Ready Reference **for Microbes**

4th Edition

APIC®
Association for Professionals in Infection Control and Epidemiology

Ready Reference for Microbes

4th Edition

About APIC

APIC's mission is to create a safer world through prevention of infection. The association's more than 15,000 members direct infection prevention programs that save lives and improve the bottom line for hospitals and other healthcare facilities. APIC advances its mission through patient safety, implementation science, competencies and certification, advocacy, and data standardization.

Ready Reference for Microbes

© 2018, Association for Professionals in Infection Control and Epidemiology, Inc. (APIC)

All rights reserved. Use of this APIC publication does not grant any right of ownership or license to any user.

Printed in the United States of America
First printing, March 2018
ISBN: 978-1-933013-72-5

All inquiries about this publication or other APIC products and services may be addressed to:

APIC
1400 Crystal Drive, Suite 900
Arlington, VA 22202
Telephone: 202-789-1890
Fax: 202-789-1899
Email: products@apic.org
Web: www.apic.org

The Association for Professionals in Infection Control and Epidemiology, its affiliates, directors, officers, and/or agents (collectively, "APIC") provides this book solely for the purpose of providing information to APIC members and the general public. The material presented in this book has been prepared in good faith with the goal of providing accurate and authoritative information regarding the subject matter covered. However, APIC makes no representation or warranty of any kind regarding any information, apparatus, product, or process discussed in this book and any linked or referenced materials contained therein, and APIC assumes no liability therefore.

Disclaimer

WITHOUT LIMITING THE GENERALITY OF THE FOREGOING, THE INFORMATION AND MATERIALS PROVIDED IN THIS BOOK ARE PROVIDED ON AN "AS-IS" BASIS AND MAY INCLUDE ERRORS, OMISSIONS, OR OTHER INACCURACIES. THE USER ASSUMES THE SOLE RISK OF MAKING USE OF AND/OR RELYING ON THE INFORMATION AND MATERIALS PROVIDED IN THIS BOOK. APIC MAKES NO REPRESENTATIONS OR WARRANTIES ABOUT THE SUITABILITY, COMPLETENESS, TIMELINESS, RELIABILITY, LEGALITY, UTILITY, OR ACCURACY OF THE INFORMATION AND MATERIALS PROVIDED IN THIS BOOK OR ANY PRODUCTS, SERVICES, AND TECHNIQUES DESCRIBED IN THIS BOOK. ALL SUCH INFORMATION AND MATERIALS ARE PROVIDED WITHOUT WARRANTY OF ANY KIND, INCLUDING, WITHOUT LIMITATION, ALL IMPLIED WARRANTIES AND CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE, AND NON-INFRINGEMENT.

IN NO EVENT SHALL APIC BE LIABLE FOR ANY INDIRECT, PUNITIVE, INCIDENTAL, SPECIAL, OR CONSEQUENTIAL DAMAGES ARISING OUT OF OR IN ANY WAY CONNECTED WITH THE USE OF THIS BOOK OR FOR THE USE OF ANY PRODUCTS, SERVICES, OR TECHNIQUES DESCRIBED IN THIS BOOK, WHETHER BASED IN CONTRACT, TORT, STRICT LIABILITY, OR OTHERWISE.

Acknowledgments

Development of this book required input and expertise from authors with expertise in microbiology. The Association for Professionals in Infection Control and Epidemiology acknowledges the valuable contributions from the following individuals.

AUTHORS

4TH EDITION

Catherine Alesich Chachere, CLS(ASCP)CM, RN, CIC
Infection Prevention Coordinator
Woman's Hospital
Baton Rouge, LA

Angela S. Hernandez, MPH, MT(ASCP)
Infection Preventionist
Presbyterian Healthcare Services
Albuquerque, NM

3RD EDITION

Kathy Brooks, RN, PhD, CPHQ
Chief, Quality Management (retired)
Overton Brooks VA Medical Center
Shreveport, LA

REVIEWERS

Carolyn Fiutem, MSOL, MT(ASCP), CIC, FAPIC
Infection Prevention Officer
TriHealth
Cincinnati, OH

Lela Luper, BS, RN, CIC, FAPIC
Infection Preventionist
Chickasaw Nation Department of Health
Ada, OK

Jianping Xu, PhD
Professor and Associate Chair of Graduate Studies
Department of Biology, McMaster University
Hamilton, ON, Canada

Elizabeth Monsees, MSN, MBA, RN, CIC, FAPIC, and **Steven J. Schweon, MPH, MSN, RN, CIC, HEM, FSHEA, FAPIC,** reviewed Appendix G: Quick Facts: Antimicrobial Stewardship.

PROJECT MANAGEMENT

Elizabeth Nishiura
Managing Editor
Chicago, IL

Susan F. Sandler
Director, Practice Resources
Association for Professionals in Infection Control and Epidemiology

Elizabeth Garman
Vice President, Communications and Practice Resources
Association for Professionals in Infection Control and Epidemiology

PRODUCTION

Sarah Vickers
Art Director (cover art)
Association for Professionals in Infection Control and Epidemiology

Project Design Company
Text Design and Layout
Washington, DC

ModernLitho
Printing
Jefferson City, MO

Declarations of Conflicts of Interest

The authors have no potential conflicts of interest to declare.

Contents

Preface

Healthcare-associated infections (HAIs) are becoming more deadly and difficult to treat as a result of multidrug-resistant organisms. According to the World Health Organization, "Of every 100 hospitalized patients at any given time, 7 in developed and 10 in developing countries will acquire at least one HAI."

As infection preventionists (IPs), we must remain up to date on changes involving evidence-based practice, evolving microorganisms, updates to guidelines, and the latest advances in the care and maintenance of medical devices. Significant strides have been made to reduce HAIs worldwide. Prevention efforts are key to further reducing HAIs and include their recognition and isolation, appropriate use of personal protective equipment, diligent hand hygiene, and thorough environmental cleaning.

This 4th edition of *Ready Reference for Microbes* has been updated to describe current and known emerging pathogens. As a quick reference, it provides straightforward information to IPs and healthcare professionals on medically common and clinically significant microorganisms found in humans: bacteria, common commensals, viruses, fungi, parasites, and organisms used as bioterrorism agents. It also includes a chapter on antimicrobial therapy, and seven "quick facts" appendixes on essential topics: common pathogens by body site, methicillin-resistant *Staphylococcus aureus, Clostridium difficile,* seasonal influenza, isolation precautions, antibiograms, and antimicrobial stewardship. References and resources are provided at the end of each chapter and appendix to offer additional information on the discussed topics and expand the reader's knowledge.

Catherine Alesich Chachere and Angela S. Hernandez
March 2018

How to Use This Reference

Each chapter of the *Ready Reference for Microbes,* 4th edition begins with an introduction and general information. The tables in the chapters provide information on specific microbes (or, in the case of Chapter 7, specific antimicrobials) with subheadings and general and specific notes provided where appropriate.

Chapter 1: Bacteria are listed in alphabetical order by genus.
- Genus > Description > Name(s) > Infections > Mode(s) of Transmission

Chapter 2: Common Commensals are listed by body site.
- Body Site > Normal Flora > Special Considerations for Specimen Collection

Chapter 3: Fungi are listed in alphabetical order by genus.
- Genus > Description > Name(s) > Infections > Mode(s) of Transmission

Chapter 4: Parasites are listed in alphabetical order by genus.
- Genus > Description > Name(s) > Infections > Mode(s) of Transmission

Chapter 5: Viruses are listed in alphabetical order by common name.
- Name(s) > Description > Family/Genus > Infections and Syndromes > Transmission and Incubation

Chapter 6: Bioterrorism agents are categorized by type of microbe: bacteria, other (nonmicrobe), parasite, and virus. The virus category includes subcategories for viral encephalitis viruses and viral hemorrhagic viruses (arenaviruses, filoviruses, and tick-borne hemorrhagic fever viruses). Within each category and subcategory, microbes are listed alphabetically.
- Microbe > Disease Name > CDC Category > Issues Related to Nosocomial Transmission > Treatment > Comments

Chapter 7: Antimicrobial therapies are listed by antimicrobial class.
- Class > Subclass > Representative Antimicrobial(s) > Antimicrobial Activity

While many microbes are discussed in the *APIC Text Online,* the table rows highlighted in **blue** in this book indicate topics where substantive additional content can be cross-referenced in that comprehensive resource.

The classification of microbes by genus, species, and common name continues to evolve. In the tables, the abbreviations "fka" (formerly known as) and "aka" (also known as) are used when additional information about microbe names is provided.

Abbreviations are spelled out on first use in a chapter, table, or appendix, and a comprehensive alphabetical key is found in "Abbreviations Used in This Reference." Finally, the index offers a quick way to review what is covered in each chapter and locate the page numbers for specific topics.

CHAPTER 1

Bacteria

Bacterial agents are a part of our everyday life. Some bacteria are helpful, and some can be harmful. Numerous strains and species of bacteria normally live benignly in and on the human body. Of the thousands of identified bacterial species, only a fraction of them are known to cause human disease.

GROWTH

Bacteria are free-living, single-cell organisms. Bacteria multiply through chromosomal replication and cellular division. A group of bacteria is referred to as a **colony**.

The bacterial cell contains several components: the deoxyribonucleic acid (DNA) molecule, ribosomes, the membrane, and the cell wall. Some bacteria may have additional components such as an outer membrane, capsule, flagella, pili, or endospores.

