

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 (*post partum 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-dīzm). Because this

condition results in sterility of a male (and also puts him at risk for cancer of the testes), surgery is usually performed during childhood to rectify this problem. **D**

Because the reproductive system organs do not function until puberty, there are few problems with this system during childhood. **Puberty** is the period of life, generally between the ages of 10 and 15 years, when the reproductive organs grow to their adult size and become functional under the influence of rising levels of gonadal hormones (testosterone in men and estrogen in women). After this time, reproductive capability continues until old age in men and menopause in women. Earlier we described the secondary sex characteristics and major events of puberty, so we will not repeat these details here. It is important to remember, however, that puberty represents the earliest period of reproductive system activity.

The events of puberty occur in the same sequence in all individuals, but the age at which they occur varies widely. In boys, the event that signals puberty's onset is enlargement of the testes and scrotum, around the age of 13 years, followed by the appearance of pubic, axillary, and facial hair. Growth of the penis goes on over the next 2 years, and sexual maturation is indicated by the presence of mature sperm in the semen. In the meantime, the young man has unexpected erections and occasional nocturnal emissions ("wet dreams") as his hormones surge and hormonal controls struggle to achieve a normal balance.

The first sign of puberty in girls is budding breasts, often apparent by the age of 11 years. The first menstrual period, called **menarche** (mē-nar'ke), usually occurs about 2 years later. Dependable ovulation and fertility are deferred until the hormonal controls mature, an event that takes nearly 2 more years.



### HOMEOSTATIC IMBALANCE

In adults, the most common reproductive system problems are infections. Vaginal infections are more common in young and elderly women and in women whose resistance is low. Common infections include those caused by *Escherichia coli* (spread from the digestive tract); sexually transmitted microorganisms (such as gonorrhea, syphilis, and herpesvirus); and yeasts

(a type of fungus). Untreated vaginal infections may spread throughout the female reproductive tract, causing pelvic inflammatory disease and sterility. Problems involving painful or abnormal menses may result from infection or hormone imbalance.

The most common inflammatory conditions in men are **urethritis**, **prostatitis**, and **epididymitis** (ep'ī-did-ī-mī'tis), all of which may follow sexual contacts in which sexually transmitted microorganisms are transmitted. **Orchiditis** (or'kī-dī'tis), inflammation of the testes, is rather uncommon but is serious because it can cause sterility. Orchiditis most commonly follows STI or mumps (in an adult man).

As noted earlier, neoplasms represent a major threat to reproductive system organs. Tumors of the breast and cervix are the most common reproductive cancers in adult women, and prostate cancer (a common sequel to prostatic hypertrophy) is a widespread problem in adult men. **D**

Most women reach peak reproductive abilities in their late twenties. After that, a natural decrease in ovarian function occurs. As estrogen production declines, ovulation becomes irregular, and menstrual periods become scanty and shorter in length. Eventually, ovulation and menses cease entirely, ending childbearing ability. This event, called **menopause**, normally occurs between the ages of 46 and 54 years and is considered to have occurred when a whole year has passed without menstruation.

Although estrogen production continues for a while after menopause, the ovaries finally stop functioning as endocrine organs. When deprived of the stimulatory effects of estrogen, the reproductive organs and breasts begin to atrophy. The vagina becomes dry; intercourse may become painful (particularly if infrequent), and vaginal infections become increasingly common. Other consequences of estrogen deficit include irritability and other mood changes (depression in some); intense vasodilation of the skin's blood vessels, which causes uncomfortable sweat-drenching "hot flashes"; gradual thinning of the skin and loss of bone mass; and slowly rising blood cholesterol levels, which place postmenopausal women at risk for cardiovascular disorders. At one time, physicians prescribed low-dose estrogen-progesterone preparations to

*(Continues on page 572)*

## Contraception: Preventing Pregnancy

In a society such as ours, where many women opt for professional careers or must work for economic reasons, **contraception** (*contra* = against; *cept* = taking), or *birth control*, is often seen as a necessity. Thus far, much of the burden for birth control has fallen on women's shoulders, and most birth control products are directed toward women.

