

8th EDITION

SIMMERS DHO HEALTH SCIENCE

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KEY TERMS

Bartholin's glands (*Bar'-tha-lens*)
breasts

Cowper's (bulbourethral) glands
(*Cow'-purrs*)

ejaculatory ducts (*ee-jack'-*
you-lah-tore''-ee)

endometrium
(*en''-doe-me'-tree-um*)

epididymis (*eh''-pih-did'-ih-muss*)

fallopian tubes (*fah-low'-pea''-an*)

fertilization (*fur''-til-ih-zay'-shun*)

labia majora (*lay'-bee''-ah*
mah''-jore'-ah)

labia minora (*lay'-bee''-ah*
ma-nore'-ah)

ovaries

penis

perineum (*pear''-ih-knee'-um*)

prostate gland

reproductive system

scrotum (*skrow'-tum*)

seminal vesicles (*sem'-ih-null*
ves'-ik-ullz)

testes (*tes'-tees*)

urethra

uterus

vagina (*vah-jie'-nah*)

vas (ductus) deferens (*vass*
deaf'-eh-rens)

vestibule

vulva (*vull'-vah*)

Related Health Careers

- Embryologist
- Genetic Counselor
- Geneticist
- Gynecologist
- Midwife
- Obstetrician
- Ultrasound Technologist (Sonographer)

The function of the **reproductive system** is to produce new life. Although the anatomic parts differ in male and female individuals, the reproductive systems of both have the same types of organs: gonads (sex glands); ducts (tubes) to carry the sex cells and secretions; and accessory organs.

Male Reproductive System

The male reproductive system consists of the testes, epididymis, vas deferens, seminal vesicles, ejaculatory ducts, urethra, prostate gland, Cowper's glands, and penis (Figure 7-78).

The male gonads are the **testes**. The two testes are located in the **scrotum**, a sac suspended between the thighs. The testes produce the male sex cells called *sperm*, or *spermatozoa*, in seminiferous tubules located within each testis. Because the scrotum is located outside the body, the temperature in the scrotum is lower than that inside the body. This lower temperature is essential for the production of sperm. The testes also produce male hormones. The main hormone is testosterone, which aids in the maturation of the sperm and also is responsible for the secondary male sex characteristics such as body hair, facial hair, large muscles, and a deep voice.

After the sperm develop in the seminiferous tubules in the testes, they enter the **epididymis**. The epididymis

is a tightly coiled tube approximately 20 feet in length and located in the scrotum and above the testes. It stores the sperm while they mature and become motile (able to move by themselves). It also produces a fluid that becomes part of the semen (fluid released during ejaculation). The epididymis connects with the next tube, the vas deferens.

The **vas (ductus) deferens** receives the sperm and fluid from the epididymis. On each side, a vas deferens joins with the epididymis and extends up into the abdominal cavity, where it curves behind the urinary bladder and joins with a seminal vesicle. Each vas deferens acts as both a passageway and a temporary storage area for sperm. The vas deferens are also the tubes that are cut during a *vasectomy* (procedure to produce sterility in the male).

The **seminal vesicles** are two small pouchlike tubes located behind the bladder and near the junction of the vas deferens and the ejaculatory ducts. They contain a glandular lining. This lining produces a thick, yellow fluid that is rich in sugar and other substances and provides nourishment for the sperm. This fluid composes a large part of the semen.

The **ejaculatory ducts** are two short tubes formed by the union of the vas deferens and the seminal vesicles.

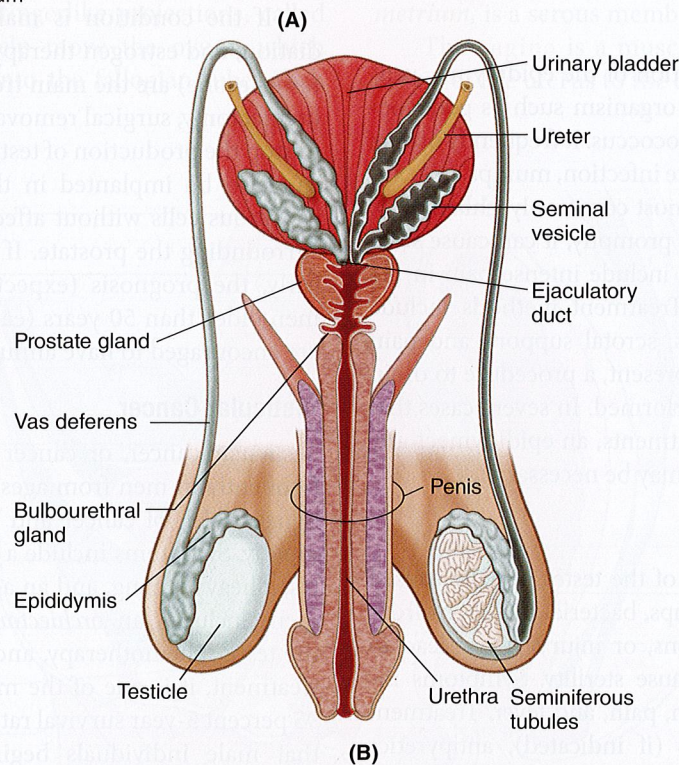
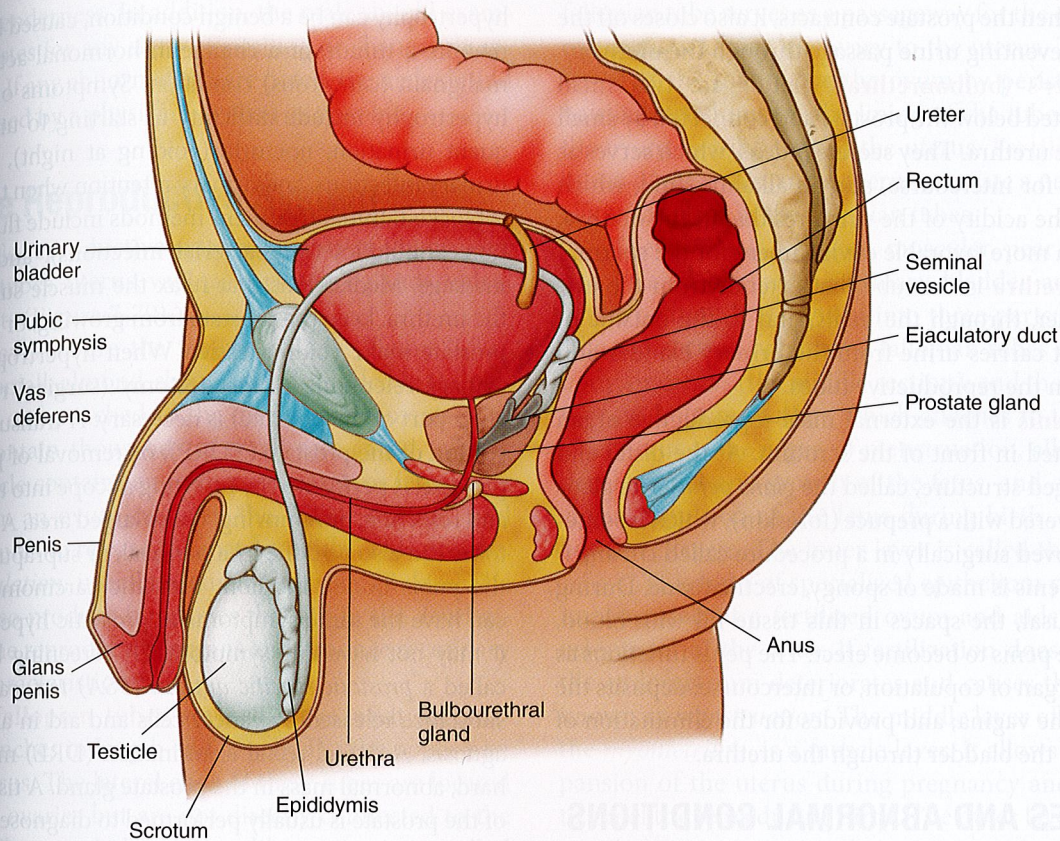


FIGURE 7-78 The male reproductive system. (A) Lateral view. (B) Anterior view. Copyright © Cengage Learning®. All Rights Reserved.

They carry the sperm and fluids known collectively as **semen** through the prostate gland and into the urethra.

The **prostate gland** is a doughnut-shaped gland located below the urinary bladder and on either side of the urethra. It produces an alkaline secretion that both

increases sperm motility and neutralizes the acidity in the vagina, providing a more favorable environment for the sperm. The muscular tissue in the prostate contracts during ejaculation (expulsion of the semen from the body) to aid in the expulsion of the semen into the

urethra. When the prostate contracts, it also closes off the urethra, preventing urine passage through the urethra.

Cowper's (bulbourethral) glands are two small glands located below the prostate and connected by small tubes to the urethra. They secrete mucus, which serves as a lubricant for intercourse, and an alkaline fluid, which decreases the acidity of the urine residue in the urethra, providing a more favorable environment for the sperm.