TAXONOMY

Bacteria are classified by phenotypes and genotypes. The primary classification is DNA sequence–based. **Phenotypic classification** includes morphological and chemical properties. In clinical microbiology laboratories, the commonly used criteria are the Gram-stain characteristics (Gram-positive versus Gram-negative), the morphological features (cocci versus bacilli [rod]), and oxygen utilization (aerobic versus anaerobic). Other cell and chemical properties that allow appropriate identification in the laboratory are determined through additional tests, such as catalase, coagulase, hemolysis on blood agar, sugar fermentation, gas production, and enzyme production. **Genotypic classification** represents the genetic makeup of the bacteria and includes the identified ribonucleic acid (RNA) and the DNA.

Bacteria are named according to genus and species. The correct format is genus (capitalized, italicized) and species (lowercase, italicized).

Examples:	Genus	species
	Escherichia	*coli*
	Pseudomonas	*aeruginosa*
	Staphylococcus	*aureus*

TOXINS

Bacterial toxins can greatly increase the virulence of pathogens. For example, Panton-Valentine leukocidin (PVL) exotoxin enhances the virulence of community-acquired methicillin-resistant *Staphylococcus aureus* (MRSA). Toxins are classified as follows:

- **Exotoxins** are secreted by bacteria, mainly Gram-positive bacteria. They
  - are often heat inactivated;
  - are neutralized by specific antibodies; and
  - may possess enzymatic activity.
- **Endotoxins** are surface components (complexes of bacterial proteins, lipids, and polysaccharides remaining firmly in the bacteria) of Gram-negative bacteria. They
  - resist inactivation by heat;
  - are partially neutralized by antibodies; and
  - interact with host systems, resulting in cascades of responses that induce fever, swelling, vascular leaking, pain, and shock.

Examples of Significant Bacterial Toxins

BACTERIA	TOXIN(S)	EFFECTS
Clostridium botulinum	botulinum toxin	Interferes with neuromuscular transmission, causing dystonia (uncontrollable muscle contractions).
Clostridium difficile	toxin A: enterotoxin toxin B: cytotoxin	Mucosal inflammation, cell/tissue damage, and pseudomembrane formation, which can lead to ulcers in the mucosa of the colon.
Clostridium tetani	tetanospasmin	Interferes with nerve conduction at the neuromuscular junction, causing continuous muscle contraction/spams.
Corynebacterium diphtheriae	diphtheria toxin	Toxic to myocardial cells, the respiratory system, nerves, and kidneys.
Escherichia coli	Shiga toxin	Multifactorial involvement between the organism and the host. Colonizes the gut, resulting in diarrhea and intestinal lesions. Reaction of tissues with toxins results in an inflammatory response. Toxin can damage kidneys.

BACTERIA	TOXIN(S)	EFFECTS
Methicillin-resistant *Staphylococcus aureus* (MRSA)	Panton-Valentine leukocidin (PVL) toxin	Kills protective neutrophils and digests subcutaneous proteins, which encourages the rapid spread of infection; high levels of the toxin cause cytolysis and inflammation resulting in tissue necrosis. PVL plays a role in necrotizing pneumonia.
Staphylococcus aureus	enterotoxins	Stimulate gastrointestinal (GI) peristalsis; activate complement; induce shock (e.g., toxic shock syndrome).
Vibrio cholera	cholera toxin	Increases fluids secretion of the GI tract; involves profuse diarrhea and fluid and electrolyte loss.

TABLE

The following table helps the user understand specific types of bacteria. Note that the table

- lists the bacteria alphabetically by genus;
- provides a description of each type of bacteria, including the reservoirs or where the bacteria are normally found;
- lists the bacteria names as well as "formerly known as" (fka) names or "also known as" (aka) names, if applicable;
- describes associated infections and the mode(s) of transmission; and
- indicates bioterrorism agents (see Chapter 6 for additional information on bioterrorism agents).

Key terms used in the table include the following:

- **Aerobe/aerobic**: requires oxygen to grow and survive
- **Anaerobe/anaerobic**: does not require oxygen to grow and is harmed by its presence
- **Facultative anaerobe**: can grow with or without oxygen
- **Aerotolerant**: does not use oxygen for growth but tolerates its presence

