

Key Terms**bacteria** (p. 65)**carrier** (p. 72)**fungus** (p. 67)**helminths** (p. 68)**infection** (p. 64)**normal flora** (p. 65)**nosocomial infection** (p. 71)**parasites** (p. 67)**pathogens** (p. 64)**protozoa** (p. 67)**rickettsia** (p. 67)**spores** (p. 66)**sporozoa** (p. 67)**vector** (p. 68)**viruses** (p. 67)**Objectives**

1. Define *disease* and *infection*.
2. List the characteristics of the different types of pathogens, including the types of bacteria by shape.
3. Describe the types of bacteria by staining characteristics.
4. Define portals of exit and portals of entry.
5. List common ways by which infections are spread.
6. Identify the microbiological principles described in Five Germ-Laden Stories.

For as long as humans have roamed the earth, we have been plagued by disease, especially infectious disease. A long and colorful history of medicine relates many tales of how we learned to dose, purge, lance, and incant. Sometimes we managed to arrest and cure the disease, but many times we killed the patient long before we killed the germs. The battle against disease is far from over. The microbial warriors are tough; they mount a great offensive and are very persistent! Although we may not tremble at the thought of the Black Death that terrorized Europe in the 1300s, we tremble at the thought of other plagues around today, as well as those that can erupt tomorrow. We are living through the terror of acquired immunodeficiency syndrome (AIDS), and we dread an outbreak of avian or swine flu, the contamination of a minor abrasion with flesh-eating streptococcus, and the possibility of contracting mad cow disease, of all things! What about the new generation of life-threatening “super bugs” that are resistant to all antibiotics? This chapter provides background information about microbiology—the world of microorganisms, those tiny critters that keep scientists glued to their microscopes. Chapter 21 describes the body’s response to this microbial challenge.

WHAT IS DISEASE?

Disease is a failure of the body to function normally. There are many types of diseases, not all caused by germs. These include inherited diseases, diseases caused by birth defects, age-related degenerative

diseases, diseases caused by nutritional deficiencies, tumors, and diseases related to trauma and environmental toxins. This chapter focuses on infectious disease. Although most microorganisms are harmless or even beneficial to the body, some are harmful, causing disease and sometimes death. A leading cause of disease in humans is the invasion of the body by **pathogens**, or disease-producing microorganisms. The invasion of the body by a pathogen and the symptoms that develop in response to this invasion are called an **infection**. A localized infection is restricted to a small area, whereas a systemic infection is more widespread throughout the body. A systemic infection is spread by the blood; it affects the entire body and generally makes you feel sick. With regard to a wound, there is often an attempt to differentiate between colonization and infection. Colonization means that the microorganism is present but is not causing illness. Infection means that the microorganism is present and is causing illness. Obviously, a wound that is colonized may eventually become infected. Table 5-1 describes several key terms used in discussing microbiology.

? Re-Think

Differentiate between a local and systemic infection.

TYPES OF PATHOGENS

The groups of microorganisms (some of which are pathogens) are bacteria, viruses, fungi, and protozoa. Other larger, disease-causing organisms include worms and arthropods (Figure 5-1).

Matching: Genetic Code and Protein Synthesis

Directions: Match the following words with their descriptions below.

- | | |
|--------------------|---|
| a. mRNA | 1. ___ Double-stranded nucleotide that stores the genetic code |
| b. ribose | 2. ___ The manner in which the genetic code is stored |
| c. base pairing | 3. ___ The manner whereby one strand of a nucleotide interacts with another |
| d. DNA | |
| e. base sequencing | |
4. ___ Single-stranded nucleotide that brings the code from the nucleus to the ribosomes
5. ___ A sugar used in the formation of a nucleotide

Multiple Choice

- Which of the following is true of the Krebs cycle and electron transport chain enzymes?
 - Are located within the mitochondria
 - Function anaerobically
 - Result in lactic acid production
 - Are responsible for glycolysis
- Which of the following is not characteristic of glycolysis?
 - Occurs within the cytoplasm
 - Operates anaerobically
 - Forms lactic acid
 - Completely metabolizes glucose to CO_2 , H_2O , and energy
- Which of the following is not characteristic of urea?
 - Formed in the liver
 - Contains nitrogen
 - Characterized as an essential amino acid
 - Excreted by the kidneys
- Which of the following is not true of amino acids?
 - Joined together by peptide bonds
 - The building blocks of protein
 - Classified as monosaccharides, disaccharides, and polysaccharides
 - Classified as essential and nonessential
- Monosaccharides
 - include glucose, fructose, and galactose.
 - include sucrose, lactose, and maltose.
 - are classified as saturated and unsaturated.
 - are the building blocks of protein.
- Which of the following is descriptive of glycogen?
 - Can be converted to glucose, thereby elevating the blood glucose level
 - Combines with three fatty acids to form a lipid
 - Contains nitrogen
 - Is a disaccharide

Go Figure

- According to Figure 4-3
 - Most ATP is generated by glycolysis.
 - Glycolysis is an aerobic catabolic pathway.
 - Under aerobic conditions, the end products of glycolysis enter the mitochondria where they are completely metabolized to CO_2 , water, and ATP.
 - Figure 4-3, A, illustrates glycolysis, whereas Figure 4-3, B, illustrates gluconeogenesis.

- According to Figure 4-3, A
 - Pyruvic acid is aerobically metabolized to lactic acid.
 - Lactic acid is generated under anaerobic conditions.
 - Lactic acid is produced within the mitochondrion under aerobic conditions.
 - Mitochondrial ATP production is dependent on the production of lactic acid.
- According to Table 4-2 and Figure 4-4
 - Cholesterol and adrenal cortical hormones are steroids.
 - All lipid substances are steroids.
 - All cholesterol is "bad."
 - Glycerol, an alcohol, can only combine with long-chain fatty acids.
- According to Box 4-1 and Figure 4-5
 - All amino acids in Box 4-1 contain an $-\text{NH}_2$ and $-\text{COOH}$ group.
 - All amino acids in Box 4-1 are essential.
 - The only amino acids that form peptide bonds are alanine and phenylalanine.
 - Peptide bonds form when the $-\text{COOH}$ group of one amino acid combines with the $-\text{COOH}$ group of a second amino acid.
- According to Figure 4-6
 - Urea is a nitrogen-containing waste product produced in the kidney.
 - Urea is transported from the kidneys to the liver, where it is excreted into the bile and eliminated from the body.
 - Urea is produced in the liver and excreted by the kidneys in the urine.
 - Urea is produced in the blood and excreted by both the liver and the kidneys.
- According to Figures 4-7 and 4-8 and Table 4-4
 - mRNA is double-stranded.
 - The base sequence codes for an amino acid.
 - The rung of the DNA ladder is formed by sugar-phosphate bonds.
 - The base sequence CAA codes for the entire hemoglobin protein.
- According to Figures 4-7 and 4-8
 - Cytosine can base-pair with thymine.
 - Adenine can base-pair with thymine.
 - Structurally, adenine resembles thymine more than it resembles guanine.
 - Thymine can base-pair with both adenine and guanine.
- According to Figure 4-9
 - mRNA is transcribed from DNA in the nucleus.
 - DNA is transcribed from mRNA in the nucleus.
 - mRNA cannot leave the nucleus.
 - The assembly of amino acids into peptide strands occurs in the nucleus.
- According to Figure 4-9
 - The assembly of amino acids occurs along the ribosomes in the cytoplasm.
 - mRNA carries the genetic code from the nucleus to the ribosomes in the cytoplasm.
 - Translation involves the base pairing between mRNA and tRNA in the cytoplasm.
 - All of the above are true.