The **urethra** is the tube that extends from the urinary bladder, through the penis, and to the outside of the body. It carries urine from the urinary bladder and semen from the reproductive tubes.

The **penis** is the external male reproductive organ and is located in front of the scrotum. At the distal end is an enlarged structure, called the *glans penis*. The glans penis is covered with a prepuce (foreskin), which is sometimes removed surgically in a procedure called *circumcision*. The penis is made of spongy, erectile tissue. During sexual arousal, the spaces in this tissue fill with blood, causing the penis to become erect. The penis functions as the male organ of copulation, or intercourse; deposits the semen in the vagina; and provides for the elimination of urine from the bladder through the urethra.

DISEASES AND ABNORMAL CONDITIONS

Epididymitis

Epididymitis is an inflammation of the epididymis, usually caused by a pathogenic organism such as gonococcus, streptococcus, or staphylococcus. It frequently occurs with a urinary tract or prostate infection, mumps, or sexually transmitted infections (most commonly, chlamydia). If epididymitis is not treated promptly, it can cause scarring and sterility. Symptoms include intense pain in the testes, swelling, and fever. Treatment methods include antibiotics, cold applications, scrotal support, and pain medication. If an abscess is present, a procedure to drain the pocket of pus may be performed. In severe cases that do not respond to other treatments, an epididymectomy (removal of the epididymis) may be necessary.

Orchitis

Orchitis is an inflammation of the testes, usually caused by the virus that causes mumps, bacterial infections from sexually transmitted infections, or injury. It can lead to atrophy of the testes and cause sterility. Symptoms include swelling of the scrotum, pain, and fever. Treatment methods include antibiotics (if indicated), antipyretics (for fever), scrotal support, and pain medication. Prevention methods include mumps vaccinations and observing measures to prevent sexually transmitted infections (STIs).

Prostatic Hypertrophy and Cancer

Prostatic hypertrophy, or hyperplasia, is an enlargement of the prostate gland. Common in men over age 50, prostatic

hypertrophy can be a benign condition, caused by inflammation, a tumor, or a change in hormonal activity; or a malignant (cancerous) condition. Symptoms of prostatic hypertrophy include difficulty in starting to urinate, frequent urination, nocturia (voiding at night), dribbling, urinary infections, and urinary retention when the urethra is blocked. Initial treatment methods include fluid restriction, antibiotics (for bacterial infections), and prostatic massage. Medications that relax the muscle surrounding the urethra, keep the prostate from growing, or shrink the prostate make voiding easier. When hypertrophy causes urinary retention, a prostatectomy (surgical removal of all or part of the prostate) is necessary. A transurethral resection of the prostate (TURP), or removal of part of the prostate, is performed by inserting a scope into the urethra and resecting, or removing, the enlarged area. A prostatectomy can also be done by a perineal, or suprapubic (above the pubis bone), incision. Prostatic carcinoma (cancer) can have the same symptoms as prostatic hypertrophy or it may not have any symptoms. A screening blood test, called a *prostatic-specific antigen (PSA) test*, can detect a substance released by cancer cells and aid in an early diagnosis. A digital rectal examination (DRE) may show a hard, abnormal mass in the prostate gland. A tissue biopsy of the prostate is usually performed to diagnose cancer.

If the condition is malignant, prostatectomy, radiation, and estrogen therapy (to decrease the effects of testosterone) are the main treatments. In some cases, an orchiectomy, surgical removal of the testes, is performed to stop the production of testosterone. Radioactive seeds can also be implanted in the prostate to destroy the cancerous cells without affecting the organs and tissue surrounding the prostate. If prostate cancer is detected early, the prognosis (expected outcome) is good. All men older than 50 years (earlier for high-risk patients) are encouraged to have annual prostate examinations.

Testicular Cancer

Testicular cancer, or cancer of the testes, occurs most frequently in men from ages 20 to 35. It is a highly malignant form of cancer and can metastasize, or spread, rapidly. Symptoms include a painless swelling of the testes, a heavy feeling, and an accumulation of fluid. Treatment includes an *orchiectomy*, or surgical removal of the testis, chemotherapy, and/or radiation. With proper treatment, it is one of the most curable cancers, with a 95 percent 5-year survival rate. It has been recommended that male individuals begin monthly testicular self-examinations at the age of 15. To perform the examination, the male individuals should examine the testicles after a warm shower when scrotal skin is relaxed. Each testicle should be examined separately with both hands by placing the index and middle fingers under the testicle and the thumbs on top. The testicle should be rolled gently between the fingers to feel for lumps, nodules, or

extreme tenderness. In addition, the male should examine the testes for any signs of swelling or changes in appearance. If any abnormalities are noted, the male should be examined by a physician as soon as possible.

Female Reproductive System

The female reproductive system consists of the ovaries, fallopian tubes, uterus, vagina, Bartholin's glands, vulva, and breasts (Figure 7-79).

The **ovaries** are the female gonads (Figure 7-80). They are small, almond-shaped glands located in the pelvic cavity and attached to the uterus by ligaments. The ovaries contain thousands of small sacs called *follicles*. Each follicle contains an immature ovum, or female sex cell. When an ovum matures, the follicle enlarges and then ruptures to release the mature ovum. This process, called *ovulation*, usually occurs once every 28 days. The ovaries also produce hormones that aid in the development of the reproductive organs and produce secondary sexual characteristics.

The **fallopian tubes** are two tubes, each approximately 5 inches in length and attached to the upper part of the uterus. The lateral ends of these tubes are located above the ovaries but are not directly connected to the ovaries. These ends have fingerlike projections, called *fimbriae*. The fimbriae help move the ovum, which is released by the ovary, into the fallopian tube. Each

fallopian tube serves as a passageway for the ovum as the ovum moves from the ovary to the uterus. The muscle layers of the tube move the ovum by peristalsis. Cilia, hairlike structures on the lining of the tubes, also keep the ovum moving toward the uterus. **Fertilization**, the union of the ovum and a sperm to create a new life, usually takes place in the fallopian tubes.

The **uterus** is a hollow, muscular, pear-shaped organ located behind the urinary bladder and in front of the rectum. It is divided into three parts: the *fundus* (the top section, where the fallopian tubes attach); the body, or *corpus* (the middle section); and the *cervix* (the narrow, bottom section, which attaches to the vagina). The uterus is the organ of menstruation, allows for the development and growth of the fetus, and contracts to aid in expulsion of the fetus during birth. The uterus has three layers. The inner layer is called the **endometrium**. This layer of specialized epithelium provides for implantation of a fertilized ovum and aids in the development of the fetus. If fertilization does not occur, the endometrium deteriorates and causes the bleeding known as *menstruation*. The middle layer of the uterus, the *myometrium*, is a muscle layer. It allows for the expansion of the uterus during pregnancy and contracts to expel the fetus during birth. The outer layer, the *perimetrium*, is a serous membrane.

The **vagina** is a muscular tube that connects the cervix of the uterus to the outside of the body. It serves