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Achromobacter	Gram-negative rod; environmental flora; multidrug-resistant organisms.	*A. denitrificans* *A. xylosoxidans*	Infected bite wounds; oral, head, neck, upper respiratory tract, and soft tissue infections; bacteremia; meningitis; peritonitis; pneumonia; urinary tract infection (UTI).	Bites; water; soil. Healthcare-associated infection (HAI) from contaminated disinfectants.
Acinetobacter	Aerobic Gram-negative rod. Widely distributed in nature; colonization of deployed military to Iraq. Cause of infections following natural disasters; most frequently observed during warm seasons.	*A. baumannii* *A. calcoaceticus* *A. haemolyticus* *A. johnsonii* *A. lwoffii*	Ventilator-associated pneumonia; bacteremia. Respiratory infections; UTI; wound infection (including at catheter sites); septicemia.	Direct, indirect, and environmental contact; endogenous. HAI from medical instruments and equipment.
Actinomadura	Aerobic Gram-positive rod; aerobic actinomycete; environmental (soil) flora.	*A. madurae* *A. pelletieri*	Localized infections result in mycetoma: a chronic purulogranulomatous disease that begins as painless nodule at site of injury, produces sinus tracts, and may develop into destructive osteomyelitis; occasionally, pulmonary or disseminated disease in immunocompromised individuals.	Puncture wound from a thorn or splinter; other wounds.
Actinomyces	Anaerobic Gram-positive rod; filamentous rods; anaerobic actinomycete; normal upper respiratory, vaginal, and GI flora.	*A. israelii*	Actinomycosis: a chronic suppurative granulomatous lesion, which can form abscesses and cause sinus drainage; involved in pelvic inflammatory disease (PID) associated with intrauterine devices; periodontal disease; soft tissue infections; polymicrobic infections.	Endogenous.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Aerococcus	Gram-positive coccoid; environmental flora; occasionally found on skin.	*A. urinae* *A. viridans*	Peritonitis; lymphadenitis; endocarditis; bacteremia; UTI.	Environmental contact.
Aeromonas	Gram-negative rod; found in fresh, polluted, chlorinated, and brackish water, as well as soil and food.	*A. caviae* *A. hydrophila* *A. sobria*	Bacteremia; wound infections in patients with indwelling catheters and drains; endocarditis; meningitis; pneumonia; osteomyelitis; peritonitis; conjunctivitis; thrombophlebitis; cholecystitis; gastroenteritis; keratitis.	Contaminated foods (meats, produce, dairy) and potable water sources (fresh, polluted, marine); breaks in the skin.
Afipia	Gram-negative rod; found in environment and normal oral flora of cats.	*A. felis*	Wound contamination; cat scratch disease.	Cat bites; environmental contact.
Aggregatibacter	Gram-negative coccobacilli or small rod; oral cavity flora. Member of the HACEK group (see HACEK group).	*A. actinomycetemcomitans* (fka *Actinobacillus actinomycetemcomitans*)	Polymicrobic infections associated with endocarditis, periodontitis, and other focal infections, including animal bites.	Endogenous.
	Normal upper respiratory tract flora. Member of the HACEK group (see HACEK group).	*A. aphrophilus* (fka *Haemophilus aphrophilus*)	Endocarditis; brain abscess; pneumonia; meningitis; bacteremia.	Endogenous.
Agrobacterium	See *Rhizobium*.			
Alcaligenes	Gram-negative rod; environmental (soil, water) flora.	*A. faecalis*	Healthcare-associated septicemia; bacteremia; ocular and ear infections; pancreatic abscesses; pneumonia; UTI.	Environmental contact. HAI from contaminated solutions and instruments.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Alloiococcus	Aerobic Gram-positive cocci; widespread.	*A. otitis*	Middle ear infections; opportunistic pathogen in immunocompromised hosts.	Endogenous.
Anaplasma	Zoonotic, pleomorphic Gram-negative obligate intracellular organism; vector borne.	*A. phagocytophilum*	Human granulocytic anaplasmosis.	Tick bite.
Arcanobacterium	Gram-positive rod; normal skin and pharynx flora.	*A. haemolyticum* (fka *Corynebacterium haemolyticum*)	Pharyngitis; peritonsillar abscess; wound infections; sepsis; osteomyelitis.	Endogenous.
Arcobacter	Zoonotic, Gram-negative curved rod; soil and plants.	*A. butzleri* *A. cryaerophilus* *A. nitrofigilis* *A. skirrowii*	Bacteremia; underreported factor in gastroenteritis and watery-diarrheal illness.	Environmental contact; ingestion.
Arthrobacter	Gram-positive rod; found in soil.	*A. cumminsii*	Low pathogenicity; opportunistic infections in immunocompromised patients.	Endogenous; environmental contact (soil).
Bacillus	Zoonotic, aerobic Gram-positive spore-forming rod; environmental flora; found in sheep, goats, and cattle.	*B. anthracis*	Characteristic blackened eschar; skin infection (malignant pustule); septicemia; pneumonia; "woolsorter's disease"; enteritis; meningitis. **Category A bioterrorism agent**.	Enters through injured skin or mucous membranes; ingestion; inhalation. Vaccine available for high-risk individuals.
	Soil flora.	*B. cereus*	Food poisoning (toxin). Opportunistic infections secondary to immunosuppression: pneumonia; empyema; septicemia; meningitis; endocarditis; osteomyelitis; wound infections; fulminant liver failure; endophthalmitis; neoplastic disease.	Environmental contact; ingestion of contaminated food.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
	Soil flora.	*B. subtilis*	Opportunistic infections; food poisoning; pneumonia; septicemia; necrotic tumors; endocarditis; meningitis; surgical wound and shunt infections.	Environmental contact.
Bacteroides	Enteric, anaerobic Gram-negative rod; normal flora of the GI tract.	*B. fragilis* group *B. ovatus* *B. thetaiotaomicron*	Polymicrobial infections; intra-abdominal closed abscesses from diverticulitis, ruptured appendix, or surgical procedures; bacteremia; lower respiratory tract infections; endocarditis; skin infections; gangrene; necrotizing fasciitis.	Endogenous; animal bites.
Bartonella	Gram-negative rod; facultative intracellular parasite; vector borne (sand fly); human reservoir.	*B. bacilliformis*	Carrión's disease: acute phase is Oroya fever, a syndrome characterized by fever, chills, headache, mental status changes, and rapid and profound anemia; later phase is verruga peruana, a syndrome characterized by blood-filled nodular skin lesions.	Sand fly bites.
	Domestic cats.	*B. henselae*	Cat scratch disease; endocarditis; bacillary angiomatosis.	Cat bite or scratch; cat fleas; direct contact with cats; poor sanitation and personal hygiene.
	Small rodents; human reservoir.	*B. quintana*	Trench fever; endocarditis; opportunistic infections in immunocompromised individuals.	Human body lice; fleas.
Bifidobacterium	Anaerobic Gram-positive rod.	*B. bifidum* *B. dentium*	Polymicrobial infections of perioperative wounds; dental caries; endodontic infections.	Endogenous.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Bordetella	Small aerobic Gram-negative coccobacilli; normal respiratory flora of mammals (e.g., dogs, cats).	*B. bronchiseptica*	Pneumonia; bacteremia; meningitis; endocarditis; UTI; pertussis-like disease.	Droplet; contact.
	Found in humans and lambs.	*B. parapertussis*	Pertussis-like disease.	Droplet.
	Colonizes cilia of mammalian respiratory epithelial; found in humans in disease state; can be carried by immune individuals.	*B. pertussis*	Pertussis (whooping cough; an uncontrollable, violent cough); pneumonia.	Droplet. Immunization available as diphtheria, tetanus, and pertussis vaccine (DTaP) for children and as tetanus, diphtheria, and pertussis (Tdap) booster. Unvaccinated children and adolescents and adults with waned immunity are at increased risk for infection.
Borrelia	Spirochete; arthropod (tick and body louse). Reservoir: rodents.	*B. burgdorferi*	Lyme disease (aka Lyme borreliosis), a multisystem disease including neurologic and cardiac abnormalities, and arthritis. Tick-borne relapsing fever.	Ticks. Vaccine available in endemic areas; serology testing ideal for identification.
		B. recurrentis	Louse-borne relapsing fever.	Ticks; human body lice. Serology testing ideal for identification.
Brucella	Zoonotic, aerobic Gram-negative coccobacilli; found in soil, cattle and goats *(B. abortus),* dogs *(B. canis),* sheep *(B. melitensis),* pigs *(B. suis).*	*B. abortus* *B. canis* *B. melitensis* *B. suis*	Recurrent fever; arthritis; osteomyelitis; epididymitis; endocarditis; granulomatous disease; nodular lung and ocular lesions. **Category B bioterrorism agent.**	Contact and droplet; ingestion of contaminated meat or dairy (unpasteurized) products; inhalation; breaks in skin and mucous membranes.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Burkholderia	Aerobic Gram-negative rod; environment (water, soil, and plants [fruits/vegetables]); colonizes respiratory tract of cystic fibrosis patients.	*B. cepacia* (fka *Pseudomonas cepacia*)	Bacteremia; peritonitis; septic arthritis; respiratory infection; UTI.	Contact. HAI may be caused by contaminated medical equipment and solutions.
	Zoonotic; primarily a disease of horses, mules, and donkeys.	*B. mallei*	Glanders; pneumonia, pulmonary abscesses, and septicemia; localized skin infection with ulceration. **Category B bioterrorism agent**.	Contact with tissues or body fluids of infected animals. Seen primarily in veterinarians, animal caretakers, meat-processing workers, and laboratory personnel.
	Tropical/subtropical environments (soil, streams, rice paddies).	*B. pseudomallei* (fka *Pseudomonas pseudomallei*)	Melioidosis; asymptomatic to fulminant sepsis; abscesses. **Category B bioterrorism agent**.	Inhalation; contact; travel-associated illness.
Campylobacter	Zoonotic; enteric, Gram-negative curved rod.	*C. coli* *C. fetus* subspecies *fetus* *C. jejuni* other *Campylobacter* species	Gastroenteritis; gastritis; sepsis, septic arthritis; endocarditis; meningitis; abscesses; peritonitis; proctitis; pancreatitis; periodontal disease. Seasonal infections (late summer/early fall).	Contact with or ingestion of contaminated soil, water, or food (poultry, beef, pork, and lamb), unpasteurized and poorly pasteurized milk.
Candidatus (new bacterium)	Zoonotic; obligate intracellular parasite. Reservoir: field mice and voles.	*Ca. Neoehrlichia mikurensis*	*Ehrlichia*-like encephalitis: fever, headache, myalgia, vomiting, and stiff neck.	Tick *(Ixodes ricinus)* bites.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Capnocytophaga	Facultative anaerobic Gram-negative rod; normal oropharynx flora of humans and animals.	*C. gingivalis* *C. ochracea* *C. sputigena*	Septicemia; endocarditis; meningitis; pneumonia; periodontal disease.	Endogenous; bite wounds (from humans, dogs).
Cardiobacterium	Facultative anaerobic pleomorphic Gram-negative rod; normal upper respiratory tract flora. *C. hominis* is a member of the HACEK group (see HACEK group).	*C. hominis*	Endocarditis.	Endogenous.