Table 5-1 Key Microbiological Terms

TERM	DEFINITION
Antibiotic	Chemical used to treat bacterial infections. A broad-spectrum antibiotic destroys many different types of bacteria, whereas a narrow-spectrum antibiotic destroys only a few types.
Communicable disease	Any disease that can be spread from one host to another. A noncommunicable disease is an infectious disease that cannot be transmitted directly or indirectly from host to host. For example, a bladder infection caused by <i>Escherichia coli</i> cannot be spread from the infected person to another person. A contagious disease is a communicable disease that is easily spread from one person to another. Measles and chickenpox are contagious diseases because they are easily spread.
Commensal	Organisms living in a harmonious and beneficial relationship with each other. The organisms derive nutritional or other environmental benefits from the other. Commensal bacteria are part of the normal flora.
Epidemic disease	A disease acquired by many people in a given area over a short period. An endemic disease is always present in a population. A pandemic is a worldwide epidemic.
Epidemiology	The study of the occurrence and distribution of a disease in a population.
Incubation period	The lapsed period of time from the exposure of a person to a pathogen to the development of the symptoms of the disease.
Normal flora	A group of microorganisms that colonize a host without causing disease. Normal flora colonize the mouth, intestinal tract, vagina, nasal cavities, and other areas of the body. Microorganisms that are not pathogenic in one area may become pathogenic when transferred to another area. For example, when the <i>E. coli</i> bacterium that is part of the normal flora of the large intestine is unintentionally transferred to the urinary bladder, it causes a bladder infection. Some body fluids such as blood, urine, and cerebrospinal fluid are sterile and do not have a normal flora.
Nosocomial infection	A hospital-acquired infection.
Reservoir of infection	A continual source of infection. A reservoir of infection can be living organisms such as humans and other animals; nonliving objects are substances that are contaminated with the pathogen. A contaminated nonliving object is called a <i>fomite</i> , such as a dirty glass and used needles. Contaminated soil and water also serve as inanimate reservoirs of infection.
Resistance	The ability to ward off diseases. A lack of resistance is called <i>susceptibility</i> .
Sterilization	A process that destroys all living organisms.
Vector	A carrier of pathogens from host to host. The mosquito is the animal vector carrying the plasmodium (malaria) to humans. A contaminated syringe is a nonliving vector (fomite).

MICROORGANISMS (MICROBES)

Bacteria (sing., bacterium) are single-celled organisms found everywhere. They were first observed under the microscope by van Leeuwenhoek, who called them “little beasties.” Most bacteria consider living conditions within the human body to be ideal, so they move right in. The good news is that many bacteria perform useful roles. For example, **normal flora** (organisms that normally and harmoniously live in or on the human body without causing disease) prevents the overgrowth of other organisms, keeping them under control. Some bacteria synthesize needed substances such as vitamin K. The bad news is that bacteria can also cause disease; in fact, bacteria make up the largest group of pathogens. When bacteria successfully invade the human body, they cause damage in two ways: (1) by entering and growing in the human cell; and (2) by secreting toxins that damage the cells.

Bacteria are classified into three groups based on shape: (1) coccus (round); (2) bacillus (rod-shaped);

and (3) curved rod. Rickettsiae and chlamydiae are also classified as bacteria, although they differ in several important ways from cocci, bacilli, and curved rods.

The cocci are round cells and are arranged in patterns. Cocci that are arranged in pairs are called diplococci (dip-loh-KOHK-eye). Streptococci (strep-toh-KOHK-eye) are arranged in chains, like a chain of beads. Staphylococci (staf-il-oh-KOHK-eye) look like bunches of grapes and are arranged in clusters. The cocci cause many diseases, including gonorrhea, meningitis, and pneumonia. The bacilli (bah-SIL-ee) are long and slender and are shaped like a cigar. Diseases caused by bacilli include tetanus, diphtheria, and tuberculosis. The curved rods include the vibrio, the spirillum (spy-RIL-um), and the spirochete (SPY-ro-keet). The vibrios have a slight curve and resemble a comma. Cholera is caused by a vibrio (*Vibrio cholerae*). The spirillum is a long cell that coils like a corkscrew. Tightly coiled spirilla that are capable of waving and

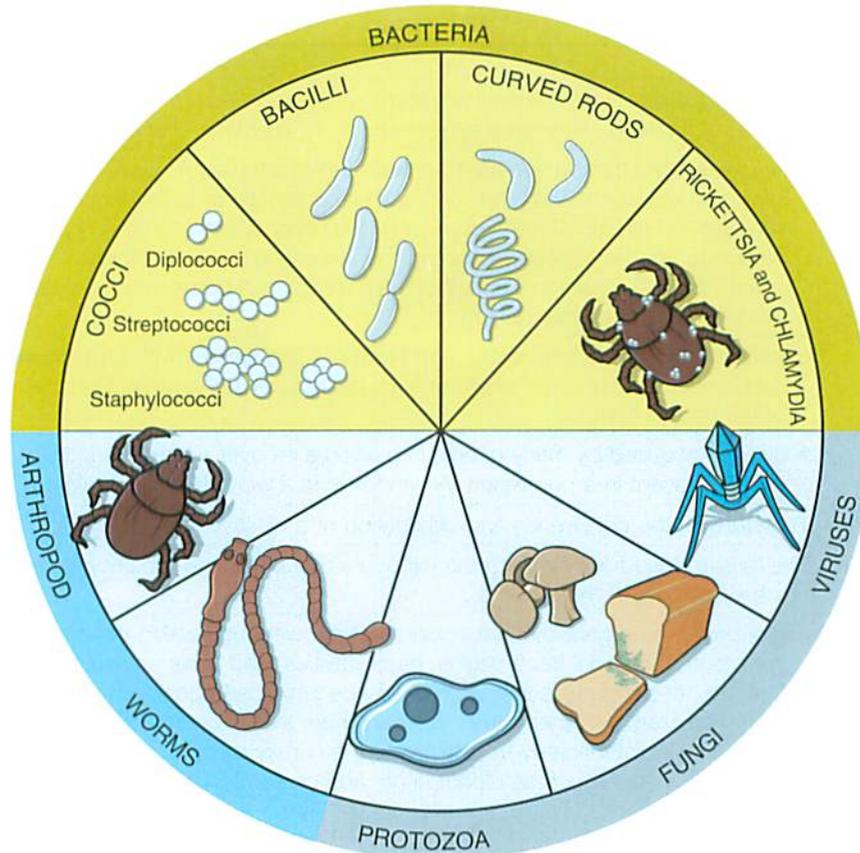


FIGURE 5-1 Pathogens: microorganisms and larger disease-causing organisms.

twisting motions are called spirochetes. The most famous spirochete, *Treponema pallidum*, causes syphilis. Syphilis has been around for centuries. Its origin, if nothing else, is colorful. The French called syphilis the Italian disease and, of course, the Italians reciprocated, calling it the French disease. The Polish referred to it as the German disease and—you guessed it—the Germans called it the Polish disease! Regardless of its origin, syphilis is well traveled.