The key to birth control is dependability. As shown by the red arrows in the accompanying flowchart, the birth control techniques and products currently available have many sites of action for blocking the reproductive process. Let's examine the relative advantages of a few of these current methods more closely.

The most-used contraceptive product in the United States is the *birth control pill*, or simply, "the pill," a preparation taken daily that contains tiny amounts of estrogens and progestins (progesterone-like hormones), except that for the last 7 days of the 28-day cycle the tablets are hormone-free. The pill tricks the hypothalamic-pituitary control system and "lulls it to sleep" because the relatively constant blood levels of ovarian hormones make it appear that the woman is pregnant (both estrogen and progesterone are produced throughout pregnancy). Ovarian follicles do not mature, ovulation ceases, and menstrual flow is much reduced. However, because hormonal balance in the body is

precisely controlled, some women simply cannot tolerate the changes caused by the pill—they become nauseated and/or hypertensive.

The pill has adverse cardiovascular effects in a small number of users, and there is still debate about whether it increases the incidence of ovarian, uterine, and particularly breast cancer. However, it appears that the new, very low dose preparations may actually help protect against ovarian and endometrial cancer and may also have reduced the incidence of serious cardiovascular side effects, such as strokes, heart attacks, and blood clots, that occurred (rarely) with earlier forms of the pill.

Presently, the pill is one of the most widely used drugs in the world; well over 50 million women use these drugs to prevent pregnancy. The incidence of failure is less than 1 percent.

A different combination hormone pill, the *morning-after pill (MAP)*, is the therapy of choice for rape victims. Marketed under various names, including Ovral, Tetragynon, and Trephasil, MAPs are becoming more widely known. Taken within 3 days of unprotected intercourse, the concentrated estrogen-progesterone combination pills "mess up" the normal hormonal signals so much that fertilization is prevented altogether or a fertilized egg is prevented from implanting.

Other hormonal approaches are progestin-only products that cause

cervical mucus to become thick, blocking sperm passage and making the endometrium inhospitable to implantation.

These include the *minipill* (a tablet); *implants* of a tiny silicon rod that releases the hormone over several years; and *Depo-Provera*, an injectable synthetic progesterone that lasts for 3 months. The failure rate of the implant or injection is even lower than that of the pill.

For several years, the second most used contraceptive method was the *intrauterine device (IUD)*, a plastic or metal device inserted into the uterus that prevented implantation of the fertilized egg (see photo on p. 572). Although the failure rate of the IUD was nearly as low as that of the pill, IUDs were taken off the market in the United States because of problems with occasional contraceptive failure, uterine perforation, or pelvic inflammatory disease (PID). New IUD products that deliver sustained doses of synthetic progesterone to the endometrium are currently being recommended for women who have given birth and for women with a lower risk of developing PID in monogamous relationships.