Chlamydia	Intracellular parasite, Gram-negative cocci; found in humans.	*C. pneumoniae* (fka *Chlamydophila pneumoniae*)	Pneumonia; bronchitis; pharyngitis, sinusitis, and flu-like illness; inflammatory response to organism resulting in tissue damage.	Droplet and contact; community-acquired pneumonia.
	Reservoir: birds.	*C. psittaci* (fka *Chlamydophila psittaci*)	Psittacosis; severe pneumonia and systemic infections; endocarditis, hepatitis, and neurologic complications. **Category B bioterrorism agent**.	Inhalation of dried bird secretions and feces.
	Aerobic intracellular parasite, difficult to visualize on gram stain, similar to Gram-negative coccobacilli. Reservoir: humans.	*C. trachomatis*	Endemic trachoma, urethritis, cervicitis, proctitis, epididymitis, endometriosis, salpingitis, perihepatitis, PID, lymphogranuloma venereum, and infertility. Ocular trachoma and conjunctivitis.	Contact; sexual transmission; self-inoculation from hand to eye.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Chromobacterium	Facultative anaerobe Gram-negative coccobacillus; endotoxin; soil and water of tropical/ subtropical regions.	*C. violaceum*	Cellulitis; abscesses (multiorgan involvement); lymphadenitis; septicemia; septic shock.	Contact.
Chryseobacterium	Gram-negative rod; environment (soil and water); has been found in hospital water sources (sinks, faucets, hemodialysis systems)	*C. indologenes* (fka *Flavobacterium indologenes*)	Infraorbital drain, aortic valve infections; sepsis; neonatal meningitis; pneumonia	Contact; indwelling devices; contaminated dialysis fluid.
Citrobacter	Enteric, Gram-negative rod; normal GI tract flora.	*C. amalonaticus* *C. farmeri* *C. freundii* *C. koseri* (fka *C. diversus*)	Respiratory tract infections; UTI; sepsis; abscesses and infections of normally sterile sites.	Endogenous; contact; HAI.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Clostridium	Anaerobic spore-containing Gram-positive rod; environment (soil); botulinum neurotoxin.	*C. botulinum*	Foodborne botulism: ingestion and absorption of preformed toxin. Infant botulism: toxin formation after intestinal colonization. Wound botulism: toxin production–caused weakness, blurred vision, and drooping eyelids; difficulty speaking and swallowing; cranial nerve palsy, and, in extreme cases, respiratory failure), mostly associated with substance abuse (injection of black-tar heroin). Intestinal botulism (colonization following surgery and following antibiotic use). **Category A bioterrorism agent**.	Ingestion; contact.
	Reservoir: human GI tract and hospital environment.	*C. difficile*	Antibiotic-associated diarrheal disease; colon inflammation; pseudo-membranous colitis; toxic megacolon and large bowel rupture. Toxins: *C. difficile* toxin A, *C. difficile* toxin B, enterotoxin, and cytotoxin.	Endogenous; contact; fecal-oral. Healthcare- and community-associated diarrheal disease.
	Reservoir: environment (soil) and GI tract.	*C. perfringens*	Gas gangrene: (alpha toxin) wounds, myonecrosis, necrotizing fasciitis, and gynecologic infections. Food poisoning: toxin production following ingestion with contaminated food (self-limiting). Enteritis necroticans: (beta toxin) necrotizing enteritis (life-threating). Toxins: botulinum; tetanus neurotoxins; Epsilon toxin is most toxic and can cause fatal enteric disease. **Epsilon toxin is a Category B bioterrorism agent**.	Ingestion; contact.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
	Environment (surfaces and equipment).	*C. sordellii*	Gas gangrene (in uterine tissue following spontaneous and induced abortions and vaginal and cesarean section births); toxic shock syndrome (TSS); myonecrosis; peritonitis; endocarditis; pneumonia.	Contact; endogenous and exogenous.
	Reservoir: environment (soil).	*C. tetani*	Tetanus (lockjaw), including generalized muscle spasms and, in untreated and extreme cases, respiratory failure. Potential exposure toxin: tetanospasmin/tetanus neurotoxin.	Contact. Combination vaccines for tetanus, diphtheria, and pertussis are available. Tetanus immune globulin (TIG) is passive immunization treatment following tetanus.
Coagulase-negative *Staphylococcus*	Gram-positive cocci; normal skin and mucosal flora; approximately 40 species and subspecies.	See *S. epidermidis; S. haemolyticus; S. lugdunensis; S. saprophyticus*		
Corynebacterium	Gram-positive rod; coryneform bacteria; environment (soil, water, plants, food); normal skin and mucosal flora. *C. diphtheriae* (diphtheria toxin) inhabits nasopharynx only in carrier state.	*C. diphtheriae* *C. minutissimum* *C. pseudodiphtheriticum* *C. striatum* *C. urealyticum* *C. xerosis*	Diphtheria (exudative membrane); pharyngitis; cutaneous wounds (nonhealing ulcers and membrane formation); conjunctivitis; rashes; skin infections; sepsis; endocarditis; pneumonia; UTI.	Contact; droplet-contaminated objects; endogenous.
Coxiella	Zoonotic; obligate intracellular Gram-negative coccobacilli. Reservoir: urine and feces of cattle, sheep, and goats.	*C. burnetii*	Q fever, an acute systemic infection; febrile illness; atypical pneumonia; endocarditis; granulomatous hepatitis; encephalitis; meningoencephalitis; osteomyelitis. **Category B bioterrorism agent**.	Inhalation of infectious aerosols. Inhalation of one organism will yield disease in 50% of the population exposed.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Edwardsiella	Enteric, facultative anaerobic Gram-negative rod; found in cold-blooded animals (fish and reptiles) and their environment.	*E. tarda*	Opportunistic bacteremia and wound infections (myonecrosis); salmonella-like enteritis is seen more often in young children and older adults, and mainly in tropical and subtropical climates.	Contact; exogenous; rare endogenous fecal-oral spread.
Ehrlichia	Zoonotic; Gram-negative obligate intracellular bacteria. Reservoir: white-tailed deer and domestic dogs.	*E. chaffeensis* *E. ewingii*	Spectrum of disease ranges from mild illness to severe or life-threatening disease. Nonspecific symptoms: fever, headache, anorexia, nausea, myalgia, and vomiting; human monocytotropic ehrlichiosis; most cases identified in south central and southeastern United States.	*Amblyomma americanum* (aka Lone Star tick) bites.
Eikenella	Facultative anaerobic Gram-negative rod; oral and GI tract normal flora. *E. corrodens* is a member of the HACEK group (see HACEK group).	*E. corrodens*	Periodontitis; pleuropulmonary surgical site infections; meningitis; endocarditis; joint wound infections and septicemia; osteomyelitis. Cellulitis in individuals who abuse intravenous (IV) drugs, from direct inoculation after oral contamination of needle paraphernalia (licking needle clean instead of sterilizing it).	Contact; endogenous; trauma, especially after fights or bites; syringes.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Elizabethkingia	Gram-negative rod; environment (soil, water, plants, food); healthcare-associated water sources (including tap water, condensation, saline solutions, and other pharmaceutical solutions).	*E. meningosepticum* (fka *Flavobacterium meningosepticum*)	Bacteremia; meningitis (healthcare-associated mini-epidemics); endocarditis; UTI; sinusitis and pneumonia; airway infections in patients with cystic fibrosis.	Contact; HAI from medical solutions and devices; respiratory colonization and infection following aerosol treatment.
Enterobacter	Enteric, Gram-negative, facultative anaerobic rod; widespread throughout the environment (water, plants, food).	*E. aerogenes* *E. asburiae* *E. cloacae* *E. gergoviae* *E. sakazakii*	Opportunistic infections in patients exposed frequently to antibiotics, invasive procedures, and indwelling catheters (e.g., patients with diabetes or neutropenia); respiratory tract infections; UTI; wound infections; sepsis.	Contact; endogenous. HAI from contaminated medical devices. Ingestion of contaminated food and water.
Enterococcus	Enteric, Gram-positive cocci, pairs or chains; facultative anaerobic; normal GI and female genital tract flora; environment (soil, food, water, plants); opportunistic agents.	*E. casseliflavus* *E. faecalis* *E. faecium* *E. gallinarum* *E. raffinosus* (fka Lancefield group D *Streptococcus*)	UTI; sepsis; surgical site and wound infections (e.g., intra-abdominal/pelvic wounds); endocarditis. *E. faecalis* and *E. faecium* have acquired vancomycin resistance. *E. casseliflavus, E. gallinarum,* and *E. raffinosus* have intrinsic (naturally occurring) vancomycin resistance.	Contact; endogenous; HAI from medical devices.
Erysipelothrix	Zoonotic; facultative anaerobic Gram-positive rod; environment (water, soil). Reservoir: mammals, birds, and fish.	*E. rhusiopathiae*	Erysipeloid: localized skin infection on hands and fingers; regional lymphangitis; endocarditis; sepsis.	Contact; handling infected animals or animal products. Occupational disease in veterinarians, butchers, and fish handlers.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Escherichia	Enteric, Gram-negative, facultative anaerobic rod; environment (soil, plants, food). Reservoir: GI and female genitourinary (GU) tracts; opportunistic pathogen.	*E. coli* *E. coli* 0157:H7 *E. coli* 0157:NM	UTI; septicemia; neonatal meningitis; HAI. Five major GI infections: (1) enteropathogenic—infantile diarrhea and chronic diarrhea; (2) enterotoxigenic—contaminated food and water; travelers' and childhood diarrhea; (3) enteroinvasive—dysentery; commonly affects children of developing countries; (4) enterohemorrhagic (serotype 0157:H7)—hemorrhagic diarrhea and colitis; hemolytic uremic syndrome (HUS); shigatoxin (verocytotoxin); (5) enteroaggregative—chronic watery diarrhea; persistent diarrhea in patients with human immunodeficiency virus (HIV). ***E. coli* 0157:H7 is a Category B bioterrorism agent**.	Contact; ingestion; fecal-oral route. *E. coli* 0157:H7: ingestion of contaminated and inadequately cooked beef; raw milk, fruits, and vegetables contaminated with ruminant feces. Neonatal infections occur from maternal genital tract.
Eubacterium	Anaerobic Gram-positive coccobacilli; normal flora of the upper respiratory system, GI tract, and vagina.	*E. brachy* *E. infirmum* *E. minutum* *E. nodatum*	Opportunistic infections and mixed-microbial infections. Intrauterine device–associated infections and PID. Chronic periodontal disease, upper respiratory infections, and necrotizing soft tissue infections.	Contact; endogenous; bites; environmental.
Finegoldia	Gram-positive cocci.	*F. magna* (fka *Peptostreptococcus magna*)	Mixed-microbial infections of wounds, oral cavity, respiratory tract, and female reproductive tract.	Opportunistic; endogenous.
Flavobacterium	See *Chryseobacterium* and *Elizabethkingia*.			