Do You Know...

What Maria, Sophia, and Leah Have in Common?

"Hey! Maria, Sophia, and Leah ... y'all got gonorrhea," shouts their main squeeze. Mr. Busy has just been informed that he has gonorrhea, a sexually transmitted infection caused by *Neisseria gonorrhoeae*. As the girls now know, gonorrhea is highly contagious. Today has been hectic for our carrier, Mr. B. He began treatment with the antibiotic ciprofloxacin and is currently burning up the phone lines informing his sexual partners (called *contacts* in public health jargon) of probable and almost certain infection. It is crucial that all four be treated for gonorrhea to prevent the "ping-pong effect": treatment and cure, followed by reexposure and reinfection. By this time next week, Maria, Sophia, and Leah should also be taking ciprofloxacin and sitting at home in front of the flat-screen contemplating the definition of "safe sex."

No one is "clapping," as in days of old, when the infected were welcomed home by the clapping sounds of their shipmates (hence the nickname "clap" for gonorrhea).



Do You Know...

That Lues, Lues Is Not a Hit Tune?

"Lues, Lues" sounds like an oldie-but-goody hit tune. In fact, it is an oldie, but definitely not a goody. Lues refers to syphilis. Lesions associated with syphilis are referred to as *luetetic lesions*. Got lues? "Singin' nothing but the blues ..."

There are two clinically important characteristics of bacteria: (1) the presence of a cell wall and (2) the ability to form spores. Although the human cell is surrounded by the cell membrane, the bacterial cell is surrounded by two structures: a cell membrane and an outer cell wall. The bacterial cell wall is a rigid wall that protects the underlying cell membrane from bursting. If the cell wall is damaged, the cell membrane of the bacterium bursts, killing the bacterium. Enter penicillin! Penicillin prevents cell wall synthesis in the bacterium, causing the cell membrane to burst and the bacterium to die. Because human cells do not have a cell wall, they are not damaged by penicillin; penicillin is therefore relatively safe when administered to humans. Because a virus does not have an outer cell wall, it is not affected by penicillin. So, do not take penicillin for a viral infection—it does not work.

Many bacteria form **spores** that allow them to survive harsh environmental conditions such as drying, heating, and exposure to certain disinfectants. Spores enable the bacteria to exist in a "sleepy," or

dormant, state until conditions improve. Then the bacteria wake up, grow, and resume their usual activities. For example, *Clostridium botulinum*, the organism that causes a deadly form of food poisoning (botulism), is a spore former and can withstand several hours of exposure to boiling water. Obviously, spore-forming microorganisms have great survival skills and present a challenge in infection control procedures.

Rickettsia (ri-KET-see-ah) and chlamydia (cla-MID-ee-uh) are classified as bacteria. However, they are smaller than most bacteria and must reproduce within the living cells of a host. Because they require a living host, they are called **parasites**. The rickettsiae are often carried by fleas, ticks, and body lice. For example, the rickettsia that causes Rocky Mountain spotted fever is carried by the tick. Body lice carry the rickettsia responsible for epidemic typhus. The chlamydiae are smaller than rickettsiae and cause several major human diseases. One of the most prevalent sexually transmitted diseases in the United States today is caused by *Chlamydia trachomatis*. Chlamydial infection is also responsible for trachoma, a serious eye infection that is a leading cause of blindness in the world. Like other bacterial infections, rickettsial and chlamydial infections are treated with antibiotics.



Do You Know...

Who Russ T. Nale Is?

By stepping on his namesake, Russ T. Nale accomplished two things. First, he allowed a potentially lethal pathogen, *Clostridium tetani*, to enter his body. Second, he had a deep puncture wound that encouraged the growth of the pathogen. Because little bleeding is associated with a puncture wound, the pathogen was not washed out of the wound. More importantly, however, a deep puncture wound prevents air (oxygen) from entering the wound. Because this pathogen grows anaerobically (without oxygen), the conditions associated with a puncture wound are ideal. Sure hope Russ is up to date on his tetanus shots!

Viruses (from the Latin *virus*, meaning “poison”) are the smallest of the infectious agents. They are not cells and consist of either ribonucleic acid (RNA) or deoxyribonucleic acid (DNA) surrounded by a protein shell. Because viruses can only reproduce within the living cells of a host, they are parasites. Examples of viral diseases are measles, mumps, influenza, poliomyelitis, and AIDS. Because of the intimacy of the virus–host relationship, the development of nontoxic antiviral agents has been slow and difficult. This point is well illustrated by the drug zidovudine (AZT), used in the treatment of AIDS. While exerting antiviral effects, the drug also causes widespread damage to the host cells. Most upper respiratory infections are viral and are not responsive to antibiotic therapy.

Fungus is a plantlike organism, such as a mushroom, that grows best in dark, damp places. Yeasts and

molds (such as bread mold) are types of fungi. Pathogenic fungi cause mycotic infections (*myco* means “fungus”). Mycotic infections are usually localized and include athlete’s foot, ringworm, thrush, and vaginitis. *Candida albicans* is a yeastlike fungus that normally inhabits the mouth, digestive tract, and vagina. When *Candida* overgrows, it can cause an infection in the mouth (thrush), intestinal symptoms, or vaginitis. Systemic fungal infections are rare, but when they occur, they are life-threatening and difficult to cure.



Do You Know...

About the Ring of Ringworm?

Ringworm is an infection of the skin caused not by worms, but a fungus. Why the circular or ring shape? The fungus grows outward from the center. The fungi in the center of the lesion die before the outer circle of fungi die. This type of fungal growth pattern leaves a clear or healed center surrounded by living fungi.

NOTE: There is a ringworm bush (*Cassia alata*) whose leaves produce a juice that is used as a cure for ringworm and poisonous bites. The two explanations for the name *ringworm* are as follows: (1) an ancient and mistaken belief existed that worms caused the infection; and (2) it was named after the ringlike or circular appearance of the lesion. Both theories have a “ring” of truth.

Protozoa (pro-toe-ZO-ah) are single-celled, animal-like microbes. The four main types of protozoa are amebas (ah-MEE-bah-z), ciliates (SIL-ee-atz), flagellates (FLAH-jel-atz), and **sporozoa** (spor-uh-ZOH-uh). Protozoa are found in the soil and in most bodies of water. Amebic dysentery and giardiasis are caused by protozoan parasites. The parasites are ingested in contaminated water and food and cause severe diarrhea. Malaria is caused by a sporozoan called a plasmodium. *Plasmodium malariae* is carried by a mosquito, which is capable of spreading malaria over a wide region. Indeed, malaria still causes more than 3 million deaths per year in the more tropical regions of the world. Two other members of the sporozoa group pose a serious health threat to those persons with impaired immune systems. *Pneumocystis jiroveci* and *Cryptosporidium* cause infections in persons with AIDS and other immunocompromised persons.



