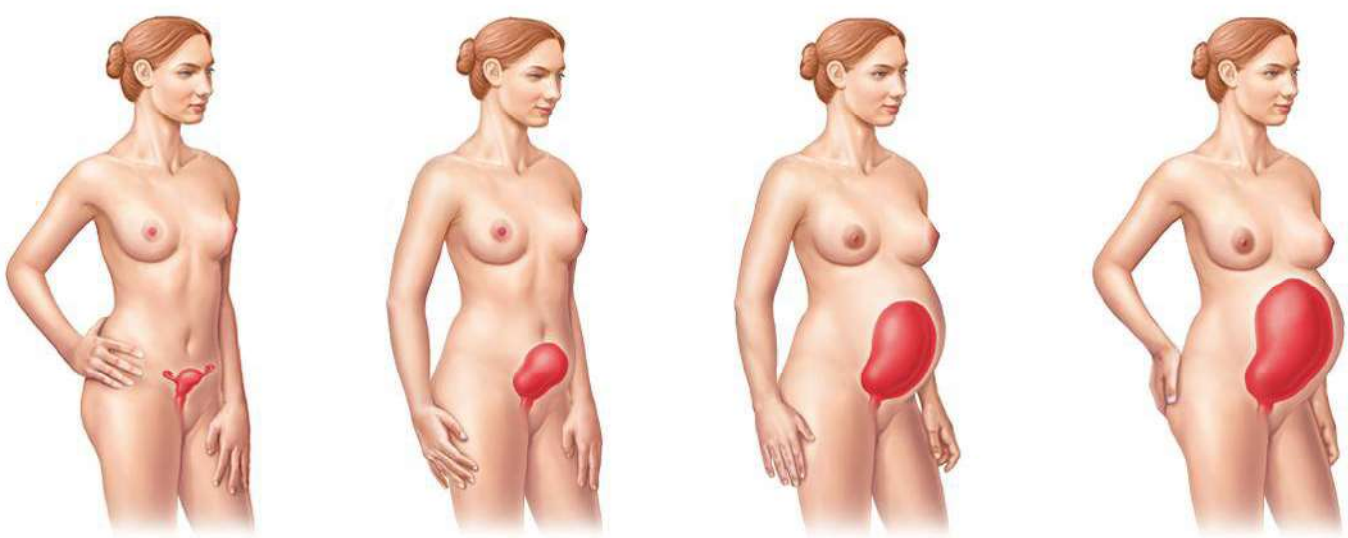
✓ List several agents that can interfere with normal fetal development.

Pregnancy (the period from conception to the birth of her baby) can be a difficult time for the mother. Not only are there obvious anatomical changes, but striking changes occur in her physiology as well.

Anatomical Changes

The ability of the uterus to enlarge during pregnancy is nothing less than remarkable. Starting as a fist-sized organ, the uterus grows to occupy most of the pelvic cavity by 16 weeks. As pregnancy continues, the uterus pushes higher and higher into the abdominal cavity (**Figure 16.20**). As birth nears, the uterus reaches the level of the xiphoid process and occupies the bulk of the abdominal cavity. The crowded abdominal organs press superiorly against the diaphragm, which intrudes on the thoracic cavity. As a result, the ribs flare, causing the thorax to widen.

The increasing bulkiness of the abdomen changes the woman's center of gravity, and



(a) Before conception (Uterus is the size of a fist and resides in the pelvis.)

(b) 4 months (Fundus of the uterus is halfway between the pubic symphysis and the umbilicus.)

(c) 7 months (Fundus is well above the umbilicus.)

(d) 9 months (Fundus reaches the xiphoid process.)

Figure 16.20 Relative size of the uterus before conception and during pregnancy.