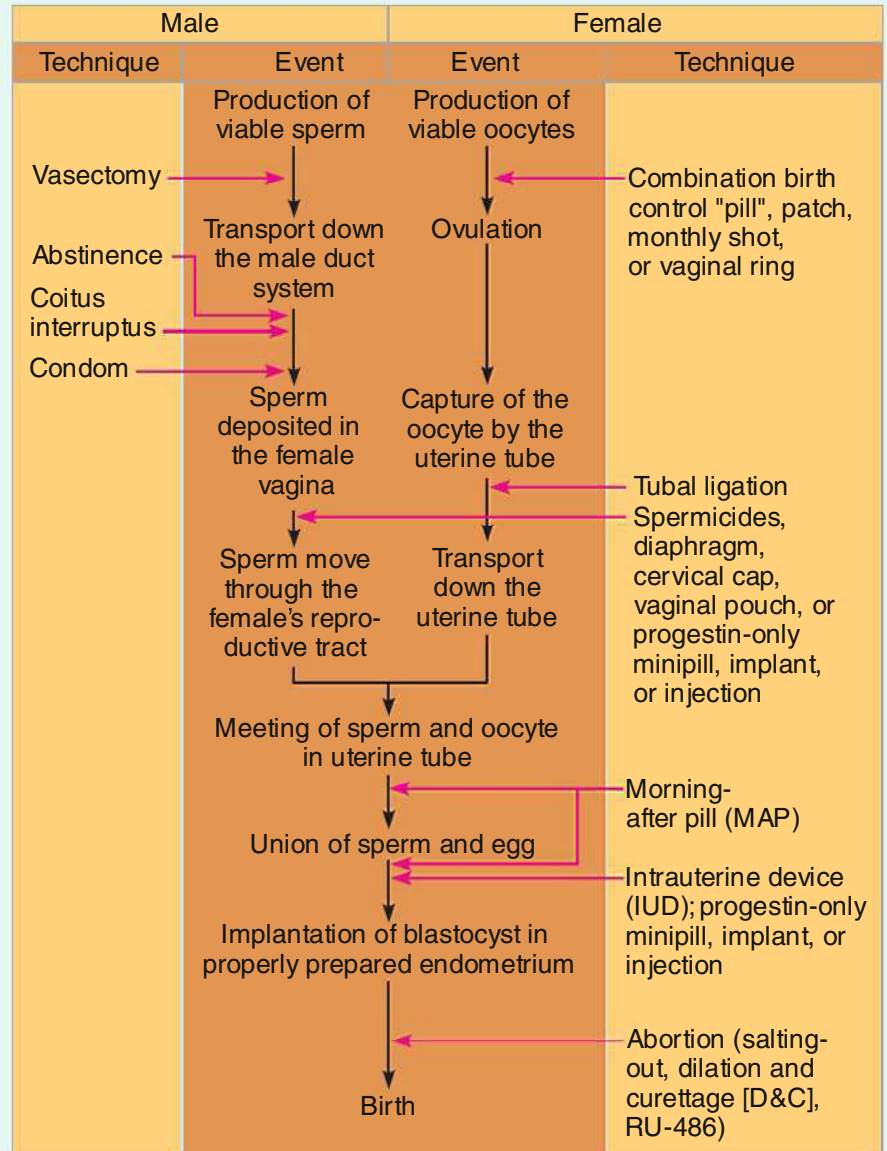
Sterilization techniques, such as *tubal ligation* and *vasectomy* (cutting or cauterizing the uterine tubes or ductus deferens, respectively), are nearly foolproof and are the choice of approximately 33 percent of couples of childbearing age in the United

States. Both procedures can be done in the physician's office. These changes are usually permanent, however, so they are not for individuals who plan to have children but want to choose the time.

*Coitus interruptus*, or withdrawal of the penis just before ejaculation, is simply against nature, and control of ejaculation is never assured.

*Rhythm*, or *fertility awareness methods*, depend on avoiding intercourse during the period of ovulation or fertility. This may be accomplished by (1) recording daily basal body temperatures (body temperature drops slightly immediately prior to ovulation and then rises slightly after ovulation) or (2) recording changes in the pattern of salivary mucus with a lipstick-sized nonprescription instrument called an Ovulite Microscope. With a failure rate of 10 to 20 percent, rhythm techniques require accurate record-keeping for several cycles before they can be used with confidence. *Barrier methods*, such as diaphragms, cervical caps, condoms (see photo), spermicidal foams, gels, and sponges, are quite effective, especially when some agent is used by both partners. But many people avoid them because they can reduce the spontaneity of sexual encounters.

*Abortion* is the termination of a pregnancy that is in progress. Spontaneous abortion, also called *miscarriage*, is common and frequently occurs before a woman is aware she has conceived. Additionally, over 1 million women opt to terminate pregnancy in the physician's office. In this arena, *RU-486*, the so-called *abortion pill* developed in France, is widely used



**Flowchart of the events that must occur to produce a baby.**

Techniques or products that interfere with the process are indicated by red arrows at the site of interference; they act to prevent the next step.