Re-Think

What is a normal flora? What is the consequence of disturbing the intestinal normal flora?

OTHER (MULTICELLULAR) DISEASE-CAUSING ORGANISMS

Other disease-causing organisms that are larger than microorganisms include multicellular organisms such as parasitic worms and arthropods.

Parasitic worms, called **helminths**, are multicellular animals that are parasitic and pathogenic to humans. In other words, worms can be germs. The identification of most worm infestations requires microscopic examination of body samples (usually stool) and reveals the presence of the adult worms or the larval forms. The worms are classified as roundworms or flatworms. Roundworms include ascarides, pinworms, hookworms, trichinae, and the tiny worms that cause filariasis (fi-LAR-eye-ah-sys) or elephantiasis. Infestation by pinworms is common in children and is very hard to control. The pinworms live in the intestinal tract but lay their eggs on the outer perianal area. The deposition of the eggs causes itching (pruritus). A child may then scratch the anal area and transfer the eggs to his or her mouth and onto others. The eggs are swallowed and the newly hatched pinworms grow into adulthood in the intestine. Most worm infestations are transmitted by the fecal–oral route (in which hands contaminated by feces introduce the worms, eggs, or larvae into the mouth). Trichinosis is transmitted by ingestion of undercooked contaminated pork, and filariasis is transmitted by biting insects.

The flatworms include the tapeworms and the flukes. Tapeworms that live in the intestines may grow from 5 to 50 feet in length. Imagine hosting a 50-foot tapeworm! Flukes are flat, leaf-shaped worms that invade the blood and organs such as the liver, lungs, and intestines. Because these large flatworms feed on the human host, infestation causes weight loss, anemia, and generalized debilitation. Infestation by worms is treated with drugs called *anthelmintics* (which means “against worms”).

Arthropods are animals with jointed legs and include insects. They are of concern for two reasons. Arthropods such as mites and lice are ectoparasites, meaning that they live on the surface of the body, skin, and mucous membranes. Ectoparasites cause itching and discomfort but are not life-threatening. More seriously, arthropods such as mosquitoes, biting flies, fleas, and ticks act as vectors of disease. (A **vector** is an object, living or nonliving, that transfers a pathogen from one organism to another.) The bite of the arthropod vector introduces pathogens into the host (the person or organism that is infected by a pathogen), causing infection. For example, the mosquito (arthropod vector) can carry the pathogens for malaria and encephalitis. The tick can carry the pathogens that cause Lyme disease and Rocky Mountain spotted fever.

Re-Think

What is meant by the fecal–oral route? How would you prevent the spread of an organism that is spread by this route of transmission?

LABORATORY IDENTIFICATION OF PATHOGENS

Many laboratory procedures and techniques are used to identify pathogens. One of these techniques is called *staining* and involves the use of dyes. A second technique is a culture.

Many bacteria are classified according to staining characteristics using the Gram stain (a dye). A gram-positive bacterium is one that stains purple or blue. *Streptococcus* is an example of a gram-positive bacterium. A gram-negative bacterium such as *Escherichia coli* does not absorb the purple Gram stain. Instead, a gram-negative bacterium picks up a pink or red stain. Because most bacteria are gram-positive or gram-negative, Gram staining is an important first step in the identification of the causative organism of an infection.

Another stain is called the *acid-fast stain*. The bacterium is first stained with a red dye and then washed with an acid. Most bacteria lose the red stain when washed with acid. However, several bacteria retain the red stain and are therefore called *acid-fast*. The most famous of the acid-fast bacteria is the *Mycobacterium tuberculosis*, the causative organism of tuberculosis (TB). This organism is commonly called the *acid-fast bacillus*. Some bacteria do not stain with any of the commonly used dyes. Thus, spirochetes and rickettsiae must be stained with special dyes and techniques.

Sometimes the physician wants to identify the specific pathogen growing in an infected wound and orders a wound culture to be done. A sample of the wound exudate (pus) is placed on culture medium (food that supports the growth of the pathogens). The pathogens are incubated and allowed to grow and multiply. The pathogens can then be stained and identified. The growth of pathogens in a culture medium is called a *culture*. The cultured pathogens can also be tested for their susceptibility to various antibiotics (culture and sensitivity test). For example, if an antibiotic is placed in the same culture and stops the growth of the pathogen, the pathogen is assumed to be responsive or sensitive to the effects of the antibiotic. The antibiotic is given to the patient to treat the infection. Other antibiotics may have no effect on the growth of the pathogens in the culture and therefore would not be used in the treatment of the infection.

You will often be asked to collect samples for laboratory analysis. Specific rules must be followed for each specimen. For example, in collecting a urine specimen that will be analyzed for the presence of pathogens, you must be careful not to contaminate the urine with microorganisms from your hands or unsterile containers. The proper identification of the pathogen depends on correct technique.

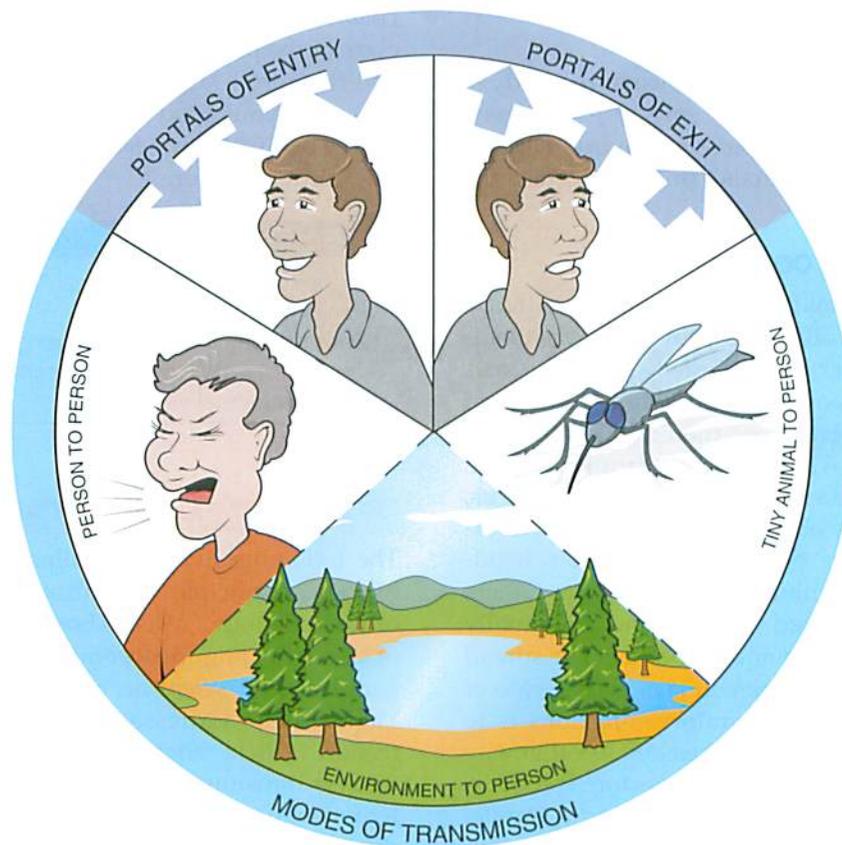


FIGURE 5-2 Spread of infection: portals of entry, portals of exit, and modes of transmission.