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Francisella	Zoonotic, intracellular aerobic Gram-negative coccobacilli; arthropod vectors: deerflies, ticks, and mosquitoes. Reservoir: wild rodents, rabbits, beavers, and muskrats; environment (water, grasslands, haystacks).	*F. tularensis*	Rabbit fever or tularemia: most common forms are ulceroglandular and glandular; systemic oropharyngeal form has 50% mortality; pneumonic form is the most severe. Following exposure or bite from a bloodsucking arthropod, lesions develop and progress to ulcerative sores, which spread to lymph nodes and bloodstream. **Category A bioterrorism agent**.	Aerosols; contact; inhalation; exogenous; infected wild animals; infected arthropod bite; contaminated water. Note: *F. tularensis* requires special handling in microbiology laboratories if isolated from clinical culture.
Fusobacterium	Anaerobic Gram-negative pleomorphic organism; normal flora of oral cavity, GI tract, upper respiratory tract, and female reproductive tract.	*F. mortiferum* *F. naviforme* *F. necrophorum* *F. nucleatum* *F. periodonticum*	Oral, dental, and bite infections; severe pharyngotonsillitis; peritonsillar abscesses; neck space infections; jugular vein septic thrombophlebitis; intra-abdominal infections; bacteremia; multiple metastatic abscesses (lungs, pleural space, liver, large joints); polymicrobic infections.	Endogenous; persists in mud, water, and decaying animal carcasses.
Gardnerella	Anaerobic Gram-variable rod or coccobacilli. Natural habitat: vagina of reproductive-age women; colonizes distal urethra of males.	*G. vaginalis*	Bacterial vaginosis; bacteremia associated with postpartum endometriosis, chorioamnionitis, septic abortion, and infection after cesarean section.	Endogenous; suspect sexual transmission.
Gemella	Aerobic Gram-positive cocci; normal oral and upper respiratory tract flora.	*G. haemolysans*	Ocular infections; brain abscesses; endocarditis; meningitis; wounds and abscesses; infections following total knee replacement.	Opportunistic; endogenous.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
		G. morbillorum	Brain abscesses; osteomyelitis; septic arthritis; peritonitis; endocarditis; empyema and lung abscess; blood, respiratory, GU, wound, and abscess infections.	Endogenous.
Gordonia	Aerobic Gram-positive rod; aerobic actinomycete.	*G. aichiensis* (fka *Rhodococcus aichiensis*) *G. bronchialis* *G. otitidis* *G. rubropertincta* *G. sputi* *G. terrae*	Cutaneous infection; chronic pulmonary disease; bacteremia; brain abscesses; primarily in immunocompromised patients.	Opportunistic; environmental contact. Catheter- and medical device–associated.
HACEK group	Acronym consisting of the first initial of each genus. Normal flora of the oral cavity.	***H****aemophilus* species ***A****ggregatibacter aphrophilus* ***C****ardiobacterium hominis* ***E****ikenella corrodens* ***K****ingella kingae*	Endocarditis with predilection for attachment to heart valves (usually damaged or prosthetic).	Opportunistic; endogenous.
Haemophilus	Gram-negative coccobacilli; normal flora of upper respiratory tract; colonizer of GI tract.			Contact; droplet; endogenous; sexual contact.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
	Normal upper respiratory tract flora.	*H. aegyptius*	Acute contagious conjunctivitis ("pink eye").	Contact; conjunctiva or upper respiratory tract discharges; contaminated fingers, clothing, other articles (e.g., shared eye makeup applicators, multidose eye medications, inadequately sterilized instruments, such as tonometers).
	Urogenital tract flora (only during infections).	*H. ducreyi* (fka Ducrey's bacillus)	Chancroid (soft chancre): an acute ulcerative disease that involves genitalia; suppurative, enlarged, draining inguinal lymph nodes (buboes) are common.	Sexual transmission.
	Normal upper respiratory tract flora.	*H. influenzae*	Meningitis; orbital cellulitis; conjunctivitis; otitis media; acute maxillary sinusitis; epiglottis; chronic bronchitis; pneumonia; septic arthritis; bacteremia. Usually found in pediatric population.	Contact; inhalation of droplets; endogenous. *H. influenzae* type B (HIB) conjugated vaccine prevents meningitis in children older than 2 months.
	Normal upper respiratory tract flora.	*H. influenzae* biotype III	Brazilian purpuric fever (high mortality in children ages 1 to 4 years); meningitis; bacteremia.	Contact; inhalation of droplets; endogenous.
	Normal upper respiratory tract flora.	*H. parainfluenzae*	Acute otitis media; acute sinusitis; chronic bronchitis and pulmonary disease; endocarditis.	Endogenous; opportunistic.
Hafnia	Enteric, Gram-negative rod; found in the GI tract and the environment: surface water, sewage, food (meat and dairy products).	*H. alvei* (fka *Enterobacter hafniae*)	Opportunistic infections and gastroenteritis; wound and abscess infections.	Environmental contact; endogenous.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Helicobacter	Gram-negative curved rod; toxin; gastric mucosa.	*H. pylori*	Peptic ulcer disease; enterohepatic disease; chronic gastritis; gastric adenocarcinoma and other cancers.	Contact; fecal-oral or oral-oral; improperly cleaned endoscopes.
	Zoonotic and human GI tract.	*H. cinaedi* *H. fennelliae* *H. heilmannii* *H. suis*	Bacteremia; infected aortic aneurism, cellulitis, proctocolitis; gastroenteritis; meningitis; osteomyelitis; suspected agent of septicemia. Infection risk is higher in immunocompromised individuals.	Fecal-oral.
Kingella	Aerobic Gram-negative coccobacillus; normal upper respiratory and GU tract flora. *K. kingae* is a member of the HACEK group (see HACEK group).	*K. kingae* *K. denitrificans* *K. oralis*	Endocarditis; infections of the bone, joints, and tendons; osteomyelitis; occasionally, bacteremia.	Hematogenous; possibly, trauma of the oral-pharyngeal mucosa.
Klebsiella	Enteric, aerobic Gram-negative rod; normal flora of GI and genital tracts.	*K. granulomatis* (fka *Calymmatobacterium granulomatis*) *K. oxytoca* *K. pneumoniae*	Lobar pneumonia, lung abscess, UTI, bacteremia, enteritis, and meningitis (in infants). Wound infections; rhinoscleroma; sexually transmitted granuloma inguinale or donovanosis.	Contact with ulcerative genital lesions; endogenous.
Kluyvera	Gram-negative, facultative anaerobic rod; found in sputum, urine, stool, blood, water, sewage, soil, food, and animals.	*K. ascorbata* (fka Enteric group 8) *K. cryocrescens*	Bacteremia; respiratory and soft tissue infections; pyelonephritis; opportunistic infections.	Contact; endogenous.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Lactobacillus	Anaerobic Gram-positive, microaerophilic facultative coccobacilli rod; normal flora of the mouth, GI tract, and female GU tract.	*L. acidophilus*	Polymicrobic infections. Generally nonpathogenic; rarely associated with pulmonary infections, chorioamnionitis, endocarditis, neonatal meningitis, and bacteremia; endodontic infections; peritonitis; PID.	Contact; endogenous; bite wounds.
Lactococcus	Gram-positive cocci; found in foods and vegetation.	*L. garviae* *L. lactis*	Endocarditis; UTI; bacteremia.	Contact; endogenous.
Legionella	Gram-negative rod; found in lakes, rivers, streams, thermally heated bodies of water, contaminated air-conditioning systems, shower heads, cooling towers, hot water tanks, humidifiers, respiratory therapy equipment, and whirlpools.	*L. pneumophila*	Legionnaires' disease: high fever and severe pneumonia, with or without abscess. Pontiac fever: flu-like illness, headache, muscle aches, fatigue, and chills.	Inhalation of aerosolized organisms from environmental sources or aspiration of organisms. No evidence of person-to-person transmission.
Leptospira	Zoonotic, aerobic Gram-negative spirochete; concentrated in urine of wild and domesticated animals (rats, swine, cattle, dogs, and raccoons); ubiquitous organism.	*L. interrogans*	Bacteremia; nephritis; hepatitis; skin, muscle, and eye lesions; meningitis; pulmonary infections.	Food borne; contact (breaks in the skin or mucous membranes) with urine of infected animals; possibly through aerosolized contaminated fluids.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Leuconostoc	Gram-positive cocci; found in plants, vegetables, and dairy.	*L. mesenteroides*	Pulmonary infections; infections of cerebral spinal fluid; infections associated with contaminated peritoneal dialysate fluid; bacteremia (especially in neonates); infections of wounds, abdominal abscesses, tracheostomy sites, fistulas; odontogenic infections; breast abscesses.	Contact.
Listeria	Gram-positive rod; found in soil and vegetable matter; may colonize GI tract.	*L. monocytogenes* serotypes Ia, Ib, and IVb	Perinatal listeriosis (may be intrauterine infection) or meningitis. Adults may develop meningoencephalitis, bacteremia, endocarditis, and, rarely, focal infections.	Food borne (raw milk, soft cheeses, vegetables, and ready-to-eat meats). Perinatal transmission. Contact; contaminated equipment.
Micrococcus	Aerobic Gram-positive cocci; coagulase-negative and can be mistaken for coagulase-negative staphylococci. Widely distributed in nature; normal flora of skin, mucosa, and oropharynx.		Nonpathogenic; rarely implicated in infections; low virulence.	Environmental contact; endogenous.
Moraxella	Aerobic Gram-negative diplobacilli; normal flora of mucosal surfaces, respiratory tract, nasopharynx, and conjunctiva.	*M. canis* *M. catarrhalis* (fka *Branhamella catarrhalis*) *M. nonliquefaciens*	Eye infections; bacteremia; endocarditis; septic arthritis; otitis media; sinusitis; pneumonia; dog bite wound infections.	Droplet; patient care equipment; dog bites; endogenous.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Morganella	Enteric, facultative anaerobic Gram-negative rod; normal GI tract flora; found in environment.	*M. morganii*	UTI; wound infections; bacteremia; meningitis; various other infections.	Endogenous; person to person, especially in hospitalized patients.