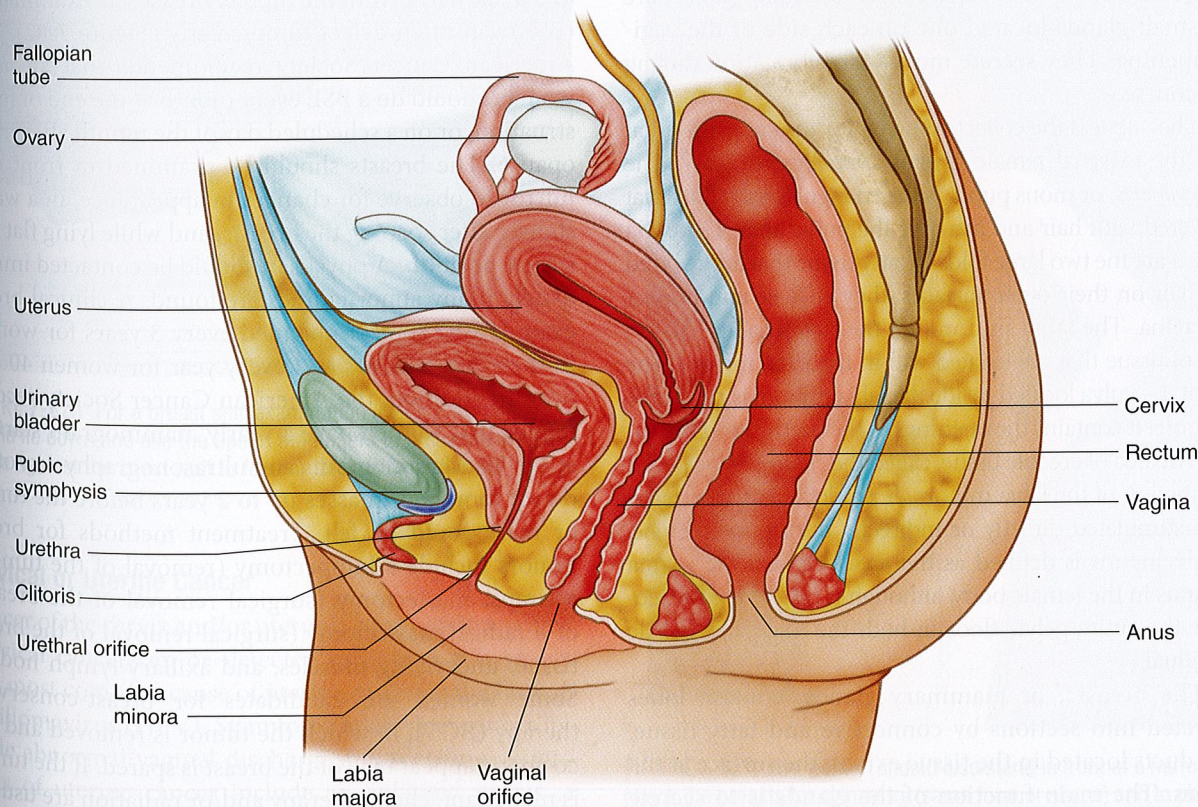


FIGURE 7-79 The female reproductive system. Copyright © Cengage Learning®. All Rights Reserved.

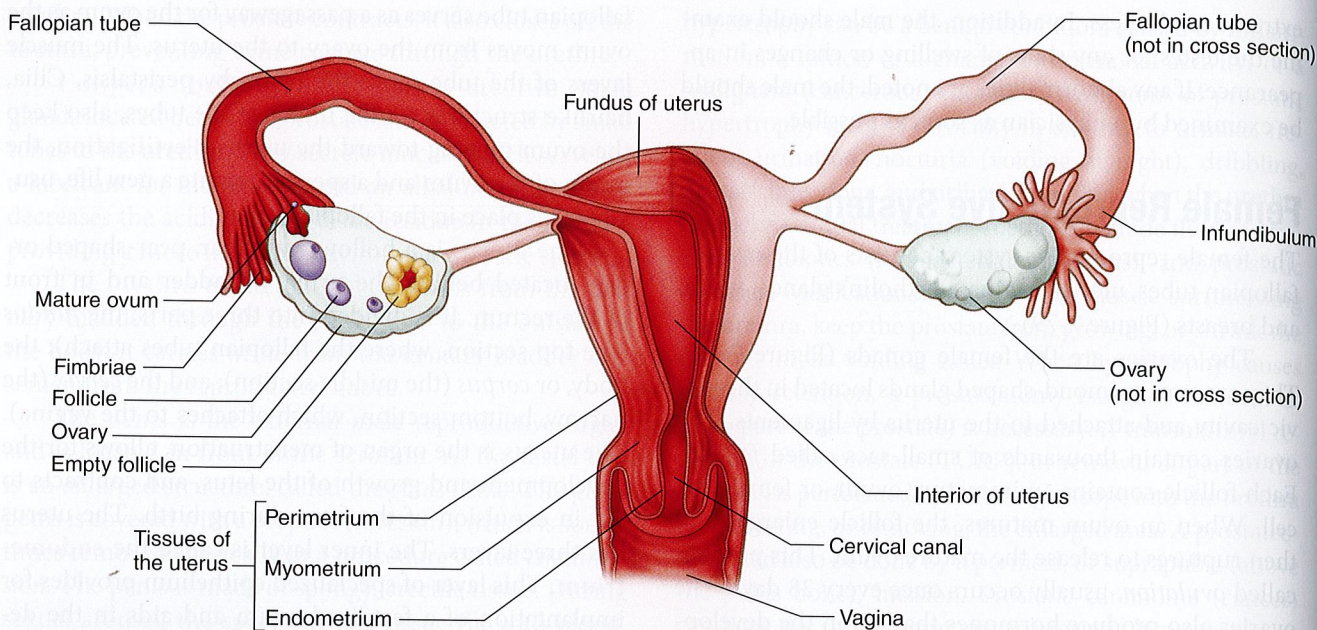


FIGURE 7-80 Anterior view of the female reproductive system. Copyright © Cengage Learning®. All Rights Reserved.

as a passageway for the menstrual flow, receives the sperm and semen from the male, is the female organ of copulation, and acts as the birth canal during delivery of the infant. The vagina is lined with a mucous membrane arranged in folds called *rugae*. The rugae allow the vagina to enlarge during childbirth and intercourse.

Bartholin's glands, also called *vestibular glands*, are two small glands located one on each side of the vaginal opening. They secrete mucus for lubrication during intercourse.

The **vulva** is the collective name for the structures that form the external female genital area (Figure 7-81). The *mons veneris*, or mons pubis, is the triangular pad of fat that is covered with hair and lies over the pubic area. The **labia majora** are the two large folds of fatty tissue that are covered with hair on their outer surfaces; they enclose and protect the vagina. The **labia minora** are the two smaller hairless folds of tissue that are located within the labia majora. The area of the vulva located inside the labia minora is called the **vestibule**. It contains the openings to the urethra and the vagina. An area of erectile tissue, called the *clitoris*, is located at the junction of the labia minora. It produces sexual arousal when stimulated directly or indirectly during intercourse. The **perineum** is defined as the area between the vagina and anus in the female body, although it can be used to describe the entire pelvic floor in both the male and female individual.

The **breasts**, or mammary glands, contain lobes separated into sections by connective and fatty tissue. Milk ducts located in the tissue exit on the surface at the nipples. The main function of the glands is to secrete milk (lactate) after childbirth.

DISEASES AND ABNORMAL CONDITIONS

Breast Tumors

Breast tumors can be benign or malignant. Symptoms include a lump or mass in the breast tissue, a change in breast size or shape (flattening or bulging of tissue), and a discharge from the nipple. Breast self-examination (BSE) can often detect tumors early (Figure 7-82). The American Cancer Society recommends that an adult woman should do a BSE every month at the end of menstruation, or on a scheduled day of the month after menopause. The breasts should be examined in front of a mirror to observe for changes in appearance, in a warm shower after soaping the breasts, and while lying flat in a supine position. A physician should be contacted immediately if any abnormalities are found. A clinical breast exam (CBE) is recommended every 3 years for women in their 20's and 30's and every year for women 40 and over. In addition, the American Cancer Society recommends that women have a yearly mammogram starting at age 40. Mammograms and ultrasonography can often detect tumors or masses up to 2 years before the tumor or mass could be felt. Treatment methods for breast tumors include a lumpectomy (removal of the tumor), a simple mastectomy (surgical removal of the breast), or a radical mastectomy (surgical removal of the breast tissue, underlying muscles, and axillary lymph nodes). Some women are candidates for breast-conserving therapy (BCT), in which the tumor is removed and the cosmetic appearance of the breast is spared. If the tumor is malignant, chemotherapy and/or radiation are usually used in addition to surgery.

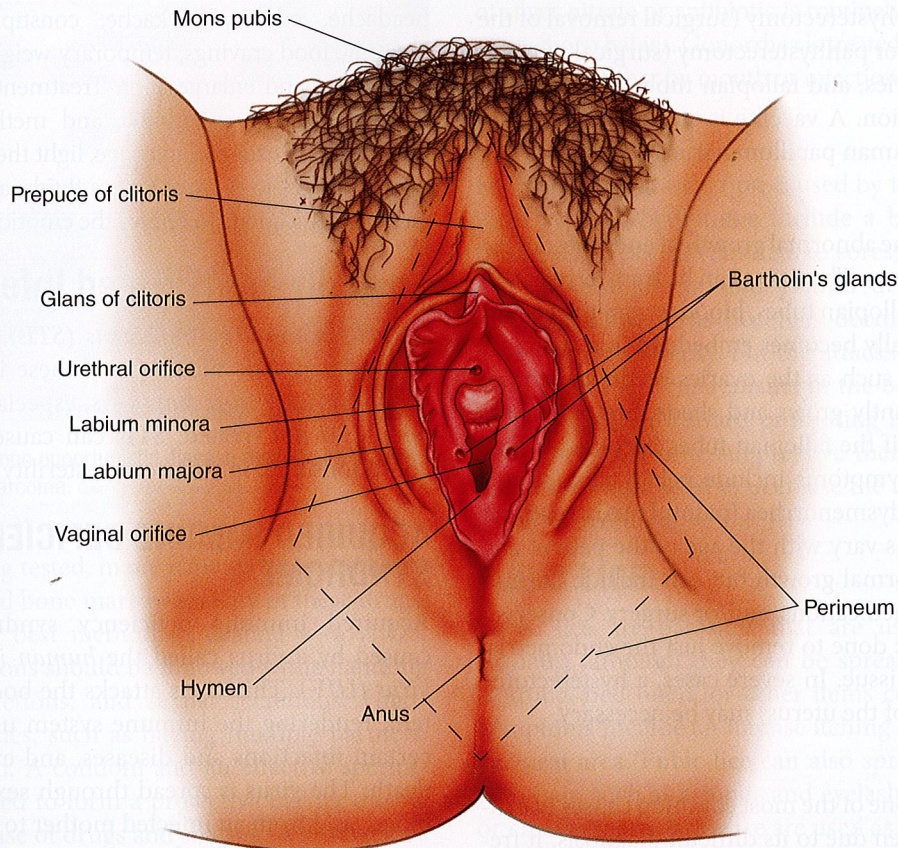


FIGURE 7-81 The external female genital area. Copyright © Cengage Learning®. All Rights Reserved.