? Re-Think

What does it mean to say that a bacterium is gram-positive or gram-negative?

THE SPREAD OF INFECTION

To understand how infection is spread, we must know how germs move—in, out, and about (Figure 5-2).

PORTALS OF ENTRY AND EXIT

How do pathogens enter the body? Pathogens enter the body by portals of entry, which include the respiratory, gastrointestinal, and genitourinary tracts, eye, skin, and parenteral route. The parenteral route includes those injuries that penetrate the skin or mucous membrane, such as bites, cuts, and surgery. A break in the skin is an excellent way for pathogens to enter the body. This is the reason that health care workers wear gloves when handling blood or other body fluids. In the event that the body fluids are contaminated (with, say, the AIDS or hepatitis viruses), the gloves prevent the entrance of the virus through tiny cuts or abrasions. Most pathogens enter the body through the respiratory tract (inhaled droplets of water and dust) and the gastrointestinal tract (by eating spoiled food or placing contaminated hands in the mouth).

How do pathogens leave the body of an infected person? Pathogens leave an infected body by portals of exit, which include the respiratory, gastrointestinal, or genitourinary tracts, the skin (intact and broken), eyes (tears), and breasts (milk). The most common portals of exit are the respiratory and gastrointestinal tracts. For example, the common cold virus is often sneezed or coughed into room air from the respiratory passages of the infected person, whereas the *Salmonella* organism in a person with typhoid fever exits the body in the stool. Discharge from the urogenital tract is also an important means of spreading infection (sexually transmitted diseases). By knowing the portal of exit of each pathogen, one can set up procedures for preventing the spread of the infection. For example, by knowing that *Salmonella typhi* is excreted in the stool, we know that the patient's underwear and bed linens are contaminated with the pathogens. We can then take measures to clean the soiled clothing and linens, thereby preventing the spread of the disease. By far, the most important procedure in preventing the spread of infection is handwashing!

? Re-Think

Give an example of a portal of entrance and portal of exit. Explain in terms of the fecal–oral route. Work the term *hand-washing* into your answer!

HOW PATHOGENS SPREAD

We know how pathogens enter and leave the body—but how do they move about, or “spread”? Pathogens are spread from person to person, environment to person, and from “tiny animals” (insects) to persons (see Figure 5-2).

PERSON-TO-PERSON CONTACT

Suppose you have a cold and go to work. Within a week, everyone in the office has your cold. What happened? First, whenever you sneezed, the cold virus was sprayed into the room air in little droplets of nasal discharge. These droplets were then inhaled by your coworkers. The virus was spread by droplet contact. Second, your hands were contaminated with the virus, and you touched many objects in the office (e.g., door-knobs, desktops, other people’s hands after hand-shaking), thereby contaminating these objects. Others touched the contaminated objects and eventually introduced the virus into their own bodies. The spread of infection from person to person is effective. One of the best ways to prevent respiratory infections is to avoid crowds during cold and flu season. Another way is to avoid contact with a fomite or vector. The door-knob is considered to be both a vector and a fomite. Remember that a vector is an object, living or nonliving, that transfers a pathogen from one organism to another. A *fomite* is a nonliving vector. Other fomites include soiled handkerchiefs and eating utensils.

ENVIRONMENT-TO-PERSON CONTACT

This mode of transmission includes contact with contaminated water, air, food, or soil. For example, you can develop typhoid fever if you drink a glass of water contaminated by *S. typhi*. Similarly you can develop food poisoning if you eat food contaminated with *E. coli*.

“TINY ANIMAL”-TO-PERSON CONTACT

This mode of transmission includes the use of insects (and other “crawling critters”) in the spread of disease; these tiny animals are living vectors. For example, a mosquito bites a person with malaria. The malaria-causing plasmodium matures in the stomach of the mosquito. The plasmodium-loaded mosquito then bites another person and voila!—malaria. You can understand why the eradication of mosquitoes is key in malaria control. A final stomach-churning example is flies hopping from dog feces to food on a picnic table. The pathogens from the dog feces are transferred by the fly feet to the food, which is then eaten by you.

Note that the mosquito and fly both spread disease. The mosquito, however, plays a more complicated and biological role. The plasmodium (causative organism of malaria) requires the mosquito as part of its life cycle; it matures in the stomach of the mosquito. Because of this role, the mosquito is called a *biological*

vector. The lowly fly does not participate in the life cycle of the pathogen; it merely walks on the dog feces and the germs stick to the feet of the fly. The fly then flies onto your food and deposits the germs on your food. The fly is only a *mechanical vector* but a very effective germ spreader.

? Re-Think

1. Explain how a doorknob can act both as a vector and fomite during flu season.
2. Describe why the malaria-causing mosquito acts as a biological vector whereas the common housefly usually acts as a mechanical vector.

FIVE GERM-LADEN STORIES

The following five stories illustrate important microbiological principles and introduce you to the language of microbiology. “Wash Those Mitts!” is a tragic story of handwashing, nosocomial infection, and the arrogance of the scientific community. “Flora and Her Vaginal Itch” addresses the normal flora and superinfection. “Rick, Nick, and the Sick Tick” describes disease transmission by an arthropod vector and differentiates between a communicable and contagious disease. “Why Typhoid Mary Needed to Lose Her Gallbladder” describes the carrier state and the efficiency of the fecal–oral route in disease transmission. Finally, “A Pox News Alert!” focuses on the pox throughout history and some of the current concerns. As you read the stories, refer to Table 5-1 for the definitions of unfamiliar terms; the table defines and expands the microbiological principles illustrated in the stories.

DR. SEMMELWEIS SCREAMS, “WASH THOSE MITTS!”

Dr. Ignaz Semmelweis was an assistant at the First Obstetrical Clinic in Vienna (circa 1850). At that time, an alarmingly high mortality rate was associated with puerperal fever or childbirth fever. Puerperal fever begins as an infection of the uterus after childbirth and is commonly caused by a strain of beta-hemolytic streptococcus. Puerperal fever progresses from an infection of the uterus to peritonitis and to generalized septicemia, ending in an agonizing death.

Semmelweis made the following two keen observations while caring for his patients:

1. A woman became ill immediately after being examined by a medical student who had previously examined a woman dying of puerperal fever.
2. If a medical student cut himself while attending a woman with puerperal fever, his wound became infected, and he subsequently died of puerperal sepsis.

Dr. Semmelweis concluded that puerperal fever is caused by conveyance to the pregnant woman of

“putrid particles derived from living organisms through the agency of the examining fingers.” This conclusion was impressive because he linked the disease to the putrid particles—tiny disease-producing critters that would not be discovered and linked to disease officially for another 25 years.

As a result of his observations, Semmelweis demanded that his medical students wash their hands with a disinfectant before examining each patient. “Wash those mitts!” he screamed, and wash they did. Mortality rates in his clinic decreased from 18% to 1%. You might conclude that Semmelweis eliminated puerperal fever and was honored by his colleagues. Not so! They ridiculed him for his insistence on hand-washing. He eventually became so distraught that he deliberately cut his finger and contaminated his injury with the vaginal discharge of a woman with puerperal fever. Ranting and raving, he was committed to the Budapest Insane Asylum, where he quickly died of the disease that he had worked so hard to eradicate.