MRSA (methicillin-resistant *Staphylococcus aureus*)	See *Staphylococcus aureus.*			
Mycobacterium	Acid-fast bacilli; free-living in diseased tissue of humans and animals.			
	Slow growing, 7 days or greater for colony growth; found in diseased tissue of humans and animals.	*M. africanum*	Tuberculosis. Seen in tropical Africa; common in East and West Africa; has been reported in other continents, including North America (United States).	Airborne.
	Slow growing; found in animals (cattle, goats, pigs, dogs, deer).	*M. bovis*	Tuberculosis-like illness.	Ingestion of contaminated milk from infected cows.
	Slow growing; vaccine-induced disease.	*M. bovis* BCG	Systemic Bacillus Calmette-Guerin (BCG) infection.	Vaccine induced.
		M. caprae	Tuberculosis-like illness.	Contact with contaminated materials.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
	Slow growing; does not grow in culture media, must be cultured in armadillos.	*M. leprae*	Hansen's disease: tuberculoid leprosy involving skin, mucous membranes, and nerve tissue.	Person to person; prolonged contact with infected host; organism is shed from the infected patient's nose. Direct through penetrating wounds or mucous membranes. Handling of the nine-banded armadillo native to the southern United States.
	Slow growing; found in diseased tissue of humans.	*M. tuberculosis* complex includes the following species: *M. africanum* *M. bovis* (see entry, above) *M. bovis* BCG (see entry, above) *M. canettii* *M. caprae* *M. microti* *M. tuberculosis*	Pulmonary tuberculosis. Can also involve GU tract, lymph nodes, central nervous system (CNS), bones, pericardium, and other body sites.	Airborne droplets.
		Multidrug-resistant *M. tuberculosis* (MDR-TB)	MDR-TB organism has resistance to at least isoniazid and rifampicin. High fatality rates. **Category C bioterrorism agent**.	Airborne droplets; direct contact with infected individuals.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
		Extensively drug-resistant *M. tuberculosis* (XDR-TB)	XDR-TB organism has resistance to at least isoniazid, rifampicin, and any fluoroquinolones; also has resistance to at least one of the following: amikacin, kanamycin, or capreomycin. High fatality rates.	Airborne droplets; direct contact with infected individuals.
Mycobacterium, nontuberculous species (aka MOTT [Mycobacteria other than tuberculosis])	Found in soil, water, plants, animals, and water systems.		Opportunistic infections in immunocompromised patients; pulmonary infections in those with preexisting pulmonary disease. Disseminated disease involves bone marrow, lungs, liver, and lymph nodes.	Environmental contact. Not transmitted between humans.
	Rapid growing, 7 days or less for colony growth; found in soil, water, plants, animals, indoor water systems, hot tubs, and pools.	*M. abscessus*	Disseminated disease in immunocompromised patients; skin, soft tissue, pulmonary, and postoperative infections (sternal and mammoplasty). Bacteremia associated with hemodialysis equipment.	Environmental contact; tap water. Not transmitted between humans.
	Nonchromogen; slow growing; found in water and soil. Most common environmental nontuberculosis *Mycobacterium* to cause disease.	*M. avium* complex (MAC; aka *M. avium-intracellulare*)	Opportunistic infections in acquired immunodeficiency syndrome (AIDS): disseminated wasting disease characterized by fever, weight loss, hepatosplenomegaly, anemia; localized lymphadenitis in the submandibular, submaxillary, and periauricular lymph nodes in children.	Environmental contact, tap water. Not transmitted between humans.
	Rapid growing; found in water, soil, and dust.	*M. chelonae*	Skin, soft tissue, postoperative wound infections; keratitis.	Environmental contact, tap water. Not transmitted between humans.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
	Rapid growing; found in water (including tap water) and soil.	*M. fortuitum*	Nonpathogenic; skin abscess at site of trauma. Can cause infections in individuals who are patrons of nail salons.	Environmental contact, tap water. Not transmitted between humans.
	Nonchromogen; slow growing; found in environment. Reservoir: pet birds and dogs.	*M. genavense*	Disseminated wasting disease in AIDS patients.	Environmental contact. Not transmitted between humans.
	Scotochromogen; slow growing; found in water (including tap water) and soil.	*M. gordonae*	Nonpathogenic.	Environmental contact. Not transmitted between humans.
	Photochromogen; slow growing; found in water and soil.	*M. kansasii*	Pulmonary disease.	Environmental contact. Not transmitted between humans.
	Nonchromogen; slow growing; found in humans and armadillos.	*M. malmoense*	Chronic pulmonary infections in persons with preexisting disease; cervical lymphadenitis in children; less common: infections of skin or bursa. Most cases seen in England, Wales, and Sweden.	Environmental contact. Not transmitted between humans.
	Photochromogen; slow growing; found in some fish.	*M. marinum*	Fish tank granuloma; cutaneous disease and skin lesions; severe complications include tenosynovitis, arthritis, bursitis, and osteomyelitis.	Contaminated freshwater or saltwater from infected fish and other marine life; enters by small breaks in skin. Usually associated with aquatic activity and fishing; can be acquired from fish tanks. Not transmitted between humans.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
	Scotochromogen; slow growing; found in water, soil, raw milk, dairy products.	*M. scrofulaceum*	Cervical adenitis in children; adenitis.	Raw milk, soil, water, dairy products. Not transmitted between humans.
	Scotochromogen; slow growing; found in water and soil.	*M. szulgai*	Nonpathogenic; opportunistic pulmonary, skin, lymph node, and joint infections seen in immunocompromised patients.	Environmental contact. Not transmitted between humans.
	Slow growing; occurs in tropical or temperate climates.	*M. ulcerans*	Buruli/Bairnsdale ulcer, indolent cutaneous and subcutaneous infections. Mycolactone (cytotoxin) causes necrosis.	Environmental contact; tropical wetlands, mud. Not transmitted between humans.
	Scotochromogen; slow growing; found in water.	*M. xenopi*	Pulmonary infections in adults; extrapulmonary infections (bone, lymph node, sinus tract) and disseminated disease.	Water, especially from hot water taps in hospitals, via aerosols; HAI and pseudoinfection from water storage tanks. Not transmitted between humans.
Mycoplasma	Aerobic pleomorphic Gram-negative, cell-wall-defective bacteria; less than 1 micron in size.			Droplet; direct contact.
	Found in genital tract.	*M. genitalium* *M. hominis*	Neonatal systemic infections, meningitis, abscess, and pneumonia. Invasive disease in immunosuppressed patients: bacteremia, abscesses, wound infections, peritonitis; GU tract infections, prostatitis, PID, bacterial vaginosis, amnionitis, urethritis.	Direct contact; sexual, cervical, and vaginal contact.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
	Found in respiratory tract.	*M. pneumoniae*	Children: upper respiratory tract infections with mild nonspecific symptoms. Adults: lower respiratory tract infections with nonproductive cough, fever, malaise.	Droplet; direct contact.
Neisseria	Gram-negative diplococci; normal upper respiratory tract flora.	*N. cinerea* *N. elongata* *N. mucosa* *N. sicca*	Opportunistic infections in immunocompromised patients; usually localized to respiratory tract, rarely disseminated.	Endogenous.
	Gram-negative intracellular diplococci.	*N. gonorrhoeae* (aka gonococcus)	Gonorrhea: proctitis, vulvovaginitis, urethritis, cervicitis, salpingitis, prostatitis, stomatitis, conjunctivitis, pharyngitis, epididymitis, bartholinitis, skin lesions, tenosynovitis, septicemia, endocarditis, and newborn ophthalmitis; tonsillitis, bacteremic dissemination, and vasculitic skin lesions.	Sexual transmission; infected mother to baby at birth.
	Colonizes oropharyngeal and nasopharyngeal mucous membranes.	*N. meningitidis* (aka meningococcus)	Meningitis: death may occur quickly because of endotoxin shock or focal cerebral involvement. Purpuric skin lesions; hemorrhage and necrosis of the adrenal glands (Waterhouse-Friderichsen syndrome). Bacteremia; pneumonia; pericarditis; arthritis.	Respiratory droplets; asymptomatic carriers may disseminate organism. Group A, C, Y, and W135 vaccines available.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Neorickettsia	Intracellular parasite of monocytes and macrophages. Reservoir: fish.	*N. sennetsu* (fka *Ehrlichia sennetsu*)	Glandular fever or Sennetsu fever: self-limited febrile illness with chills, headache, malaise, sore throat, anorexia, and generalized lymphadenopathy (similar to infectious mononucleosis); identified in Japan, Laos, and Malaysia; neorickettsiosis.	Ingestion of raw fish containing trematodes.
Nocardia	Long, thin Gram-positive beaded bacilli with branching filaments; aerobic actinomycete; partial acid-fast positive; found in soil and water.	*N. asteroides* complex *N. brasiliensis*	Actinomycotic mycetoma; nocardiosis; mycetoma; lung, brain, skin, and soft tissue infections.	Traumatic inoculation or inhalation.
Orientia	Obligate, intracellular Gram-negative coccobacilli; vector borne; found in Southeast Asia and the South Pacific. Reservoir: rodents.	*O. tsutsugamushi* (fka *Rickettsia tsutsugamushi*)	Scrub typhus (tsutsugamushi fever): clinically resembles epidemic typhus; maculopapular rash; site of bite develops black eschar; interstitial pneumonia and lymphadenitis.	Chigger bites; trombiculid mites.
Paenibacillus	Facultative anaerobic Gram-positive spore-forming rod; widely distributed in nature; transient colonizer of skin, GI and respiratory tracts.	*P. alvei* (fka *Bacillus alvei*)	Endophthalmitis; meningitis; prosthetic hip and wound infections.	Environmental contact.