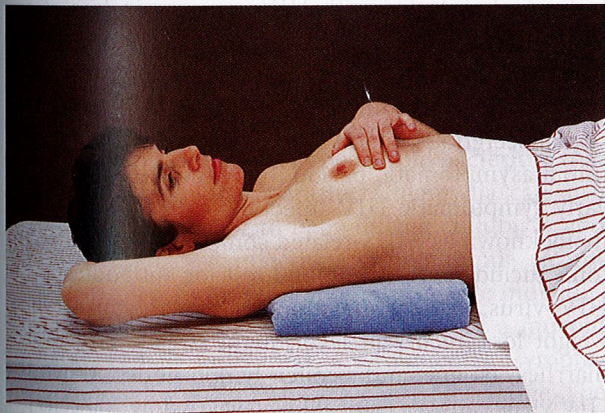


FIGURE 7-82A For a breast self-examination (BSE), a woman should lie down and use the tips of the fingers to press the breast tissue against the chest wall to feel for thickening or lumps.

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Cervical or Uterine Cancer

Cancer of the cervix and/or uterus is common in women. Cervical cancer can be detected early by a Pap smear. The most common cause of uterine cancer is the human papillomavirus (HPV). Symptoms of cervical cancer include abnormal vaginal discharge and bleeding. Symptoms of uterine cancer include an enlarged uterus, a watery discharge, and abnormal bleeding. Treatment



FIGURE 7-82B The woman should also stand in front of a mirror to check the breasts for symmetry (same form or shape) and to observe any change in appearance. Copyright © Cengage Learning®. All Rights Reserved.

methods include a hysterectomy (surgical removal of the uterus and cervix) or panhysterectomy (surgical removal of the uterus, ovaries, and fallopian tubes); chemotherapy; and/or radiation. A vaccine is available to prevent infection by the human papillomavirus (HPV).

Endometriosis

Endometriosis is the abnormal growth of endometrial tissue outside the uterus. The tissue can be transferred from the uterus by the fallopian tubes, blood, or lymph, or during surgery. It usually becomes embedded in a structure in the pelvic area, such as the ovaries or the peritoneal tissues, and constantly grows and sheds. Endometriosis can cause sterility if the fallopian tubes become blocked with scar tissue. Symptoms include pelvic pain, abnormal bleeding, and dysmenorrhea (painful menstruation). Treatment methods vary with the age of the patient and the degree of abnormal growth but can include hormonal therapy, pain medications, and/or surgery. Conservative therapy can be done to remove just the endometrial growths and scar tissue. In severe cases, a hysterectomy (surgical removal of the uterus) may be necessary.

Ovarian Cancer

Ovarian cancer is one of the most common causes of cancer deaths in women due to its difficult diagnosis. It frequently occurs between ages 40 and 65. Initial symptoms are vague and include abdominal discomfort and mild gastrointestinal disturbances such as constipation and/or diarrhea. As the disease progresses, pain, abdominal distention, and urinary frequency occur. Three-fourths of the cases are undetected until it has spread into the abdomen. Treatment includes surgical removal of all of the reproductive organs and affected lymph nodes, chemotherapy, and radiation in some cases.

Pelvic Inflammatory Disease

Pelvic inflammatory disease (PID) is an inflammation of the cervix (cervicitis), the endometrium of the uterus (endometritis), fallopian tubes (salpingitis), and at times, the ovaries (oophoritis). It is usually caused by pathogenic organisms such as bacteria (commonly from a sexually transmitted infection), viruses, and fungi. Symptoms include pain in the lower abdomen, fever, and a purulent (pus) vaginal discharge. Treatment methods include antibiotics (for bacterial infections), increased fluid intake, rest, and/or pain medication.

Premenstrual Syndrome

Premenstrual syndrome (PMS) is actually a group of symptoms that appear 3–14 days before menstruation. A large percentage of women experience some degree of PMS. Symptoms usually peak in the late 20s and early 30s. The cause is unknown but may be related to a hormonal or biochemical imbalance, poor nutrition, or stress. Symptoms vary and may include nervousness, irritability, depression,

headache, edema, backache, constipation, abdominal bloating, food cravings, temporary weight gain, and breast tenderness and enlargement. Treatment is geared mainly toward relieving symptoms, and methods include diet modification, exercise, massage, light therapy, stress reduction, diuretics to remove excess fluids, analgesics for pain, and/or medications to relieve the emotional symptoms.

Sexually Transmitted Infections

Sexually transmitted infections (STIs), affect both men and women. The incidence of these infections has increased greatly in recent years, especially among young people. If not treated, STIs can cause serious chronic conditions and, in some cases, sterility or death.

ACQUIRED IMMUNE DEFICIENCY SYNDROME

Acquired immune deficiency syndrome (AIDS) is caused by a virus called the *human immunodeficiency virus (HIV)*. This virus attacks the body's immune system, rendering the immune system unable to fight off certain infections and diseases, and eventually causing death. The virus is spread through sexual secretions or blood, and from an infected mother to her infant during pregnancy or childbirth.

The HIV virus does not live long outside the body and is not transmitted by casual, nonsexual contact. Individuals infected with HIV can remain free of any symptoms for years after infection. During this asymptomatic period, infected individuals can transmit the virus to any other individual with whom they exchange sexual secretions, blood, or blood products. After this initial asymptomatic period, many individuals develop early symptomatic HIV infection, called Class B (formally known as AIDS-related complex or ARC). Symptoms include a positive blood test for antibodies to the HIV virus, lack of infection resistance, appetite loss, weight loss, recurrent fever, night sweats, skin rashes, diarrhea, fatigue, and swollen lymph nodes. When the HIV virus causes a critical low level (below 200 cells per cubic millimeter of blood) of special leukocytes (white blood cells) called CD4 or T cells, and/or opportunistic diseases appear, AIDS is diagnosed. Three of the most common opportunistic diseases include the rare type of pneumonia called *Pneumocystis jiroveci*, a yeast infection called *Candidiasis*, and the slow-growing cancer called *Kaposi's sarcoma* (Figure 7-83).

Currently, there is no cure for AIDS, although much research is being directed toward developing a vaccine to prevent and drugs to cure AIDS. Treatment with highly active antiretroviral therapy (HAART), a combination of several drugs called a drug cocktail, is used to slow progression of the disease. These drugs, however, do not cure the disease. Although several experimental drugs



FIGURE 7-83 A common opportunistic disease that occurs in AIDS patients is Kaposi's sarcoma. Courtesy of the National Cancer Institute

are currently being tested, many patients cannot tolerate the side effects and bone marrow toxicity of these drugs. Prevention is the best method in dealing with AIDS. Standard precautions should be followed while handling blood, body secretions, and sexual secretions. High-risk sexual activities, such as having multiple partners, should be avoided. A condom and an effective spermicide should be used to form a protective barrier during intercourse. The use of drugs and sharing of intravenous (IV) needles should be avoided. Females infected with HIV should avoid pregnancy. *Everyone* must concern themselves with eliminating the transmission of AIDS.

CHLAMYDIA

Chlamydia (klah'-mid-e-ah) is one of the most frequently occurring STIs and is caused by several strains of the chlamydia organism, a specialized bacterium that lives as an intracellular parasite. Chlamydia can also be spread from mother to baby during childbirth and can cause serious eye infections or pneumonia. Symptoms are similar to those of gonorrhea. Male individuals experience burning when urinating and a mucoid discharge. Female individuals are frequently asymptomatic, although some may have a vaginal discharge. The infection frequently causes pelvic inflammatory disease and sterility in women, if not treated. Chlamydia can be treated with tetracycline or erythromycin antibiotics.

GONORRHEA

Gonorrhea (gon-oh'-re-ah), frequently called "the clap," is caused by the gonococcus bacterium *neisseria gonorrhoeae*. Symptoms in male individuals include a greenish yellow discharge, burning when urinating, sore throat, and swollen glands. Female individuals are frequently asymptomatic but may experience dysuria, pain in the lower abdomen, and greenish-yellow vaginal discharge. An infected woman can transmit the gonococcus organism to her infant's eyes during childbirth, causing blindness. To prevent this, a drop

of silver nitrate or antibiotic is routinely placed in the eyes of newborn babies. Gonorrhea is treated with large doses of antibiotics, either by mouth or injection.