Table 16.1 Development of the Human Fetus

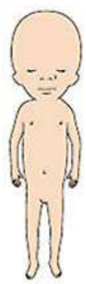
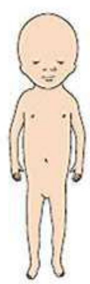
Time	Changes/accomplishments
8 weeks (end of embryonic period)	Head nearly as large as body; all major brain regions present
	Liver disproportionately large and begins to form blood cells
	Limbs present; though initially webbed, fingers and toes are free by the end of this interval
	Bone formation begun
	Heart has been pumping blood since the fourth week
8 weeks	All body systems present in at least rudimentary form
	Approximate crown-to-rump length: 22 mm (0.9 inch); weight: 2 grams (0.07 ounce)
9–12 weeks (third month)	Head still dominant, but body elongating; brain continues to enlarge
	Facial features present in crude form
	Walls of hollow visceral organs gaining smooth muscle
	Blood cell formation begins in bone marrow
12 weeks	Bone formation accelerating
	Sex readily detected from the genitalia
	Approximate crown-to-rump length at end of interval: 90 mm (9 cm)
13–16 weeks (fourth month)	General sensory organs are present; eyes and ears assume characteristic position and shape; blinking of eyes and sucking motions of lips occur
	Face looks human and body beginning to outgrow head
	Kidneys attain typical structure
16 weeks	Most bones are distinct and joint cavities apparent
	Approximate crown-to-rump length at end of interval: 140 mm (14 cm)
17–20 weeks (fifth month)	Vernix caseosa (fatty secretions of sebaceous glands) covers body; silklike hair (lanugo) covers skin
	Fetal position (body flexed anteriorly) assumed because of space restrictions
	Limbs achieve near-final proportions
	Quickening occurs (mother feels spontaneous muscular activity of fetus)
	Approximate crown-to-rump length at end of interval: 190 mm
21–30 weeks (sixth and seventh months)	Substantial increase in weight (may survive if born prematurely at 27–28 weeks, but hypothalamus still too immature to regulate body temperature, and surfactant production by the lungs is still inadequate)
	Myelination of spinal cord begins; eyes are open
	Skin is wrinkled and red; fingernails and toenails are present
	Body is lean and well proportioned

Table 16.1 *(continued)*

Time	Changes/accomplishments
	Bone marrow becomes sole site of blood cell formation
	Testes enter scrotum in seventh month (in males)
At birth	Approximate crown-to-rump length at end of interval: 280 mm
30–40 weeks (term) (eighth and ninth months)	Fat laid down in subcutaneous tissue of skin
	Approximate crown-to-rump length at end of interval: 360 mm (14 inches); weight: 3.2 kg (7 pounds)

many women develop an accentuated lumbar curvature (lordosis), often accompanied by backaches, during the last few months of pregnancy. Placental production of the hormone **relaxin** causes pelvic ligaments and the pubic symphysis to relax, widen, and become more flexible. This increased motility eases birth passage, but it may also result in a waddling gait during pregnancy.

Good maternal nutrition is necessary throughout pregnancy if the developing fetus is to have all the building materials (proteins, calcium, iron, and the like) to form its tissues and organs. The old expression "A pregnant woman is eating for two" has encouraged many women to eat *twice* the amount of food actually needed during pregnancy, which, of course, leads to excessive weight gain. Actually, a pregnant woman needs only about 300 additional calories daily to sustain proper fetal growth. The emphasis should be on high-quality food, not just more food.

HOMEOSTATIC IMBALANCE

Many potentially harmful substances can cross through the placental barrier into the fetal blood; therefore, the pregnant woman should be very much aware of what she is taking into her body. Substances that may cause life-threatening birth defects (and even fetal death) include alcohol, nicotine, and many types of drugs (anticoagulants, antihypertensives, sedatives, and some antibiotics). Maternal infections, particularly German measles (rubella), may also cause severe fetal damage. Termination of a pregnancy by loss of a fetus during the first 20 weeks of pregnancy is called **abortion.**

Physiological Changes

Gastrointestinal System Many women suffer nausea, commonly called *morning sickness,* during the first few months of pregnancy, until their system adjusts to the elevated levels of progesterone and estrogens. *Heartburn* is common because the esophagus is displaced and the stomach is crowded by the growing uterus, which favors reflux of stomach acid into the esophagus. Another problem is constipation, because motility of the digestive tract declines during pregnancy.

Urinary System The kidneys have the additional burden of disposing of fetal metabolic wastes, and they produce more urine during pregnancy. Because the uterus compresses the bladder, urination becomes more frequent, more urgent, and sometimes uncontrollable. (The last condition is called *stress incontinence.*)

Respiratory System The nasal mucosa responds to estrogen by becoming swollen and congested; thus, nasal stuffiness and occasional nosebleeds may occur. Vital capacity and respiratory rate increase during pregnancy, but residual volume declines, and many women exhibit *dyspnea* (difficult breathing) during the later stages of pregnancy.