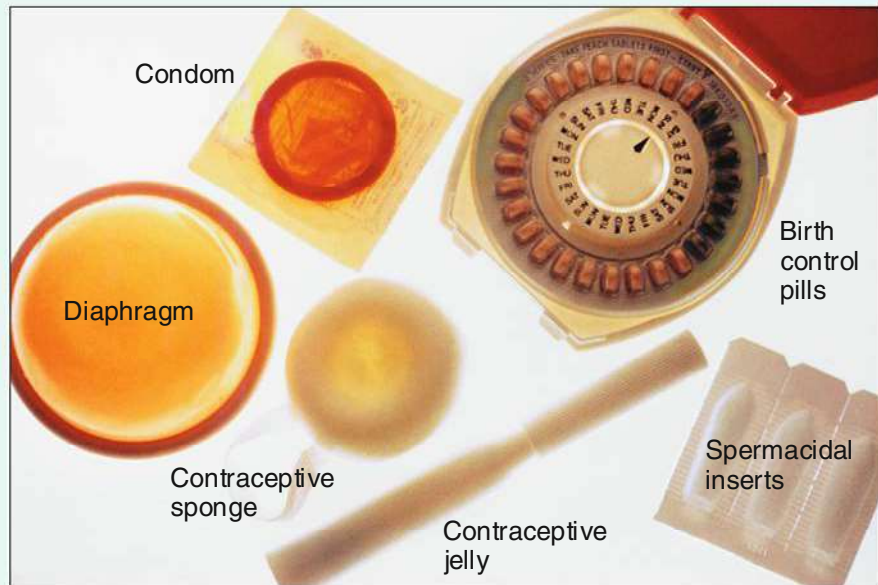
in the United States. When taken during the first 7 weeks of pregnancy in conjunction with a tiny amount of prostaglandin to induce uterine contractions, it induces miscarriage by blocking

progesterone's quieting effect on the uterus. RU-486 has a 96 to 98 percent success rate with few side effects other than cramping and short-term spotting. However, a small number of deaths due to



infection and sepsis prompted the FDA in July 2005 to issue a warning about using RU-486. These incidents were very rare, but further studies on this drug are ongoing. Now approved by the FDA, it has become a topic of bitter controversy among pro-choice and pro-life groups in the United States.

This summary has barely touched on the large number of experimental birth control drugs now awaiting clinical trials; and other methods are sure to be developed in the near future. In the final analysis, however, the only 100 percent effective means of birth control is the age-old one—*total abstinence*.



**Some contraceptive devices.**

help women through this often difficult period and to prevent the skeletal and cardiovascular complications. These seemed like great bonuses, and until July 2002, some 14 million American women were taking some form of estrogen-containing hormone replacement therapy (HRT). Then, on July 9, the Women's Health Initiative (WHI) abruptly ended a clinical trial of 16,000 postmenopausal women, reporting that in those taking a popular progesterone-estrogen hormone combination there was an increase of 51 percent in heart disease, 24 percent in invasive breast cancer, 31 percent in stroke, and a doubling of the risk of dementia compared to those taking placebos. The backlash of this information is still spreading through physicians' offices and research labs, and it has dampened enthusiasm for HRT in both the medical community and postmenopausal women. A new and encouraging study in 2006 reported a significant drop in

breast cancers, with the drop due nearly entirely to fewer women using HRT.

There is no equivalent of menopause in males. Although aging men exhibit a steady decline in testosterone secretion and a longer latent period after orgasm, their reproductive capability seems unending. Healthy men well into their eighties and beyond are able to father offspring.