With the passing of Semmelweis, the practice of handwashing was discontinued and the mortality rate from puerperal fever again soared. Puerperal fever, although rarely seen today, is a great example of a nosocomial infection. A **nosocomial** (noh-soh-CO-mee-al) **infection** is a hospital-acquired infection that is most often transmitted from patient to patient by direct contact (through the agency of the examining finger, according to Semmelweis). Today, a nosocomial infection is transmitted by health professionals who *do not wash their hands*. We go from patient to patient, carrying germs from one to another. Historically, nosocomial infections have been a tremendous problem. Today, 15% of hospitalized patients develop a nosocomial infection. “Wash those mitts!” echoes through the centuries but generally falls on deaf ears.

? Re-Think

Explain why the same problem dealt with by Semmelweis is the same as today's issue with nosocomial infection.

FLORA AND HER VAGINAL ITCH

Stuffed up and miserable, Flora went to her physician. She was given an antibiotic for a sinus infection. Within a week, the sinus infection was cured; the misery, however, had headed south. Flora now had an antibiotic-induced vaginal discharge.

The vagina is normally inhabited by a population of diverse microbes. These microbes are permanent residents and, when present in normal amounts, do not produce disease. This population of microbes within the vagina is called the *normal flora*. Other body cavities or areas such as the skin, large intestine, mouth, and respiratory tract contain their own diverse populations of microbes and therefore have their own normal flora.

The presence of a normal flora within the vagina prevents the overgrowth of yeast called *Candida albicans* that is present in small numbers within the vagina. If the normal flora is destroyed by an antibiotic, the yeast grows uncontrollably and causes candidiasis, a vaginal yeast infection, characterized by discharge, odor, and itching. Candidiasis is an example of a superinfection. Organisms that do not cause disease in their normal habitat become pathogenic when allowed to overpopulate the area. What was the cause of Flora's itch? Flora's normal flora had become abnormal. Watch those antibiotics!

? Re-Think

Why may antibiotic therapy cure one infection but cause a superinfection in the same patient?

RICK, NICK, AND THE SICK TICK

One week after returning from a camping trip with his friend Nick, Rick went to his physician feeling awful. He had chills, a high fever, headache, muscle pain, and a red, measles-like spotted rash that was prominent on the palms of his hands and the soles of his feet. On examination, the physician removed a tick from Rick's back. He was diagnosed with Rocky Mountain spotted fever (RMSF) and treated with the antibiotic tetracycline. Microbiologically speaking, Rick had become the perfect host (an organism who had become infected with a pathogen).

Enough about Rick! What's with the tick? The tick that bit Rick was sick; it was infected with the pathogen called *Rickettsia rickettsii*, the causative organism of RMSF. When the tick bit Rick, the infected saliva was injected into the bite site. The rickettsia then feasted on Rick's blood by growing, multiplying, and eventually causing the signs and symptoms that sent Rick to the doctor.

The tick acts as an arthropod vector for RMSF. An animal vector is an organism that transmits a pathogen such as rickettsia. An arthropod is a class of tiny animals that have jointed legs. In this case, the arthropod is the sick tick. The rickettsia is transmitted by saliva (the bite of the tick) or the feces of the tick that are rubbed into the bite. The tick also serves as a reservoir of infection, which harbors pathogens; in this case, the tick is the reservoir.

The tick is not killed by the rickettsia. Mama tick coexists with the rickettsia and passes the rickettsia through her eggs to her baby ticks, thereby perpetuating and expanding generations of sick ticks.

Why didn't Nick catch Rick's infection? RMSF is considered a communicable disease inasmuch as the infection can be spread (through the bite of a tick). RMSF, however, is not considered a contagious disease—that is, one easily spread from host to host like a common cold or impetigo. Thus, Nick remained well, despite his close association with Rick.

One last thing about RMSF: it is an example of zoonosis, an animal disease that is transmissible to humans. Other zoonotic diseases include malaria and endemic typhus.

? Re-Think

Explain the role of the arthropod vector in Rocky Mountain spotted fever.

WHY TYPHOID MARY NEEDED TO LOSE HER GALLBLADDER

Mary Mallon (Typhoid Mary) lived in New York in the early 1900s. While employed as a cook, she unintentionally infected many persons with typhoid fever. Hearing several rumors of Mary's unfortunate associations with this disease, her wealthy employer hired a sanitary engineer, George Soper, to investigate the sudden outbreak of typhoid fever within the former's home. Soper soon informed Mary that she was a **carrier** of the germ that caused typhoid fever. Mary vehemently denied that she was the infecting culprit, because she herself did not feel ill. Understandably, she chased Soper from her kitchen with a carving fork. But Soper was correct—Mary was indeed a carrier of typhoid fever.

The *S. typhi* bacterium, the causative organism of typhoid fever, is transmitted by the fecal–oral route through contaminated food or water. Mary's vocation as a cook was a perfect way to spread the salmonella organism via her contaminated hands touching food. Carriers of typhoid fever never rid their systems of *Salmonella*; instead, they harbor the organisms in the bile stored within the gallbladder. Salmonella-laden bile then enters the intestine and contaminates the feces. Removal of the gallbladder rids the body of the salmonella, thereby eliminating the carrier state. Surgical removal of the gallbladder would have made an enormous difference in Mary's life. Unfortunately, surgery was not an option and Mary was forced into isolation on a coastal island, where she lived unhappily for 26 years.

? Re-Think

How may a cholecystectomy (gallbladder removal) and antibiotics have rendered Mary "safe"?

A POX NEWS ALERT!

Pox News, responding to an ancient medieval curse "A pox be upon you," has issued an update on the pox. Here it is, fair and balanced!

- There has been much confusion about the pox throughout history. The ancients referred to any infectious disease as a "dose of the pox." (Because pox infection was so ugly and visible, the ancients

commonly invoked pox curses on their enemies.) Later, the term *pox* was restricted to any disease characterized by a vesicular skin lesion. The term *pox* focuses only on the skin lesion and does not address its cause or treatment. Today, the medical focus is placed on the type of virus that causes a pox.