		P. macerans	Opportunistic infections in patients with neutropenia. Wound infections; brain abscesses; catheter-associated bacteremia.	Traumatic introduction into sterile site; exposure to contaminated medical equipment.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Pantoea	Enteric, aerobic Gram-negative bacilli; found in the environment.	*P. agglomerans* (fka *Enterobacter agglomerans*)	Opportunistic infections in immunocompromised patients. Soft tissue infections; septic arthritis; osteomyelitis.	Penetrating trauma by objects contaminated with soil or vegetative matter. HAI; contaminated IV fluids or parenteral nutrition.
Pasteurella	Facultative anaerobic, small Gram-negative coccobacilli or rod; found in nasopharynx and GI tracts of wild and domestic animals and respiratory flora of animal handlers.	*P. canis* *P. dagmatis* *P. multocida* *P. stomatis*	Focal soft tissue infections following bite or scratch; chronic respiratory infections in persons with preexisting chronic lung disease and heavy exposure to animals; bacteremia with metastatic abscess formation in persons with no history of animal exposure; sinusitis; bronchitis.	Animal (dog or cat) bite or scratch.
Pediococcus	Facultative anaerobic Gram-positive cocci; found in foods and vegetation; colonizes GI tract of immunocompromised patients.	*P. acidilactici*	Bacteremia and hepatic abscesses. Usually only capable of causing infections in severely immunocompromised patients; whenever encountered in clinical specimens, first consider as probable contaminant.	Environmental contact; endogenous.
Peptococcus	Gram-positive anaerobic cocci; present in vagina of 20% to 30% of pregnant women.	*P. niger*	Nonpathogenic.	Endogenous.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Peptostreptococcus	Anaerobic Gram-positive coccus; normal flora of skin, oropharynx, and respiratory, GI, and GU tracts.	*P. anaerobius* *P. asaccharolyticus* *P. micros* *P. prevotii* *P. tetradius*	Cutaneous, respiratory, oral, or female pelvic infections (tubo-ovarian abscesses, septic abortions, bacteremia, amnionitis and chorioamnionitis); periodontitis; chronic otitis media; chronic sinusitis; purulent nasopharyngitis; brain abscess; endocarditis; pneumonitis; lung abscess; empyema; necrotizing pneumonia. Intestinal perforation or cancer may lead to peritonitis with mixed infections, liver abscess.	Endogenous.
Plesiomonas	Facultative anaerobic Gram-negative rod; found in freshwater in warmer climates.	*P. shigelloides* (fka *Aeromonas shigelloides*)	Gastroenteritis; septicemia in immunocompromised adults and in infants who experience a complicated delivery.	Ingestion of contaminated water or seafood; exposure to cold-blooded animals, such as amphibians and reptiles.
Porphyromonas	Anaerobic Gram-negative coccobacilli; normal flora of upper respiratory and GI tracts.	*P. asaccharolytica* *P. catoniae* *P. gingivalis* *P. levii*	Oral, dental, bite infections; head, neck, lower respiratory tract, and GU tract infections.	Endogenous.
		P. bennonis (new species)	Perirectal, buttock, and wound infections.	Endogenous.
Prevotella	Anaerobic Gram-negative coccobacilli; normal flora of oral cavity and upper respiratory, GI, and GU tracts.	*P. bivia* *P. disiens*	Female genital tract infections. Less frequently, oral infections.	Endogenous.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
		P. buccae *P. oris*	Oral, pleuropulmonary, human bite wound, and other infections.	Human bites; endogenous.
		P. dentalis (fka *Hallella seregens*)	Infected root canals, periodontal pockets, mandibular, and gum abscesses; sialadenitis.	Endogenous.
		P. melaninogenica (fka *Bacterioides melaninogenica*)	Head, neck, pleuropulmonary infections; infected human bite wounds.	Endogenous.
Propionibacterium	Anaerobic and aerotolerant diphtheroid-like Gram-positive rod; normal flora of skin, oral cavity, respiratory tract, and vagina. Considered a common commensal (see Chapter 2).	*P. acnes* *P. proprionicum*	Acne; uveitis; endophthalmitis; bone, joint, and CNS infections; endocarditis; infected dog and cat bite wounds; oral cavity infections; eye infections. Associated with SAPHO syndrome (synovitis, acne, pustulosis, hyperostosis, and osteomyelitis). Most common anaerobic blood culture contaminant (linked to surgical procedures or foreign bodies).	Endogenous; cat and dog bites.
Proteus	Enteric, facultative anaerobic Gram-negative rod; normal GI flora.	*P. mirabilis* *P. penneri* *P. vulgaris*	Wide variety of HAIs of respiratory tract, urinary tract, blood, and several other normally sterile sites; seriously debilitated patients are at greatest risk.	Endogenous; person to person.
Providencia	Aerobic and facultative anaerobic enteric, coccobacilli, or straight rod; normal GI flora.	*P. alcalifaciens* *P. rettgeri* *P. stuartii*	Wide variety of HAIs of respiratory tract, urinary tract, blood, and several other normally sterile sites; seriously debilitated patients are at greatest risk.	Endogenous; person to person.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Pseudomonas	Enteric, aerobic Gram-negative rod; worldwide distribution in water, soil, plants; found in aqueous solutions, sink traps, and hydrotherapy and respiratory equipment.	*P. aeruginosa*	Community-acquired infections in nonimmunocompromised individuals: folliculitis; swimmer's ear; more severe ear infections in people with diabetes and older adults with temporal bone and basilar skull osteomyelitis. Meningitis; eye infections associated with contact lens use; osteomyelitis of calcaneus in children from a nail penetrating a sneaker; endocarditis in IV drug users. Leading cause of respiratory tract HAI; UTI; wound infections; peritonitis in persons on chronic ambulatory peritoneal dialysis; and bacteremia, particularly in burn patients. An unusual "mucoid" phenotype chronically infects 70% to 80% of adolescents and adults with cystic fibrosis.	Contaminated water (e.g., swimming pools, water slides, whirlpools, hot tubs), solutions, foods; exposure to contaminated equipment.
	Found in soil and water.	*P. alcaligenes*	Catheter-associated endocarditis in bone marrow transplant recipient.	Environmental contact.
	Found in soil and water.	*P. fluorescens*	Transfusion-associated septicemia.	Blood transfusions.
	Found in soil, water, fruits, vegetables, and moist hospital environments.	*P. oryzihabitans* (fka *Flavimonas oryzihabitans*)	Catheter-associated HAIs: bacteremia in immunocompromised persons with central venous catheters; peritonitis in persons undergoing chronic ambulatory peritoneal dialysis; cellulitis, abscesses, wound infections; meningitis following neurosurgical procedures; septicemia.	Environmental contact.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
	Found in soil and water.	*P. putida*	Catheter-associated bacteremia in persons with cancer.	Environmental contact.
	Found in soil and water.	*P. stutzeri*	Bacteremia in immunosuppressed patients and in persons undergoing hemodialysis with contaminated dialysis fluid; wound infections; UTI; osteomyelitis; pneumonia in people with alcoholism and intubated patients; meningitis in patients with HIV.	Environmental contact; contaminated water and solutions.
Rhizobium	Gram-negative rod; found in soil and plants.	*R. radiobacter* (aka *Agrobacterium radiobacter*)	Opportunistic infections associated with indwelling devices.	Contact.
Rhodococcus	Aerobic Gram-positive coccoid to rod shaped; normally found in soil and water, associated with livestock.	*R. equi*	Opportunistic infections in immunocompromised patients; pulmonary infection, bacteremia, skin infections, endophthalmitis, peritonitis, catheter-associated sepsis, prostatic abscesses.	Inhalation.
Rickettsia	Obligate intracellular Gram-negative coccobacilli; intracellular parasites.		Rocky Mountain spotted fever; murine typhus; louse-borne fever; flea-borne spotted fever; boutonneuse fever. Systemic diseases (spotted fever, typhus, scrub typhus) with rash, headache, and fever; infections may be severe or even fatal.	Arthropod borne. Organisms infect wild animals and their arthropod parasites; incidental infections occur in humans.
	Etiologic agent of rickettsialpox; occurs worldwide. Reservoir: mice and rats.	*R. akari*	Rickettsialpox: mild disease characterized by a chickenpox-like rash and fever; initial site of bite develops a black eschar.	Mite bites.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
	Occurs worldwide; found in humans and flying squirrels.	*R. prowazekii*	Epidemic typhus (classic typhus): fever, prostration, and rash starting on the trunk region. **Category B bioterrorism agent**.	Body louse.
	Reservoir: deer, dogs, rodents, foxes, rabbits, birds, and humans.	*R. rickettsii*	Rocky Mountain spotted fever: fever, headache, vomiting, muscle pain progressing to a rash, which starts peripherally, in contrast to that of epidemic and endemic typhus; can be fatal.	Ixodid (hard) tick bites.
	Found in Europe and Asia. Reservoir: rodents.	*R. sibirica*	North Asian tick typhus or Siberian tick typhus: a mild form of spotted fever.	Tick bites.
	Reservoir: rats, other rodents, and opossums.	*R. typhi*	Endemic (murine) typhus: similar to but milder than epidemic typhus.	Rat flea bites or feces.
Rothia	Gram-positive cocci; normal oral and upper respiratory tract flora.	*R. mucilaginosa* (fka *Stomatococcus mucilaginosus*)	Endocarditis; bacteremia; intravascular catheter infection; meningitis; peritonitis; predisposing risk factors are neutropenia, chemotherapy, radiotherapy, and IV drug use.	Endogenous.
Salmonella	Enteric, facultative anaerobic Gram-negative rod; normally found in water. *S. typhi* is found only in humans. Non-typhi (zoonotic) forms found in pet turtles, chickens, uncooked eggs.	*S. enterica* *S. enterica* ser Enteritidis *S. enterica* ser. Typhi *S. enterica* ser. Typhimurium *Salmonella* group strains I–VI	Salmonellosis; typhoid fever. Symptoms include gastroenteritis, diarrhea, and septicemia (which can be rapidly fatal). **Category B bioterrorism agen**t.	Fecal-oral; ingestion of contaminated water or food (such as eggs, ice cream, meringue, shellfish, and undercooked chicken, fish, and pork). Contact with reptiles and amphibians.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Serratia	Enteric, facultative Gram-negative rod; normal GI tract flora.	*S. liquefaciens* *S. marcescens*	Pneumonia; bacteremia associated with contaminated multidose medication vials; UTI; surgical site infections; contact lens-induced red eye.	Contact; HAI pathogens and colonizers; contaminated IV fluids; medical equipment (respiratory therapy).