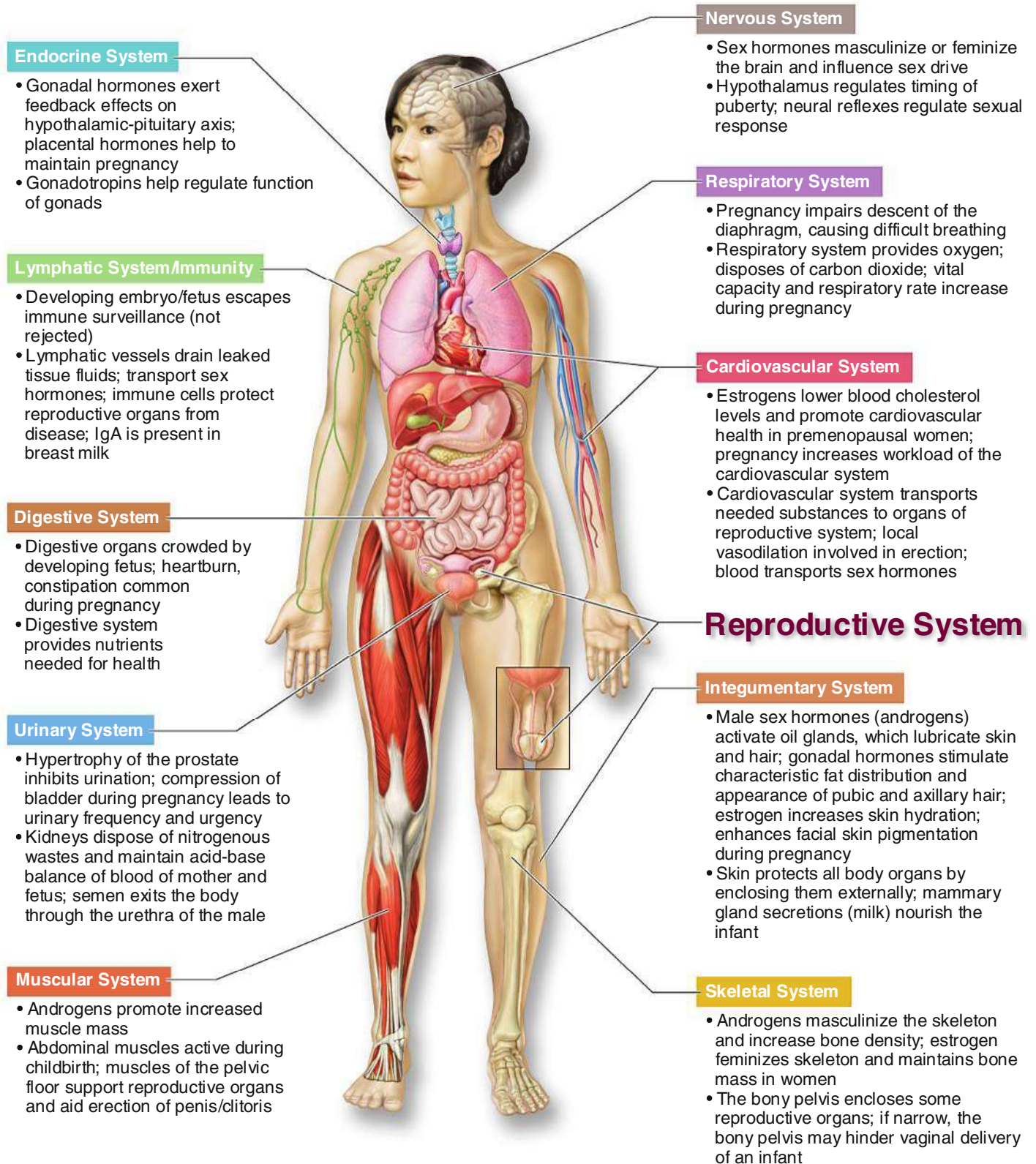
### **DID YOU GET IT ?**

- 25.** Which sex chromosome combination yields a boy—XX or XY? What hormone must be produced by an XY fetus during development to stimulate its formation of the male duct system?
- 26.** What is cryptorchidism, and what results if it is not rectified?
- 27.** What are the major health threats to the adult woman's reproductive system?