HERPES

Herpes is a viral infection caused by the herpes simplex virus type II. Symptoms include a burning sensation, fluid-filled vesicles (blister-like sores) that rupture and form painful ulcers, and painful urination. After the sores heal, the virus becomes dormant. Many people have repeated attacks, but the attacks are milder. There is no cure; the virus remains in the body for life. Treatment is directed toward promoting healing and easing discomfort. Chronic suppressive therapy with antiviral medications are used to decrease the number and severity of recurrences.

PUBIC LICE

Pubic lice are parasites that are usually transmitted sexually, although they can be spread by contact with clothing, bed linen, or other items containing the lice. Symptoms include an intense itching and redness of the perineal area. Pubic lice can also spread to other areas with hair, such as armpits and eyelashes. Topical lotions or creams that kill the lice are used as treatment. To prevent a recurrence, it is essential to wash all clothing and bed linen to destroy any lice or nits (eggs).

SYPHILIS

Syphilis is caused by a spirochete bacterium. The symptoms occur in stages. During the primary stage, a painless chancre (shang'-ker), or sore, appears, usually on the penis of the male and in the vulva or on the cervix of the female, but it can occur anywhere on the body (Figure 7-84). This chancre heals within

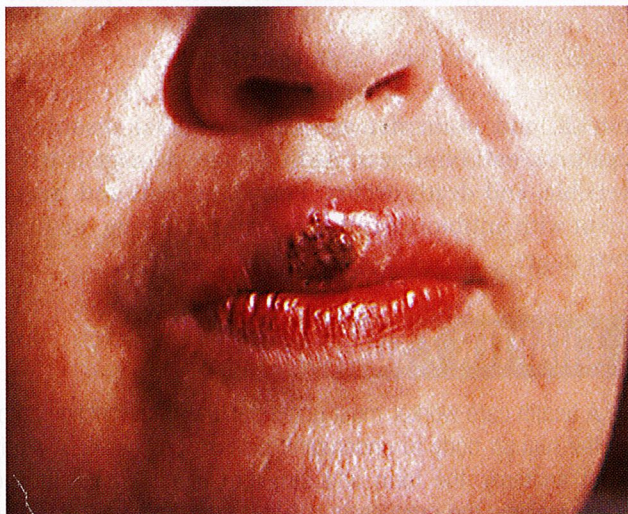


FIGURE 7-84 A painless chancre, or sore, can appear anywhere on the body during the primary stage of syphilis. CDC

15

Infection Control

CHAPTER OBJECTIVES

After completing this chapter, you should be able to:

- Identify five classes of microorganisms by describing the characteristics of each class
- List the six components of the chain of infection
- Differentiate between antisepsis, disinfection, and sterilization
- Define bioterrorism and identify at least four ways to prepare for a bioterrorism attack
- Wash hands following aseptic technique
- Observe standard precautions while working in the laboratory or clinical area
- Wash, wrap, and autoclave instruments, linen, and equipment
- Operate an autoclave with accuracy and safety
- Follow basic principles on chemical disinfection
- Clean instruments with an ultrasonic unit
- Open sterile packages with no contamination
- Don sterile gloves with no contamination
- Prepare a sterile dressing tray with no contamination
- Change a sterile dressing with no contamination
- Don and remove a transmission-based isolation mask, gloves, and gown
- Relate specific basic tasks to the care of a patient in a transmission-based isolation unit
- Define, pronounce, and spell all key terms

KEY TERMS

acquired immune deficiency
syndrome (AIDS)

aerobic

airborne precautions

anaerobic

antisepsis (*ant''-ih-sep'-sis*)

asepsis (*a-sep'-sis*)

autoclave

bacteria

bioterrorism

cavitation (*kav''-ih-tay'-shun*)

chain of infection

chemical disinfection

clean

communicable disease

contact precautions

contaminated

disinfection

KEY TERMS (CONT.)

droplet precautions
 endogenous
 epidemic
 exogenous
 fomites
 fungi (*fun' -guy*)
 helminths
 hepatitis B
 hepatitis C
 infectious agent
 microorganism
 (*my-crow-or' -gan-izm*)

mode of transmission
 nonpathogens
 nosocomial
 opportunistic
 pandemic
 pathogens (*path' -oh-jenz'*)
 personal protective equipment (PPE)
 portal of entry
 portal of exit
 protective (reverse) isolation
 protozoa (*pro-toe-zo' -ah*)

reservoir
 rickettsiae (*rik-et' -z-ah*)
 standard precautions
 sterile
 sterile field
 sterilization
 susceptible host
 transmission-based isolation
 precautions
 ultrasonic
 viruses

15:1 Understanding the Principles of Infection Control



Science



OBRA

Understanding the basic principles of infection control is essential for any health care worker in any field of health care.

The principles described in this unit provide a basic knowledge of how disease is transmitted and the main ways to prevent disease transmission.

A **microorganism**, or microbe, is a small, living organism that is not visible to the naked eye. It must be viewed under a microscope. Microorganisms are found everywhere in the environment, including on and in the human body. Many microorganisms are part of the normal flora (plant life adapted for living in a specific environment) of the body and are beneficial in maintaining certain body processes. These are called **nonpathogens**. Other microorganisms cause infection and disease and are called **pathogens**, or germs. At times, a microorganism that is beneficial in one body system can become pathogenic when it is present in another body system. For example, a bacterium called *Escherichia coli* (*E. coli*) is part of the natural flora of the large intestine. If *E. coli* enters the urinary system, however, it causes an infection.

To grow and reproduce, microorganisms need certain things. Most microorganisms prefer a warm environment, and body temperature is ideal. Darkness is also preferred by most microorganisms, and many are killed quickly by sunlight. In addition, a source of food and moisture is needed. Some microorganisms, called **aerobic** organisms, require oxygen to live. Others, called

anaerobic organisms, live and reproduce in the absence of oxygen. The human body is the ideal supplier of all the requirements of microorganisms.

Classes of Microorganisms

There are many different classes of microorganisms. In each class, some of the microorganisms are pathogenic to humans. The main classes include:

- **Bacteria:** These are simple, one-celled organisms that multiply rapidly. They are classified by shape and arrangement. *Cocci* are round or spherical in shape (Figure 15-1). If cocci occur in pairs, they are diplococci. Diplococci bacteria cause diseases such as gonorrhea, meningitis, and pneumonia. If cocci occur in chains, they are streptococci. A common streptococcus causes a severe sore throat (strep throat) and rheumatic fever. *Streptococcus pyogenes*, also called *Strep A* or flesh-eating strep, causes necrotizing fasciitis that destroys tissues and can result in amputation and/or death (Figure 15-2). If cocci occur in clusters or groups, they are staphylococci. These are the most common pyogenic (pus-producing) microorganisms. Staphylococci cause infections such as boils, urinary tract infections, wound infections, and toxic shock. Rod-shaped bacteria are called *bacilli* (Figure 15-3). They can occur singly, in pairs, or in chains. Many bacilli contain flagella, which are threadlike projections that are similar to tails and allow the organisms to move. Bacilli also have the ability to form spores, or thick-walled capsules, when conditions for growth are poor. In the spore form, bacilli are extremely difficult

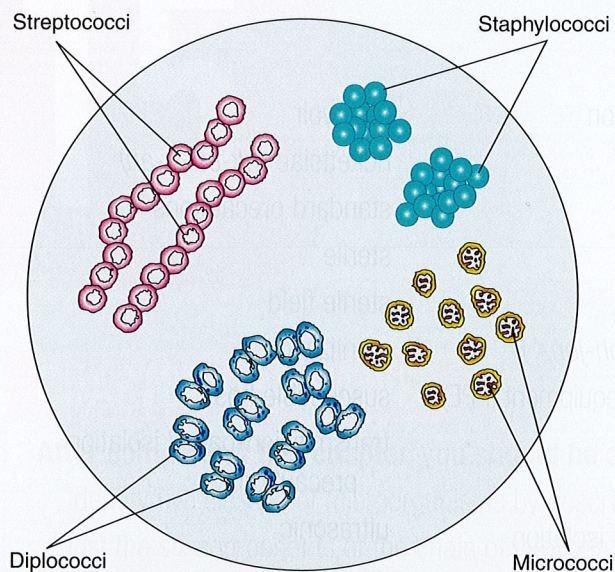


FIGURE 15-1 Kinds of cocci bacteria. Copyright © Cengage Learning®. All Rights Reserved.