Cardiovascular System Perhaps the most dramatic physiological changes occur in the cardiovascular system. Total body water rises and blood volume

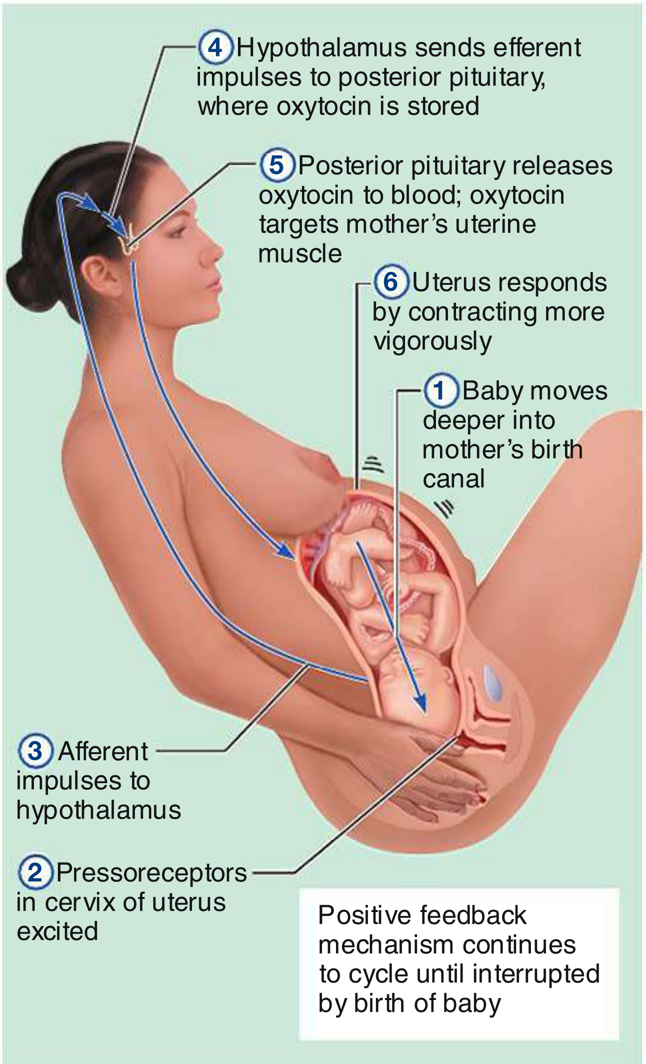


Figure 16.21 The positive feedback mechanism by which oxytocin promotes labor contractions during birth.

increases by 25 to 40 percent to accommodate the additional needs of the fetus. The rise in blood volume also acts as a safeguard against blood loss during birth. Blood pressure and pulse typically rise and increase cardiac output by 20 to 40 percent; this helps propel the greater blood volume around the body. Because the uterus presses on the pelvic blood vessels, venous return from the lower limbs may be impaired somewhat, resulting in varicose veins.

Childbirth

✓ Describe how labor is initiated, and briefly discuss the three stages of labor.

Childbirth, also called **parturition** (par″tu-rish′un; "bringing forth young"), is the culmination of pregnancy. It usually occurs within 15 days of the calculated due date (which is 280 days from the last menstrual period). The series of events that expel the infant from the uterus is referred to as **labor.**

Initiation of Labor

Several events interlock to trigger labor. During the last few weeks of pregnancy, estrogens reach their highest levels in the mother's blood. This has two important consequences: it causes the myometrium to form abundant *oxytocin* receptors (so that it becomes more sensitive to the hormone oxytocin), and it interferes with progesterone's quieting influence on the uterine muscle. As a result, weak, irregular uterine contractions begin to occur. These contractions, called *Braxton Hicks contractions,* have caused many women to go to the hospital, only to be told that they were in **false labor** and sent home.

As birth nears, two more chemical signals cooperate to convert these false labor pains into the real thing. Certain cells of the fetus begin to produce oxytocin, which in turn stimulates the placenta to release *prostaglandins.* Both hormones stimulate more frequent and powerful contractions of the uterus. At this point, the increasing emotional and physical stresses activate the mother's hypothalamus, which signals for oxytocin release by the posterior pituitary. The combined effects of rising levels of oxytocin and prostaglandins initiate the rhythmic, expulsive contractions of true labor. Once the hypothalamus is involved, a positive feedback mechanism is propelled into action: stronger contractions cause the release of more oxytocin, which causes even more vigorous contractions, forcing the baby ever deeper into the mother's pelvis, and so on (**Figure 16.21**).