- Pox diseases are not limited geographically, nor are they restricted to humans. There are "flocks of pox": monkey pox, parrot pox, camel pox, squirrel pox, goat pox, fox pox, ox pox—even plants have pox (plum pox).
- What about chickenpox? Chickenpox is caused by the varicella-zoster virus, a member of the Herpesvirus group. It is characterized by a vesicular pox, accompanied by severe pruritus, and capable of causing pock marks. Why the name *chickenpox*? Explanations abound. In England, children were often called "chicken." Because chickenpox is primarily a disease of children, the pox was dubbed "childrenpox." Others suggest that the name is derived from the appearance of the pock mark; it looks like the skin has been pecked by a chicken. Others observe the pox as resembling chick peas. There's no telling what it means.
- Think that's strange? Pox News has just learned that some parents are throwing "pox parties" in which they are deliberately exposing their unvaccinated children to those who currently have chickenpox! Some parents are convinced that the chickenpox vaccine is unsafe and that the only safe way to build up immunity is to "get" a real case of chickenpox. When a child contracts chickenpox, their friends are invited to a party. The infected child is told to blow a whistle and to then pass the whistle to the friends. The whistle, acting as a vector, then spreads the virus from child to child. The practice is effective but dangerous; whereas most children recover uneventfully from chickenpox, some develop serious complications. In particular, children who are immunocompromised may develop a lethal multiple organ infection by the virus; this carries a 17% mortality. Pox parties are probably not the best approach to infectious disease control.
- Poxes come in different sizes. There is the dreaded lethal smallpox and the infamous Great Pox. Pox News, however, has just learned that the Great Pox is no pox at all; its pocky lesion is a chancre and is caused by a spirochete called *Treponema pallidum*. Yikes! The Great Pox is syphilis, the source of untold misery. Just ask Beethoven, Hitler and his lovely bunker mate Eva B, Henry VIII and his tower ladies, to mention a few. As for the "Chief of Grief" (syphilis), its cause was accurately described by the ancients: "It is taken when one pocky person doth synne (sin) in lechery with one another." Prevention is obvious: "Sin thou not with a pocky person."

**Do You Know...****That Dr. Herbie Zoster Hung Out His Shingle?**

Meet Dr. Herbie Zoster, a herpes specialist according to his newly hung shingle. Today, he is seeing his first patient, Ms. Vera Cella. Ms. Cella is miserable; she has a string of painful skin lesions around her waist. Dr. Zoster makes an immediate diagnosis: It is shingles, medically known as *herpes zoster*. Shingles is an acute infection of the peripheral nervous system caused by the varicella-zoster virus, the same virus that causes chickenpox. After a person recovers from chickenpox, the virus hides in a posterior root ganglion. Later in life, often in response to stress or immunosuppressive therapies, the virus leaves the ganglion and travels along the sensory neurons to the skin. This results in a line of skin blisters along the infected nerve and severe pain. As a complication, some persons develop a postherpetic neuralgia (pain that lingers long after the skin lesions have cleared). Yes, shingles can be triggered by exposure to a child with chickenpox.

**Re-Think**

What is the relationship between chickenpox and shingles?

2+2 Sum It Up!

Infectious disease has plagued us forever. Today the battle continues against the tiny but tough disease-producing organisms called pathogens. Pathogens include bacteria, viruses, fungi, protozoa, parasitic worms, and arthropods. To understand the transmission of an infection, one should know the portals of entry (how the pathogen enters the body), the portals of exit (how the pathogen leaves the body), and how the pathogen is spread (person-to-person, environment-to-person, or "tiny animal"-to-person). Important microbiological principles are illustrated in Five Germ-Laden Stories.

Table 5-2 Disorders Caused by Pathogens

PATHOGEN	DISORDER
Cocci	
<i>Neisseria</i>	<i>N. gonorrhoeae</i> causes gonorrhea and inflammation of the mucous membranes of the reproductive and urinary tracts. May cause sterility and pelvic inflammatory disease (PID). Infants of infected mothers may develop ophthalmia neonatorum. <i>N. meningitidis</i> causes meningitis, or inflammation of the membranes covering the brain and the spinal cord.
<i>Staphylococcus</i>	<i>S. aureus</i> causes skin infections such as boils and impetigo, pneumonia, kidney and bladder infections, osteomyelitis, septicemia, and food poisoning. <i>S. aureus</i> is a leading cause of nosocomial (hospital-acquired) infections.
<i>Streptococcus</i>	<i>S. pneumoniae</i> causes pneumonia, middle ear infection, and meningitis. <i>S. pyogenes</i> causes septicemia, strep throat, middle ear infection, scarlet fever, pneumonia, and endocarditis. An immunological response can cause rheumatic fever with permanent damage to the heart valves, and glomerulonephritis (kidney damage).
Bacilli	
<i>Bordetella pertussis</i>	<i>Bordetella</i> causes pertussis (whooping cough), a severe infection of the trachea and bronchi characterized by episodes of violent coughing. The "whoop" is an effort to inhale after the coughing bouts.
<i>Clostridium</i>	<i>C. botulinum</i> causes botulism, a potentially fatal form of food poisoning caused by improper processing of foods. <i>C. perfringens</i> causes gas gangrene, in which death of the tissue is accompanied by the production of a gas. <i>C. tetani</i> causes tetanus, or lockjaw.
<i>Escherichia coli</i>	<i>E. coli</i> is part of the normal flora of the intestines. <i>E. coli</i> causes local and systemic infections, food poisoning, diarrhea, septicemia, and septic shock; it is a leading cause of nosocomial infection.
<i>Haemophilus</i>	<i>H. aegyptius</i> causes conjunctivitis, a highly contagious infection that occurs in areas where there are many young children. <i>H. influenzae</i> causes meningitis in children and upper respiratory infection in older adults.
<i>Helicobacter pylori</i>	<i>H. pylori</i> causes gastritis and ulceration of the stomach and duodenum.
<i>Legionella pneumophila</i>	<i>L. pneumophila</i> is responsible for legionnaires' disease, a type of pneumonia. The organism contaminates water supplies, as in air-conditioning units.