*For answers, see Appendix D.*

# SYSTEMS IN SYNC

## Homeostatic Relationships between the Reproductive System and Other Body Systems



## Summary

➤ Access more review material and fun learning activities online—visit [www.anatomyandphysiology.com](http://www.anatomyandphysiology.com) and select Essentials of Human Anatomy & Physiology, 10th edition. In addition, references to Interactive Physiology are included below.

**iP** = Interactive Physiology

### Anatomy of the Male Reproductive System (pp. 539–544)

1. The paired testes, the male gonads, reside in the scrotum outside the abdominopelvic cavity. Testes have both an exocrine (sperm-producing) and an endocrine (testosterone-producing) function.
2. The male duct system includes the epididymis, ductus deferens, and urethra. Sperm mature in the epididymis. When ejaculation occurs, sperm are propelled through duct passageways to the body exterior.
3. Male accessory glands include the seminal vesicles, prostate, and bulbourethral glands. Collectively, these glands produce a fluid that activates and nourishes sperm.
4. External genitalia:
  - a. Scrotum—a skin sac that hangs outside the abdominopelvic cavity and provides the proper temperature for producing viable sperm.
  - b. Penis—consists of three columns of erectile tissue surrounding the urethra. Erectile tissue provides a way for the penis to become rigid so it may better serve as a penetrating device during sexual intercourse.

### Male Reproductive Functions (pp. 544–548)

1. Spermatogenesis (sperm production) begins at puberty in seminiferous tubules in response to FSH. Spermatogenesis involves meiosis, a special nuclear division that halves the chromosomal number in resulting spermatids. An additional process that strips excess cytoplasm from the spermatid, called spermiogenesis, is necessary for production of functional, motile sperm.
2. Testosterone production begins in puberty in response to LH. Testosterone is produced by interstitial cells of the testes. Testosterone causes the appearance of male secondary sex characteristics and is necessary for sperm maturation.

### Anatomy of the Female Reproductive System (pp. 548–552)

1. The ovaries, the female gonads, are located against the lateral walls of the pelvis. They produce female sex cells (exocrine function) and hormones (endocrine function).
2. The duct system:
  - a. Uterine (fallopian) tubes extend from the vicinity of an ovary to the uterus. Ends are fringed and “wave” to direct ovulated oocytes into uterine tubes, which conduct the oocyte (embryo) to the uterus by peristalsis and ciliary action.
  - b. The uterus is a pear-shaped muscular organ in which the embryo implants and develops. Its mucosa (endometrium) sloughs off each month in menses unless an embryo has become embedded in it. The myometrium contracts rhythmically during the birth of a baby.
  - c. The vagina is a passageway between the uterus and the body exterior that allows a baby or the menstrual flow to leave the body. It also receives the penis and semen during sexual intercourse.
3. Female external genitalia include labia majora and minora (skin folds), clitoris, and urethral and vaginal openings.

### Female Reproductive Functions and Cycles (pp. 552–556)

1. Oogenesis (production of female sex cells) occurs in ovarian follicles, which are activated at puberty by FSH and LH to mature and eject oocytes (ovulation) on a cyclic basis. The egg (ovum) is formed only if sperm penetrates the secondary oocyte. In females, meiosis produces only one functional ovum (plus three nonfunctional polar bodies), as compared with the four functional sperm per meiosis produced by males.
2. Hormone production: Estrogens are produced by ovarian follicles in response to FSH. Progesterone, produced in response to LH, is the main hormonal product of the corpus luteum. Estrogens stimulate development of female secondary sex characteristics.
3. The menstrual cycle involves changes in the endometrium in response to fluctuating blood levels of ovarian hormones. There are three phases:

- a. Menstrual phase. Endometrium sloughs off and bleeding occurs. Ovarian hormones are at their lowest levels.
  - b. Proliferative phase. Endometrium is repaired, thickens, and becomes well vascularized in response to increasing levels of estrogens.
  - c. Secretory phase. Endometrial glands begin to secrete nutrients, and lining becomes more vascular in response to increasing levels of progesterone.
4. If fertilization does not occur, the phases are repeated about every 28 days.