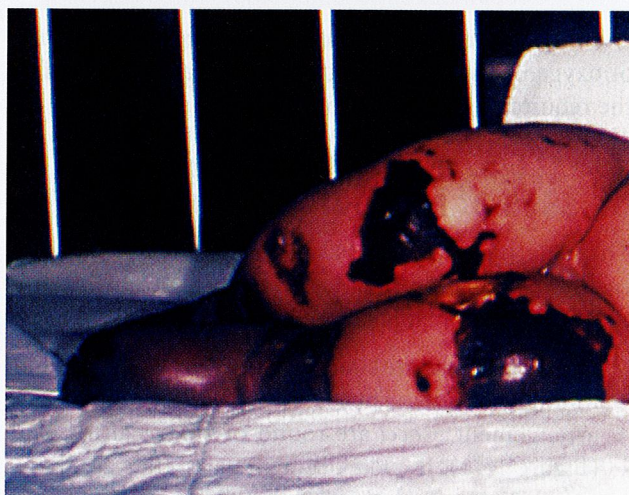


FIGURE 15-2 *Streptococcus pyogenes*, also called *Strep A* or flesh-eating strep, causes necrotizing fasciitis that destroys tissues and can result in amputation and/or death if not treated immediately. Courtesy CDC

to kill. Diseases caused by different types of bacilli include tuberculosis, tetanus, pertussis (whooping cough), botulism, diphtheria, and typhoid. Bacteria that are spiral or corkscrew in shape are called *spirilla* (Figure 15-4). These include the comma-shaped vibrio and the corkscrew-shaped spirochete. Diseases caused by spirilla include syphilis and cholera. Antibiotics are used to kill bacteria. However, due to the overuse and misuse of antibiotics, some strains of bacteria have become antibiotic-resistant, which means that the antibiotic is no longer effective against the bacteria. If a bacterium becomes resistant to

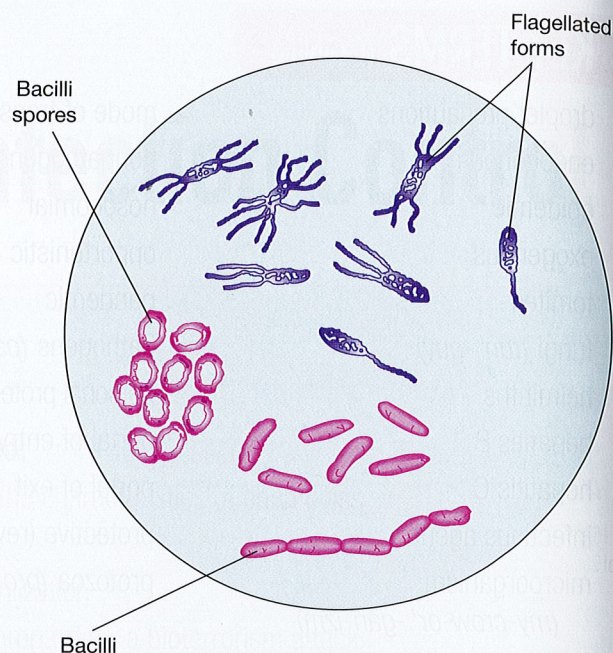


FIGURE 15-3 Bacilli bacteria. Copyright © Cengage Learning®. All Rights Reserved.

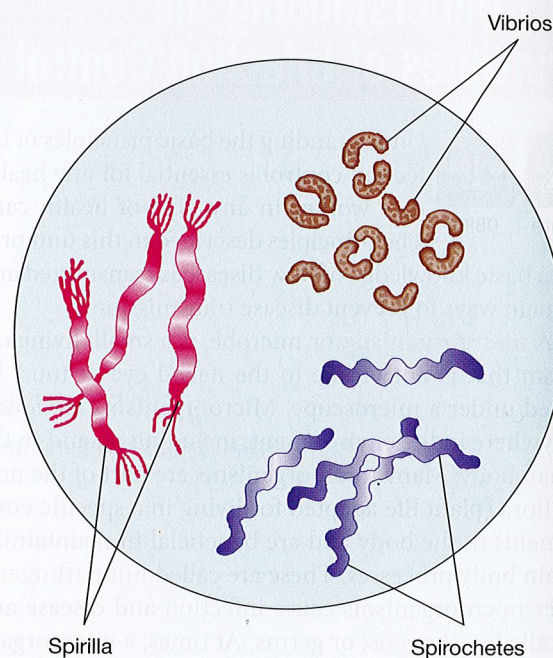


FIGURE 15-4 Spirilla bacteria. Copyright © Cengage Learning®. All Rights Reserved.

several drugs, it is called multidrug resistant, or a "superbug." Methicillin-resistant staphylococcus aureas (MRSA) is an example. It causes a severe staph infection that is difficult to treat because it is resistant to many different antibiotics. Vancomycin-resistant enterococcus (VRE) is a bacterium that is resistant to vancomycin and several other drugs. Because no single antibiotic can eliminate VRE, drug combinations

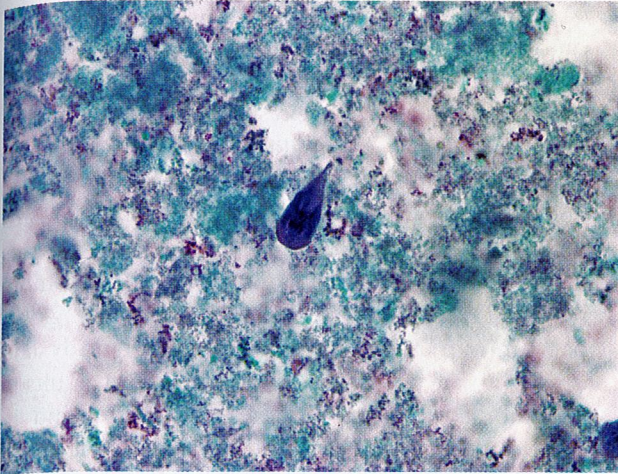


FIGURE 15-5 An intestinal protozoan, *Giardia intestinalis*, is the blue stained mass in the center of the photo. Courtesy CDC/DPDx-Melanie Moser

are often used to treat it. Multidrug-resistant *acinetobacter baumannii* (MRAB) is an example of a bloodstream infection that is difficult to treat due to drug resistance. In some cases, *A. baumannii* has been resistant to all drugs tested. Carbapenem-resistant enterobacteriaceae (CRE) are resistant to most antibiotics and can cause pneumonia, kidney and bladder disease, and septicemia (pathogenic organisms in the bloodstream). A major campaign has been launched to push for less antibiotic use, unless specifically indicated, to help prevent drug resistance.

- **Protozoa:** These are one-celled animal-like organisms often found in decayed materials, animal or bird feces, insect bites, and contaminated water (Figure 15-5). Many contain flagella, which allow them to move freely. Some protozoa are pathogenic and cause diseases such as malaria, amebic dysentery (intestinal infection), trichomonas, and African sleeping sickness.
- **Fungi:** These are simple, plantlike organisms that live on dead organic matter. Yeasts and molds are two common forms that can be pathogenic. They cause diseases such as ringworm, athlete's foot, histoplasmosis, yeast vaginitis, and thrush (Figure 15-6). Antibiotics do not kill fungi. Antifungal medications are available for many of the pathogenic fungi, but they are expensive, must be taken internally for a long period, and may cause liver damage.
- **Rickettsiae:** These are parasitic microorganisms, which means they cannot live outside the cells of another living organism. They are commonly found in fleas, lice, ticks, and mites, and are transmitted to humans by the bites of these insects. Rickettsiae cause diseases such as typhus fever and Rocky Mountain

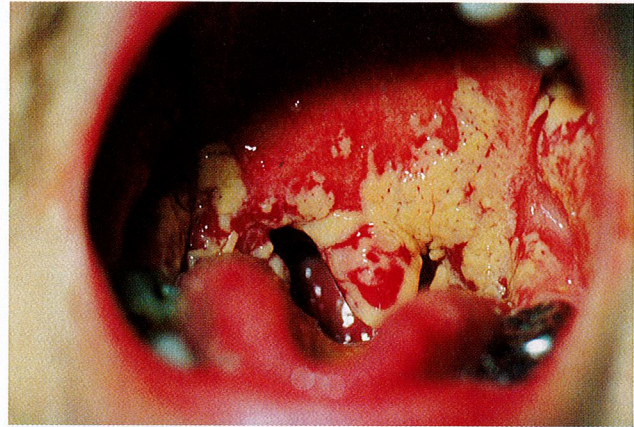


FIGURE 15-6 The yeast (fungus) called *thrush* causes these characteristic white patches on the tongue and in the mouth.

Courtesy CDC

spotted fever. Antibiotics are effective against many different rickettsiae.