Continued

Table 5-2 Disorders Caused by Pathogens—cont'd

PATHOGEN	DISORDER
<i>Mycobacterium tuberculosis</i>	<i>M. tuberculosis</i> causes tuberculosis (TB). The organism, also called the tubercle bacillus, causes primary lesions called <i>tubercles</i> . The bacillus most commonly affects the lungs. The incidence of TB is high in the homeless population, persons with AIDS, and closed populations such as in prisons. Formerly called the "white plague," TB is making a comeback in a more virulent and drug-resistant strain.
<i>Pseudomonas aeruginosa</i>	<i>P. aeruginosa</i> is the common cause of wound and urinary tract infections in debilitated patients, such as patients with severe burns, cancer, and other chronic conditions.
<i>Salmonella</i>	<i>S. enteritidis</i> causes salmonellosis, food poisoning characterized by severe diarrhea. <i>S. typhi</i> causes typhoid fever, an intestinal infection. Typhoid fever is rare in the United States because of the chlorination of the water supply, but the incidence increases during periods of flooding when the water supply is contaminated with sewage.
<i>Shigella dysenteriae</i>	<i>S. dysenteriae</i> causes dysentery.
Curved Rods	
<i>Borrelia burgdorferi</i>	<i>B. burgdorferi</i> causes Lyme disease and is characterized by a rash, palsy, and joint inflammation. It is transmitted by a small deer tick.
<i>Treponema pallidum</i>	<i>T. pallidum</i> causes syphilis.
<i>Vibrio cholerae</i>	<i>V. cholerae</i> causes cholera.
Rickettsia and Chlamydia	
<i>Rickettsia</i>	<i>R. prowazekii</i> causes epidemic typhus, which is transmitted to humans by lice. <i>R. rickettsii</i> causes Rocky Mountain spotted fever, which is transmitted to humans by ticks. <i>R. typhi</i> causes endemic or murine typhus, which is transmitted to humans by fleas.
<i>Chlamydia</i>	<i>C. trachomatis</i> causes trachoma, the leading cause of blindness in the world. Another form causes nongonococcal urethritis, the most common sexually transmitted disease in the United States.
Viruses	
Encephalitis viruses	Encephalitis is the inflammation of the brain.
Hepatitis viruses	Several forms of hepatitis exist, causing inflammation of the liver, as follows: Hepatitis A is spread by the fecal-oral route. Hepatitis B is spread by sexual activity or contact with contaminated blood and body fluids. Hepatitis C is caused by contaminated blood transmitted via transfusions, through needles in drug abuse, and to health care workers on the job. Hepatitis can become chronic, develop into a carrier state, or deteriorate to hepatic failure.
Herpes simplex viruses	<i>Type 1</i> : Cold sores or fever blisters appear on the lip, in the oral cavity, or in the nose. The virus lies dormant in the nerves between attacks. <i>Type 2</i> : Genital herpes is a common sexually transmitted disease characterized by painful lesions in the genitalia.
Herpes varicella-zoster	Chickenpox (varicella) is a mild infection characterized by generalized skin lesions. On remission of the infection, the virus becomes dormant and may reactivate in later years as shingles (herpes zoster).
Human papillomavirus (HPV)	HPV causes genital warts, which are transmitted sexually.
Influenza viruses	Influenza ("flu") is caused by different strains of the influenza viruses.
Measles virus	Measles (rubeola) is an acute respiratory inflammation characterized by fever, sore throat, skin rash, and Koplik's spots (white spots in the mouth).
Mumps virus	Mumps is epidemic parotitis (inflammation of a salivary gland).
Polio virus	Poliomyelitis (infantile paralysis) is an acute infection that may destroy nerve cells in the spinal cord, causing paralysis.
Rhabdovirus	Rabies is a fatal disease characterized by headache, fever, seizures, and spasm of the throat muscles while swallowing (hydrophobia). It is spread by the saliva of infected animals such as dogs and other wild animals (e.g., bats, raccoons).
Rhinoviruses	Rhinoviruses are responsible for the common cold (coryza).
Rubella virus	Causes German measles. The virus causes severe teratogenic birth defects that occur during the first trimester, such as blindness, deafness, brain damage, and heart defects.

Table 5-2 Disorders Caused by Pathogens—cont'd

PATHOGEN	DISORDER
Fungi	
Tinea	Tinea causes ringworm, a highly contagious fungal infection of the skin. One form of ringworm (tinea pedis) is found on the foot and is called <i>athlete's foot</i> . Other forms of ringworm are found on the scalp (tinea capitis) and on the bearded areas of the face and neck (tinea barbae). (Ringworm is not caused by a worm, nor is the lesion always ring-shaped.)
Protozoa	
<i>Entamoeba histolytica</i>	<i>E. histolytica</i> causes amebic dysentery.
<i>Giardia lamblia</i>	Giardiasis is characterized by gastrointestinal discomfort and diarrhea.
<i>Trichomonas vaginalis</i>	Trichomoniasis is a sexually transmitted disease.
Worms	
Ascaris	These are long worms that live in the small intestine.
Hookworm (<i>Necator</i>)	Larval worms burrow their way through the skin of a bare foot, migrate to the intestine, and hook on to the intestinal wall. The worms feed on the blood of the host, causing anemia, fatigue, and wasting.
Pinworm (<i>Enterobius</i>)	Pinworm is the most common worm infestation in the United States.
Tapeworms (<i>Taenia</i> , others)	Tapeworms are acquired by eating poorly cooked contaminated food such as beef, fish, and pork.

Get Ready for Exams!

Summary Outline

The human body is often invaded by disease-producing organisms; these pathogens disrupt normal structure and function and are a common cause of disability and death.

I. Disease and Pathogens

- Disease is a failure of the body to function normally.
- Infections are diseases caused by pathogens.

II. Types of Pathogens

- Microorganisms
 - Bacteria (cocci, bacilli, curved rods, chlamydia, rickettsia)
 - Viruses
 - Fungi
 - Protozoa (amebas, ciliates, flagellates, sporozoa)
- Other larger pathogens
 - Worms
 - Arthropods

III. Laboratory Identification

- Staining (Gram stain, acid-fast stain)
- Culture

IV. Spread of Infection

- Portals of entry (most pathogens enter the body through the respiratory tract and the gastrointestinal tract).
- Portals of exit (the most common portals of exit are the respiratory and gastrointestinal tracts).
- Modes of transmission
 - Person-to-person
 - Environment-to-person
 - "Tiny animals"-to-person

V. Five Germ-Laden Stories

- "Wash Those Mitts!"
- "Flora and Her Vaginal Itch"
- "Rick, Nick, and the Sick Tick"
- "Why Typhoid Mary Needed to Lose Her Gallbladder"
- "Pox News Alert!"

Review Your Knowledge

Matching: Microorganisms and Other Pathogens

Directions: Match the following words with their descriptions below. Some words are used more than once.

- | | |
|---------------|--|
| a. virus | 1. ___ Coccus, bacillus, curved rods |
| b. bacteria | 2. ___ RNA or DNA surrounded by a protein shell; parasitic |
| c. arthropods | 3. ___ Yeasts and molds |
| d. worms | 4. ___ Ascarides, trichinae, flukes |
| e. fungi | 5. ___ Helminths |
| f. protozoa | 6. ___ Ectoparasites |
| | 7. ___ Mycotic infections |
| | 8. ___ Chlamydia and rickettsia |
| | 9. ___ Animals with jointed legs |
| | 10. ___ Arranged in pairs, chains, and bunches of grapes |
| | 11. ___ Amebas, ciliates, flagellates, and sporozoa |

Multiple Choice

1. A vaginal yeast infection (*Candida albicans*) is most apt to develop
 - a. as a consequence to antibiotic therapy.
 - b. in response to eating contaminated food.
 - c. as an allergic response to penicillin.
 - d. in response to being bitten by a "sick tick."
2. The plasmodium
 - a. is pathogenic to mosquitoes.
 - b. causes malaria.
 - c. is an arthropod.
 - d. is a biological vector.
3. Cocci, bacilli, and curved rods
 - a. are eradicated by anthelmintics.
 - b. cause mycotic infections.
 - c. are types of bacteria.
 - d. always act as pathogens.
4. Which of the following is most descriptive of *Staphylococcus*?
 - a. Viral
 - b. Parasitic
 - c. Gram-positive
 - d. Chainlike arrangement
5. Spores
 - a. allow the bacterium to stain blue (gram-positive).
 - b. only develop in parasites.
 - c. are characteristic of arthropods.
 - d. make a bacterium heat-resistant and hard to kill.

Go Figure

1. According to Figures 5-1 and 5-2
 - a. Cocci are classified as viruses.
 - b. Strep and staph are classified as bacilli.
 - c. Worms can be pathogenic.
 - d. A virus is classified as an arthropod vector.
2. According to Figures 5-1 and 5-2, and Table 5-1
 - a. The normal flora in the large intestine differs from the normal flora in the nose.
 - b. A nosocomial infection is hospital-acquired.
 - c. Fungi can be pathogenic.
 - d. All of the above are true.