### Mammary Glands (pp. 556–558)

1. Mammary glands are milk-producing glands found in the breasts. After the birth of a baby, they produce milk in response to hormonal stimulation.

### Pregnancy and Embryonic Development (pp. 558–568)

1. An oocyte can be fertilized up to 24 hours after release; sperm are viable within the female reproductive tract for up to 48 hours. Hundreds of sperm must release their acrosomal enzymes to break down the egg's plasma membrane.
2. Following sperm penetration, the secondary oocyte completes meiosis II. Then ovum and sperm nuclei fuse (fertilization), forming a zygote.
3. If fertilization occurs, embryonic development begins immediately. Cleavage, a rapid series of mitotic divisions without intervening growth, begins with the zygote and ends with a blastocyst.
4. By day 14 after ovulation, the young embryo (blastocyst) has implanted in the endometrium, and the placenta is being formed. Human chorionic gonadotropin (hCG) released by the blastocyst maintains hormone production of the corpus luteum, preventing menses, until the placenta assumes its endocrine role.
5. The placenta serves respiratory, nutritive, and excretory needs of the embryo and produces hormones of pregnancy.
6. All major organ systems have been laid down by eight weeks, and at nine weeks the embryo is called a fetus. Growth and tissue/organ specialization are the major events of the fetal period.
7. A pregnant woman has increased respiratory, circulatory, and urinary demands placed on her system by the developing fetus. Good nutrition is necessary to produce a healthy baby.

8. Childbirth (parturition) includes a series of events called labor. It is initiated by several factors but most importantly by rising levels of oxytocin and prostaglandins, which promote vigorous uterine contractions. The three stages of labor are dilation, expulsion, placental.

### Developmental Aspects of the Reproductive System (pp. 568–572)

1. Reproductive system structures of males and females are identical during early development. Gonads begin to develop in the eighth week. The presence or absence of testosterone determines whether male or female accessory reproductive organs are formed.
2. Important congenital defects result from abnormal separation of sex chromosomes during sex cell formation.
3. The reproductive system is inactive during childhood. Reproductive organs mature and become functional for childbearing at puberty.
4. Common reproductive problems during young adulthood are infections of the reproductive tract. Neoplasms of breast and cervix are major threats to women. Prostate cancer is the most common reproductive system cancer seen in men.
5. During menopause, female reproductive capabilities end, and reproductive organs begin to atrophy. Hot flashes and mood changes may occur. Reproductive capacity does not appear to decline significantly in aging men.

## Review Questions

### Multiple Choice

*More than one choice may apply.*

1. Which of the following are accessory sex structures in the male?
  - a. Gonads
  - b. Gametes
  - c. Broad shoulders
  - d. Seminal vesicles
2. In terms of development, which of these pairs is mismatched?
  - a. Vagina—penis
  - b. Testis—ovary
  - c. Labia majora—scrotum
  - d. Uterine tube—ductus deferens