OBRA

- **Viruses:** These are the smallest microorganisms, visible only using an electron microscope (Figures 15-7A and B). They cannot reproduce unless they are inside another living cell. They are spread from human to human by blood and other body secretions. It is important to note that viruses are more difficult to kill because they are resistant to many disinfectants and are not affected by antibiotics. Viruses cause many diseases including the common cold, measles, mumps, chicken pox, herpes, warts, influenza, and polio. New and different viruses emerge constantly because viruses are prone to mutating and changing genetic information. In addition, viruses that infect animals can mutate to infect humans, often with lethal results. There are many examples of these viruses. *Severe acute respiratory syndrome (SARS)* is caused by a variant of the coronavirus family that causes the common cold. It is characterized by flu-like symptoms that can lead to respiratory failure and death. *West Nile virus (WNV)* is a mosquito-borne flavivirus that first infected birds but now infects humans. In some individuals, it causes only a mild febrile illness. In other individuals who are older or have poor immune systems, it can cause severe neurologic illnesses such as encephalitis or meningitis, which can lead to death. *Monkeypox*, a hantavirus that affects monkeys, other primates, and rodents, mutated and spread to humans. Infection usually occurs after contacting body secretions or excretions (urine and stool) of infected animals or ingesting food that has been contaminated by fluids from infected animals. A major outbreak

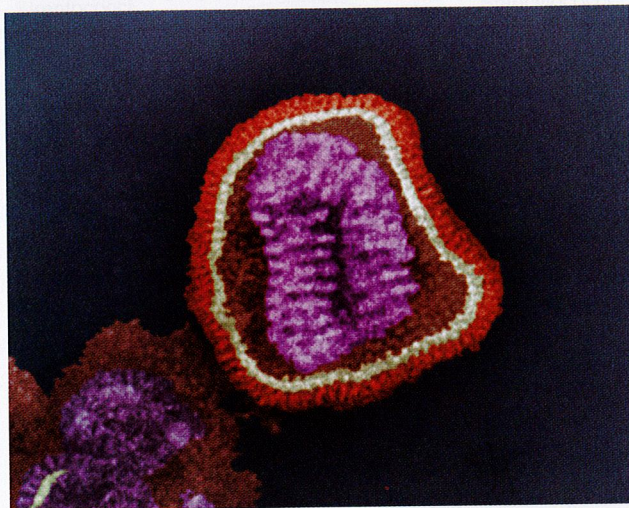


FIGURE 15-7A Electron micrograph of the influenza virus.

Courtesy CDC/Erskine L. Palmer, Ph.D.; M.L. Martin. Photo credit: Frederick Murphy

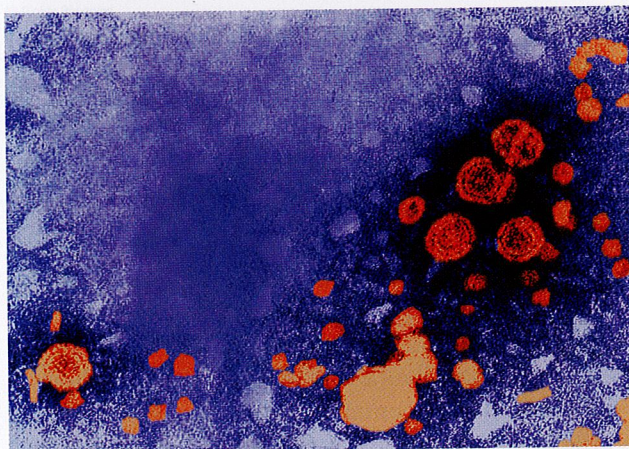


FIGURE 15-7B Electron micrograph of the hepatitis B virus.

Courtesy CDC/Dr. Erskine Palmer.

occurred in the American Southwest when infected prairie dogs contaminated food with fecal material. Monkeypox is similar to smallpox. It causes severe flu-like symptoms, lymphadenopathy (disease of the lymph nodes), and pustules that cause severe scarring of the skin. If the eyes are infected, blindness can occur. It can be prevented and/or treated with a smallpox vaccination. Filoviruses such as *Ebola* and *Marburg* first affected primates and then spread to humans. These viruses cause hemorrhagic fever, a disease that begins with fever, chills, headache, myalgia (muscle pain), and a skin rash. It quickly progresses to jaundice, pancreatitis, liver failure, massive hemorrhaging throughout the body, delirium, shock, and death. Most outbreaks of hemorrhagic fever have been in Africa, but isolated cases have appeared in other parts of the world when individuals were in

contact with infected primates. The *H5N1* virus that causes avian or bird flu has devastated bird flocks in many countries. The infection has appeared in humans, but most cases have resulted from contact with infected poultry or contaminated surfaces. The spread from one person to another has been reported only rarely. However, because the death rate for bird flu is between 50 and 60 percent, a major concern is that the *H5N1* virus will mutate and spread more readily. *H1N1*, or swine flu, was declared a global pandemic in 2009. The virus spreads quickly and causes flu-like symptoms. In severe cases, it results in pneumonia, respiratory distress or failure, and in some cases, death. As with the bird flu, it rarely spreads from one person to another. Most cases result from contact with infected hogs. In addition to these viruses, there are three other viral diseases of major concern to the health care worker: hepatitis B, hepatitis C, and acquired immune deficiency syndrome (AIDS). **Hepatitis B**, or serum hepatitis, is caused by the HBV virus and is transmitted by blood, serum, and other body secretions. It affects the liver and can lead to the destruction and scarring of liver cells. A vaccine has been developed to protect individuals from this disease. The vaccine is expensive and involves a series of three injections. Under federal law, employers must provide the vaccination at no cost to any health care worker with occupational exposure to blood or other body secretions that may carry the HBV virus. An individual does have the right to refuse the vaccination, but a written record must be kept proving that the vaccine was offered. **Hepatitis C** is caused by the hepatitis C virus, or HCV, and is transmitted by blood and blood-containing body fluids. Many individuals who contract the disease are asymptomatic (display no symptoms); others have mild symptoms that are often diagnosed as influenza or flu. In either case, HCV can cause serious liver damage. At present, there is no preventive immunization, but a vaccine is being developed. Both HBV and HCV are extremely difficult to destroy. These viruses can even remain active for several days in dried blood. Health care workers must take every precaution to protect themselves from hepatitis viruses. **Acquired immune deficiency syndrome** is caused by the human immunodeficiency virus (HIV) and suppresses the immune system. An individual with AIDS cannot fight off many cancers and infections that would not affect a healthy person. Presently, there is no cure and no vaccine is available, so it is important for the health care worker to take precautions to prevent the spread of this disease.



FIGURE 15-8 Hookworms attached to the mucosal lining of the intestine are one type of helminth. Courtesy CDC.

- **Helminths:** These are multicellular parasitic organisms commonly called *worms* or *flukes*. They are transmitted to humans when humans ingest the eggs or larvae in contaminated food, ingest meat contaminated with the worms, or get bitten by infected insects. Some worms can also penetrate the skin to enter the body. Examples of helminths include: hookworms, which attach to the small intestine and can infect the heart and lungs (Figure 15-8); ascariasis, which live in the small intestine and can cause an obstruction of the intestine; trichinella spiralis, which causes trichinosis and is contracted by eating raw or inadequately cooked pork products; enterobiasis, which is commonly called *pinworm* and affects mainly young children; and taenia solium or pork tapeworm, which is contracted by eating inadequately cooked pork.

Types of Infection

Pathogenic microorganisms cause infection and disease in different ways. Some pathogens produce poisons, called *toxins*, which harm the body. An example is the bacillus that causes tetanus, which produces toxins that damage the central nervous system. Some pathogens cause an allergic reaction in the body, resulting in a runny nose, watery eyes, and sneezing. Other pathogens attack and destroy the living cells they invade. An example is the protozoan that causes malaria. It invades red blood cells and causes them to rupture.

Infections and diseases are also classified as endogenous, exogenous, nosocomial, or opportunistic. **Endogenous** means the infection or disease originates within the body. These include metabolic disorders, congenital abnormalities, tumors, and infections caused by

microorganisms within the body. **Exogenous** means the infection or disease originates outside the body. Examples include pathogenic organisms that invade the body, radiation, chemical agents, trauma, electric shock, and temperature extremes. A **nosocomial** infection, also known as a *hospital-acquired* or *healthcare-associated infection* (HAI), is one acquired by an individual in a health care facility such as a hospital or long-term care facility. Nosocomial infections are usually present in the facility and transmitted by health care workers to the patient. Many of the pathogens transmitted in this manner are antibiotic-resistant and can cause serious and even life-threatening infections in patients. Common examples are staphylococcus, pseudomonas, and enterococci. Infection-control programs are used in health care facilities to prevent and deal with nosocomial infections. The infection control professionals that run these programs are called *infection preventionists*, according to the Association for Professionals in Infection Control and Epidemiology (APIC). Their job is to reduce the incidence of HAIs. **Opportunistic** infections are those that occur when the body's defenses are weak. These diseases do not usually occur in individuals with intact immune systems. Examples include the development of a yeast infection called *candidiasis*, Kaposi's sarcoma (a rare type of cancer), or *Pneumocystis jiroveci* pneumonia in individuals with AIDS.