Because both oxytocin and prostaglandins are needed to initiate labor in humans, anything that interferes with production of either of these hormones will hinder the onset of labor. For example, antiprostaglandin drugs such as aspirin and ibuprofen can inhibit labor at the early stages, and such drugs are used occasionally to prevent premature births.

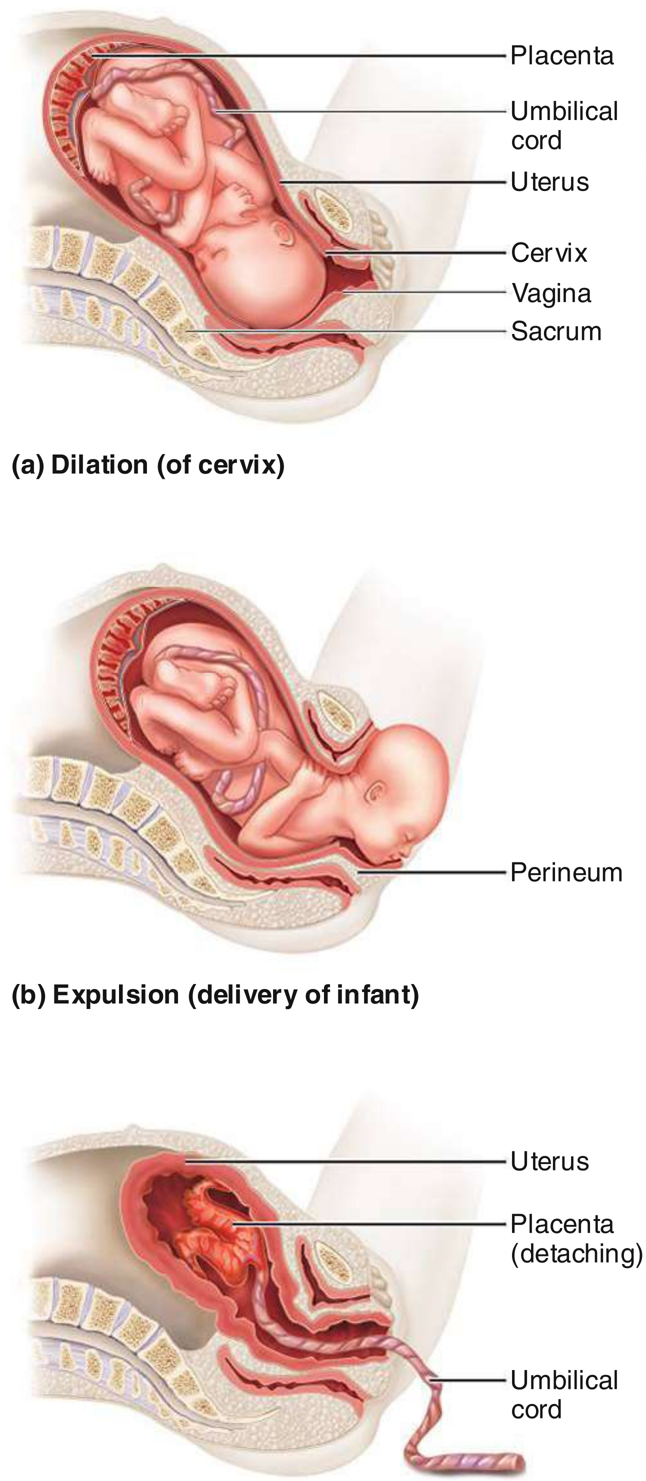
Stages of Labor

The process of labor is commonly divided into three stages (**Figure 16.22**).

Stage 1: Dilation Stage The **dilation stage** is the time from the appearance of true contractions until the cervix is fully dilated by the baby's head (about 10 cm in diameter). As labor starts, regular but weak uterine contractions begin in the upper part of the uterus and move downward toward the vagina. Gradually, the contractions become more vigorous and more rapid, and, as the infant's head is forced against the cervix with each contraction, the cervix begins to soften, becomes thinner (*effaces*), and dilates. Eventually, the amnion ruptures, releasing the amniotic fluid, an event commonly referred to as "breaking the water." The dilation stage is the longest part of labor and usually lasts for 6 to 12 hours or more.

Stage 2: Expulsion Stage The **expulsion stage** is the period from full dilation to delivery of the infant. In this stage, the infant passes through the cervix and vagina to the outside of the body. During this stage, a mother experiencing natural childbirth (that is, undergoing labor without local anesthesia) has an increasing urge to push, or bear down, with the abdominal muscles. Although this phase can take as long as 2 hours, it is typically 50 minutes in a first birth and around 20 minutes in subsequent births.