3. The myometrium is the muscular layer of the uterus, and the endometrium is the \_\_\_\_\_ layer.
  - a. serosa
  - b. adventitia
  - c. submucosa
  - d. mucosa
4. All of the following are true of the gonadotropins except that they are
  - a. secreted by the pituitary gland.
  - b. LH and FSH.
  - c. hormones with important functions in both males and females.
  - d. the sex hormones secreted by the gonads.
5. The approximate area between the anus and clitoris in the female is the
  - a. peritoneum.
  - b. perineum.
  - c. vulva.
  - d. labia.
6. Which of the following attach to the ovary?
  - a. Fimbriae
  - b. Ovarian ligament
  - c. Suspensory ligaments
  - d. Broad ligament
7. Human ova and sperm are similar in that
  - a. about the same number of each is produced per month.
  - b. they have the same degree of motility.
  - c. they are about the same size.
  - d. they have the same number of chromosomes.
8. Select the false statement about the cervix of the uterus.
  - a. It is the superiormost part of the uterus.
  - b. It projects into the vagina.
  - c. Its cervical glands secrete mucus.
  - d. It contains the cervical canal.
9. Each month, typically only one
  - a. primary follicle is stimulated.
  - b. follicle secretes estrogen.
  - c. vesicular follicle undergoes ovulation.
  - d. ovary is stimulated.
10. After ovulation, the ruptured follicle
  - a. degenerates.
  - b. becomes a corpus luteum.
  - c. sloughs off as waste material.
  - d. mends and produces another oocyte.
11. The outer layer of the blastocyst, which attaches to the uterine wall, is the
  - a. yolk sac.
  - b. inner cell mass.
  - c. amnion.
  - d. trophoblast.
12. The usual and most desirable presentation for birth is
  - a. vertex.
  - b. breech.
  - c. nonvertex.
  - d. head first.
13. During human embryonic development, organogenesis occurs
  - a. during the first trimester.
  - b. during the second trimester.
  - c. during the third trimester.
  - d. just before birth.

### Short Answer Essay

14. What are the primary sex organs, or gonads, of males? What are their two major functions?
15. What is the function of seminal fluid? Name the three types of glands that help produce it.
16. The penis contains erectile tissue that becomes engorged with blood during sexual excitement. What term is used to describe this event?
17. Define *ejaculation*.
18. Why are the male gonads not found in the abdominal cavity? Where are they found?
19. How does enlargement of the prostate interfere with a man's reproductive function?
20. When does spermatogenesis begin? What causes it to begin?
21. Testosterone causes the male secondary sex characteristics to appear at puberty. Name three examples of male secondary sex characteristics.
22. Explain why a man's sexual responsiveness and secondary sex characteristics generally remain unchanged after a vasectomy.
23. Name the female gonad, and describe its two major functions.
24. Why is the term *urogenital system* more applicable to males than females?
25. Name the structures of the female duct system, and describe the important functions of each.
26. Given that the uterine tubes are not continuous with the ovaries, how can you explain the fact that all ovulated "eggs" do not end up in the female's peritoneal cavity?

27. What is a follicle? What is ovulation?
28. The female cell that is ovulated is not a mature sex cell (ovum). When or under what conditions does it become mature?
29. What ovarian structures produce estrogens? Name the second hormone produced by the same structures.
30. List and describe the events of the menstrual cycle. Why is the menstrual cycle so important?
31. Define *menopause*. What does this mean to a woman?
32. Define *fertilization*. Where does fertilization usually occur? Describe the process of implantation.
33. How is body functioning of a pregnant woman altered by her pregnancy?
34. What events trigger labor?
35. Delivery of the infant occurs during which stage of labor?
36. What is the *indifferent stage* of embryonic development?
37. What are the major events of puberty?
38. Compare the effects of aging on the male and female reproductive systems.



## Critical Thinking and Clinical Application Questions

39. A pregnant woman in substantial pain called her doctor and explained (between sobs) that she was about to have her baby “right away.” The doctor calmed her and asked how she had come to that conclusion. She said that her water had broken and that her husband could see the baby’s head. **(a)** Was she right to believe that birth was imminent? If so, what stage of labor was she in? **(b)** Do you think she had time to make it to the hospital 60 miles away? Why or why not?
40. Lucy had both her left ovary and her right uterine tube removed surgically at age 17 because of a cyst and a tumor in these organs. Now, at age 32, she remains healthy and is expecting her second child. How could Lucy conceive a child with just one ovary and one uterine tube, widely separated on opposite sides of the pelvis like this?