Chain of Infection

For disease to occur and spread from one individual to another, certain conditions must be met. These conditions are commonly called the **chain of infection** (Figure 15-9). The parts of the chain include:

- **Infectious agent:** a pathogen, such as a bacterium or virus that can cause a disease
- **Reservoir:** an area where the infectious agent can live; some common reservoirs include the human body, animals, the environment, and **fomites**, or objects contaminated with infectious material that contains the pathogens. Common fomites include doorknobs, bedpans, urinals, linens, instruments, and specimen containers.
- **Portal of exit:** a way for the infectious agent to escape from the reservoir in which it has been growing. In the human body, pathogens can leave the body through urine, feces, saliva, blood, tears, mucous discharge, sexual secretions, and draining wounds.
- **Mode of transmission:** a way that the infectious agent can be transmitted to another reservoir or host where it can live. The pathogen can be transmitted

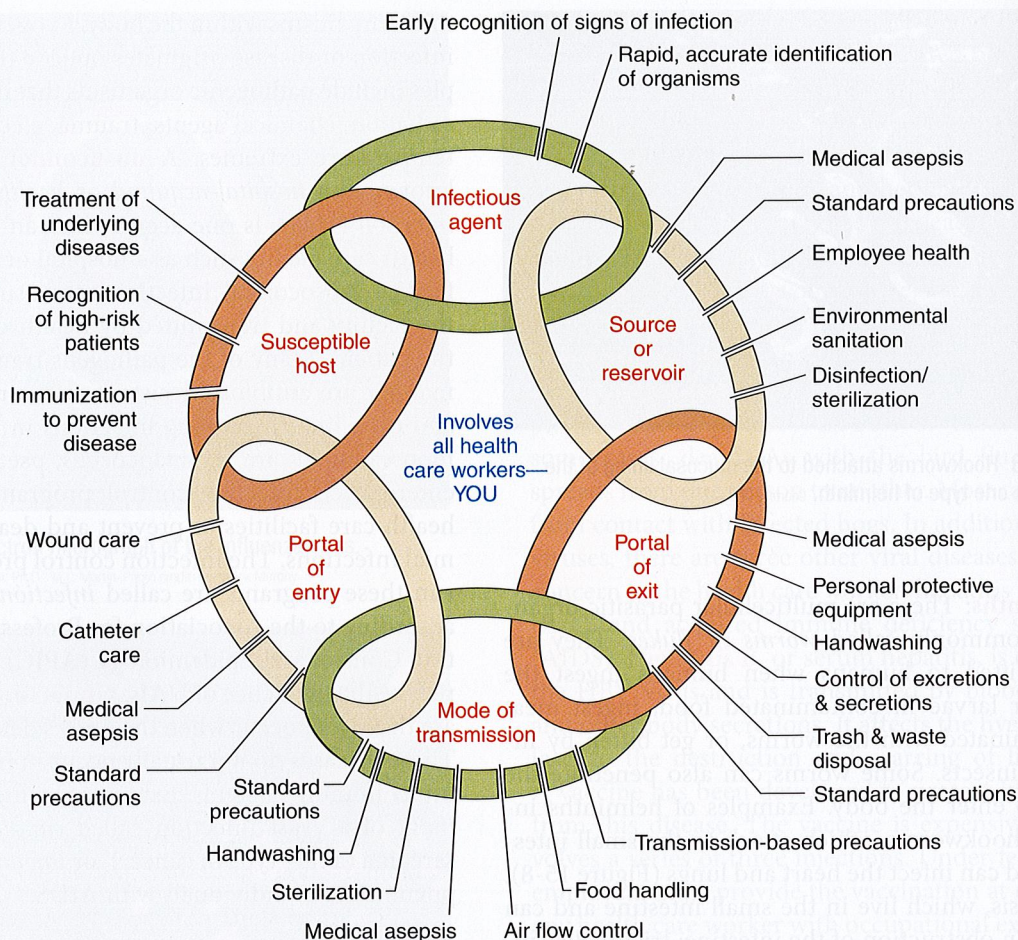


FIGURE 15-9 Note the components in the chain of infection and the ways in which the chain can be broken. Copyright © Cengage Learning®. All Rights Reserved.

in different ways. One way is by *direct contact*, which includes person-to-person contact (physical or sexual contact) or contact with a body secretion containing the pathogen. Contaminated hands are one of the most common sources of direct contact transmission. Another way is by *indirect contact*, when the pathogen is transmitted from contaminated substances such as food, air, soil, insects, feces, clothing, instruments, and equipment. Examples include touching contaminated equipment and spreading the pathogen on the hands, breathing in droplets carrying airborne infections, and contacting *vectors* (insects, rodents, or small animals), such as being bitten by an insect carrying a pathogen.

- **Portal of entry:** a way for the infectious agent to enter a new reservoir or host. Some ways pathogens can enter the body are through breaks in the skin, breaks in the mucous membrane, the respiratory tract, the digestive tract, the genitourinary tract, and the circulatory system. If the defense mechanisms of the body are intact and the immune system

is functioning, a human can frequently fight off the infectious agent and not contract the disease. Body defenses include:

Mucous membrane: lines the respiratory, digestive, and reproductive tracts and traps pathogens

Cilia: tiny, hairlike structures that line the respiratory tract and propel pathogens out of the body

Coughing and sneezing: expels pathogens out of the body

Hydrochloric acid: destroys pathogens in the stomach

Tears in the eye: contain bacteriocidal (bacteria-killing) chemicals

Fever: high temperatures destroy some pathogens

Inflammation: leukocytes, or white blood cells, destroy pathogens

Immune response: body produces antibodies, which are protective proteins that combat pathogens, and protective chemicals secreted by cells, such as interferon and complement.

- **Susceptible host:** a person likely to get an infection or disease, usually because body defenses are weak.

Health care workers must constantly be aware of the parts in the chain of infection. If any part of the chain is eliminated, the spread of disease or infection will be stopped. A health care worker who is aware of this can follow practices to interrupt or break this chain and prevent the transmission of disease. It is important to remember that pathogens are everywhere and that preventing their transmission is a continuous process.

Aseptic Techniques

A major way to break the chain of infection is to use aseptic techniques while providing health care. **Asepsis** is defined as the absence of disease-producing microorganisms, or pathogens.

Sterile means free from all organisms, both pathogenic and nonpathogenic, including spores and viruses. **Contaminated** means that organisms and pathogens are present. Any object or area that may contain pathogens is considered to be contaminated. Aseptic techniques are directed toward maintaining cleanliness and eliminating or preventing contamination. Common aseptic techniques include handwashing, good personal hygiene, use of disposable gloves when contacting body secretions or contaminated objects, proper cleaning of instruments and equipment, and thorough cleaning of the environment.

Various levels of aseptic control are possible. These include:

- **Antisepsis:** Antiseptics prevent or inhibit growth of pathogenic organisms but are not effective against spores and viruses. They can usually be used on the skin. Common examples include alcohol and betadine.
- **Disinfection:** This is a process that destroys or kills pathogenic organisms. It is not always effective against spores and viruses. Chemical disinfectants are used in this process. Disinfectants can irritate or damage the skin and are used mainly on objects, not people. Some common disinfectants are bleach solutions and zephiran.
- **Sterilization:** This is a process that destroys all microorganisms, both pathogenic and nonpathogenic, including spores and viruses. Steam under pressure, gas, radiation, and chemicals can be used to sterilize objects. An autoclave is the most common piece of equipment used for sterilization.

In the sections that follow, correct methods of aseptic techniques are described. It is important for the health care worker to know and use these methods in every aspect of providing health care to prevent the spread and transmission of disease.

STUDENT: Go to the workbook and complete the assignment sheet for 15:1, Understanding the Principles of Infection Control.

15:2 Bioterrorism

Introduction

Bioterrorism is the use of microorganisms, or biologic agents, as weapons to infect humans, animals, or plants. Throughout history, microorganisms have been used in biologic warfare. Some examples include:

- The Tartar army throwing bodies of dead plague victims over the walls of a city called Caffa in 1346, causing an epidemic of plague in the city
- The British army providing Delaware Indians with blankets and handkerchiefs contaminated with smallpox in 1763, resulting in a major outbreak of smallpox among the Indian population
- The Germans using a variety of animal and human pathogens in World War I
- The Japanese military using prisoners of war to experiment with many different pathogens in World War II
- The United States, Canada, the Soviet Union, and the United Kingdom developing biologic weapons programs until the late 1960s
- The release of sarin gas in Tokyo in 1995
- The mail attack with anthrax by an unknown individual or individuals in the United States in 2001

Today, there is a major concern that these biologic agents will be used not only in wars, but also against unsuspecting civilians.

Biologic Agents

Many different microorganisms can cause diseases in humans, animals, and plants. However, only a limited number are considered to be ideal for bioterrorism. Six characteristics of the "ideal" microorganism include:

- Inexpensive and readily available or easy to produce
- Spread through the air by winds or ventilation systems and inhaled into the lungs of potential victims, or spread by ingesting contaminated food or water
- Survives sunlight, drying, and heat
- Causes death or severe disability
- Easily transmitted from person to person
- Difficult to prevent and/or has no effective treatment