When the infant is in the usual head-first (*vertex*) position, the skull (its largest diameter) acts as a wedge to dilate the cervix. The head-first presentation also allows the baby to be suctioned free of mucus and to breathe even before it has completely exited from the birth canal. Once the head has been delivered, the rest of the baby's body is delivered much more easily. After birth, the umbilical cord is clamped and cut. In *breech* (buttocks-first) presentations and other nonvertex presentations, these advantages are lost and delivery is often much more difficult, sometimes requiring the use of forceps or a vacuum extractor.



(a) Dilation (of cervix)

(b) Expulsion (delivery of infant)

(c) Placental (delivery of the placenta)

Figure 16.22 **The three stages of labor.**

HOMEOSTATIC IMBALANCE

During an extremely prolonged or difficult stage 2, a condition called **dystocia** (dis-to′se-ah) may occur. In dystocia, oxygen delivery to the infant is inadequate, leading to fetal brain damage (resulting in cerebral palsy or epilepsy) and decreased viability of the infant. To prevent these outcomes, a **cesarean** (se-zayr′e-an) **section,** also called a **C-section,** may be performed. A C-section is delivery of the infant through a surgical incision made through the abdominal and uterine walls.

Stage 3: Placental Stage The **placental stage,** or the delivery of the placenta, is usually accomplished within 15 minutes after birth of the infant. The strong uterine contractions that continue after birth compress uterine blood vessels, limit bleeding, and cause the placenta to detach from the uterine wall. The placenta and its attached fetal membranes, collectively called the **afterbirth,** are then easily removed by a slight tug on the umbilical cord. It is very important that all placental fragments be removed to prevent continued uterine bleeding after birth (*postpartum bleeding*).

DID YOU GET IT?

23. Explain how pregnancy affects a woman's respiratory and digestive processes.

24. What are the three stages of labor?

For answers, see Appendix D.

Developmental Aspects of the Reproductive System

- ✓ Describe the importance of the presence/absence of testosterone during embryonic development of the reproductive system organs.
- ✓ Define *menarche* and *menopause.*
- ✓ List common reproductive system problems seen in adult and aging men and women.

Although the genetic sex of an individual is determined at the time of fertilization (males have X and Y sex chromosomes and females have two X sex chromosomes), the gonads do not begin to form until about the eighth week of embryonic development. Prior to this time, the embryonic reproductive structures of males and females are identical and are said to be in the *indifferent stage.* After the gonads have formed, development of the accessory structures and external genitalia begins. Whether male or female structures will form depends entirely on whether testosterone is present or absent. The usual case is that, once formed, the embryonic testes produce testosterone, and the development of the male duct system and external genitalia follows. When testosterone is not produced, as is the case in female embryos that form ovaries, the female ducts and external genitalia result.

HOMEOSTATIC IMBALANCE

Any interference with the normal pattern of sex hormone production in the embryo results in abnormalities. For example, if the embryonic testes fail to produce testosterone, a genetic male develops the female accessory structures and external genitalia. If a genetic female is exposed to testosterone (as might happen if the mother has an androgen-producing tumor of her adrenal gland), the embryo has ovaries but develops male accessory ducts and glands, as well as a penis and an empty scrotum. Individuals with external genitalia that do not "match" their gonads are called **pseudohermaphrodites** (su″do-her-maf′ro-dītz) to distinguish them from true **hermaphrodites,** rare individuals who possess both ovarian and testicular tissues. In recent years, many pseudohermaphrodites have sought sex change operations to match their outer selves (external genitalia) with their inner selves (gonads).

Additionally, abnormal separation of chromosomes during meiosis can lead to congenital defects of this system. For example, males who have an extra female sex chromosome have the normal male accessory structures, but their testes atrophy, causing them to be sterile. Other abnormalities occur when a child has only one sex chromosome. An XO female appears normal but lacks ovaries; YO males die during development. Other, much less serious, conditions affect males primarily; these include **phimosis** (fi-mo′sis), which essentially is a narrowing of the foreskin of the penis, and misplaced urethral openings.

The male testes, formed in the abdominal cavity at approximately the same location as the female ovaries, descend to enter the scrotum about one month before birth. Failure of the testes to make their normal descent leads to a condition called **cryptorchidism** (krip-tor′ki-dĭzm). Because this