Shigella	Enteric, facultative anaerobic Gram-negative rod; found in the environment.	*S. dysenteriae* (fka group A *Shigella*)	Shigellosis; bloody diarrhea (dysentery); nonbloody diarrhea; fever; abdominal cramps. Complications include HUS and reactive arthritis. **Category B bioterrorism agent**.	Fecal-oral; ingestion of contaminated food and water; unsafe food handling; anal intercourse.
		S. boydii (fka group C *Shigella*) *S. flexneri* (fka group B *Shigella*) *S. sonnei* (fka group D *Shigella*)	Bloody diarrhea.	Same as group A transmission.
Sphingomonas	Strict aerobe, negative rod; widely distributed in the environment and water.	*S. paucimobilis* (fka *Pseudomonas paucimobilis*)	Bacteremia; UTI; peritoneal fluid, wound, and respiratory infections. Significance in clinical specimens is questionable.	Water and environmental contact; endogenous.
Staphylococcus	Gram-positive cocci in grapelike clusters; normal flora of skin, anterior nares, nasopharynx, and perineal area. *S. aureus* is considered the most important human pathogen.	*S. aureus*	Abscess, pneumonia, empyema, osteomyelitis, purpural sepsis, bacteremia, endocarditis. MRSA strains are common in hospitals. Enterotoxins: TSS, food poisoning, Staphylococcus scalded skin syndrome. **Enterotoxin B is a Category B bioterrorism agent**.	Endogenous; contact; unwashed hands and contaminated patient-care equipment.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
	Normal flora of skin and mucous membranes. Considered a common commensal (see Chapter 2).	*S. epidermidis* (aka coagulase-negative *Staphylococcus*)	Infections associated with prosthetic devices and indwelling catheters; sepsis; meningitis; endocarditis; UTI.	Endogenous; contact; unwashed hands and contaminated patient-care equipment.
	Normal flora of skin and mucous membranes. Considered a common commensal (see Chapter 2).	*S. haemolyticus* (aka coagulase-negative *Staphylococcus*)	Native valve endocarditis; septicemia; peritonitis; UTI; wound, bone and joint infections.	Contact; unwashed hands and contaminated patient-care equipment.
	Normal flora of skin and mucous membranes. Considered a common commensal (see Chapter 2).	*S. lugdunensis* (aka coagulase-negative *Staphylococcus*)	Foreign body–associated infections; native valve endocarditis; chronic osteomyelitis; abscesses.	Contact; endogenous; contaminated medical equipment.
	Normal flora of skin and GU tract mucosa.	*S. saprophyticus* (aka coagulase-negative *Staphylococcus*)	Opportunistic UTI in females and nongonococcal urethritis in males. Wound infections; septicemia.	Contact; unwashed hands and contaminated patient care equipment.
Stenotrophomonas	Aerobic Gram-negative rod; naturally inhabits water, soil, plants, vegetables; colonizer in immunosuppressed and cystic fibrosis patients.	*S. maltophilia*	Bacteremia; meningitis; UTI; pneumonia; mastoiditis; epididymitis; conjunctivitis; endocarditis; peritonitis; bursitis; keratitis; endophthalmitis; cholangitis; mucocutaneous, soft tissue, ocular, and wound infections.	Environment; contact; droplets.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Streptobacillus	Facultative anaerobic Gram-negative bacillus; natural habitat in rats and mice.	*S. moniliformis*	Systemic infection, Haverhill fever ("rat-bite fever"): fever, chills, headache, vomiting, severe migratory arthralgias, large-joint swelling, nonpruritic rash on palms, soles, and extremities.	Animal bite; contact with blood from infected animals.
Streptococcus	Normal flora of the GI tract and female GU tract.	*S. agalactiae* (aka group B beta-hemolytic *Streptococcus*)	Neonatal sepsis, meningitis, pneumonia; postpartum infections; GU tract infections; bacteremia; endocarditis; skin and soft tissue infections; abscesses; osteomyelitis.	Endogenous; contact; genital tract secretions.
	Viridans group; normal oropharyngeal, GI tract, and female genital tract flora.	*S. anginosus* *S. gordonii* *S. intermedius* *S. mitis* *S. oralis* *S. sanguis*	Subacute bacterial endocarditis, especially in persons with prosthetic heart valves; deep-seated brain, liver, and oral abscesses; female genital infections. Sometimes considered a contaminant.	Oropharyngeal secretions; endogenous.
	Normal flora of the skin, nasopharynx, and GI and GU tracts.	*S. dysgalactiae* subspecies *equisimilis* (aka group C beta-hemolytic *Streptococcus*)	Bacteremia; endocarditis; meningitis; septic arthritis; skin infections; abscesses; respiratory tract infections.	Endogenous; contact.
	Colonizes nasopharynx.	*S. pneumoniae* (aka pneumococcus [*Diplococcus pneumoniae*])	Pneumonia; sepsis; sinusitis; otitis media; endocarditis; meningitis.	Secretions; endogenous. Vaccine available.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
	Gram-positive cocci in chains or pairs; inhabits skin and upper respiratory tract; colonizes nasopharynx.	*S. pyogenes* (aka group A beta-hemolytic *Streptococcus*)	Pharyngitis (strep throat); respiratory and ear infections. Ludwig's angina; skin infections (impetigo, erysipelas, necrotizing fasciitis); soft tissue infections; abscesses; endocarditis; meningitis; sepsis; septic arthritis; rheumatic fever; scarlet fever; glomerulonephritis; toxic shock-like syndrome.	Endogenous; contact; droplets, respiratory secretions.
Streptomyces	Gram-positive rod with branching filaments; found in sandy soil.	*S. paraguayensis* *S. somaliensis* *S. sudanensis*	Mycetoma; chronic soft tissue infections.	Environmental contact; inhalation.
Treponema	Gram-negative spirochete. Reservoir: humans.	*T. pallidum* subspecies *pallidum*	Syphilis: acute and chronic sexually transmitted disease characterized by primary lesion; secondary eruption involving skin and mucous membranes; long periods of latency and late lesions of skin, bone, viscera, CNS, and cardiovascular system; fatal infections can occur in late tertiary stage.	Sexual contact; direct contact with exudate from lesions. Blood transfusion if donor is in early stages of infection. Fetal infection through placental transfer at delivery.
Ureaplasma	Smallest free-living microorganism contained only by a cell membrane; present in GU tract.	*U. urealyticum* (fka T strains of *Mycoplasma*)	Bacterial vaginosis; nonchlamydial-nongonococcal urethritis; PID; chorioamnionitis. Extragenital disease in immunocompromised persons and premature neonates. Present in mixed infections.	Endogenous; direct intimate contact.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Veillonella	Anaerobic Gram-negative diplococci; normal flora of upper respiratory and GI tracts and vagina.	*V. atypica* *V. dispar* *V. parvula*	Bacteremia; meningitis; osteomyelitis; prosthetic joint infections; endocarditis; discitis; vertebral osteomyelitis. Rare opportunistic organism. Oral, bite wound, head, neck, and miscellaneous soft tissue infections.	Endogenous.
Vibrio	Facultative anaerobic Gram-negative rod; natural inhabitants of freshwater, brackish water, and saltwater worldwide. More than 30 species, 12 of which are human pathogens.	*V. cholerae* O1, subtypes: *Inaba, Ogawa, Hikojima*; biotypes: classical, El Tor (fka *V. comma*)	Cholera pandemics, epidemics, and outbreaks occur worldwide. Cholera toxin: acute bacterial enteric disease; severe form involves sudden onset, profuse, painless watery stools, occasional vomiting, and, if untreated, rapid dehydration, acidosis, circulatory collapse, and renal failure. Asymptomatic and mild cases are common. **Category B bioterrorism agent**.	Fecal-oral; ingestion of raw or inadequately cooked seafood from contaminated waters (coastal and estuarine).
	Aquatic birds are carriers; found inland as well as along Gulf Coast and Great Lakes region.	*V. cholerae* non-O1 (fka nonagglutinable *V. cholerae*)	Gastroenteritis. Systemic infections are most common in immunocompromised patients.	Fecal-oral; ingestion of contaminated seafood.
	Isolated in 1993 from outbreak around Bay of Bengal.	*V. cholerae* O139 (fka Bengal cholera)	Produces toxin and cholera illness.	Fecal-oral; ingestion of contaminated seafood.
	Outbreak in Bangladesh; rare in U.S. Gulf Coast region.	*V. fluvialis*	Gastroenteritis; sepsis (rare).	Contact with coastal water and possibly ingestion of contaminated seafood.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
	Multiple outbreaks in Japan. Reservoir: fish.	*V. parahaemolyticus* (fka Kanagawa phenomenon)	Enteric infection characterized by watery diarrhea and abdominal cramps, nausea, vomiting, fever, headache, bloody mucoid stools, high white blood cell count.	Ingestion of contaminated raw fish; sea water.
		V. vulnificus (fka lactose-positive *Vibrio*)	Septicemia in persons with chronic liver disease, chronic alcoholism, hemochromatosis, or immunocompromised status; bullous skin lesions; thrombocytopenia. Wounds sustained in coastal or estuarine waters range from mild self-limited lesions to cellulitis and myositis; necrotizing fasciitis; endotoxic shock.	Ingestion of raw or inadequately cooked seafood; exposure to coastal/ estuarine seawater.
VRE (vancomycin-resistant *Enterococcus*)	See *Enterococcus*.			
Xanthomonas	See *Stenotrophomonas maltophilia*.			

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Yersinia	Zoonotic, facultative anaerobic, enteric Gram-negative rod; 11 species, 3 of which are known human pathogens. Organisms usually infect rats and other rodents (ground squirrels, prairie dogs); humans are accidental hosts.			
	Infections more common in northern latitudes; found in pigs, rabbits, livestock, rodents, dogs, and cats.	*Y. enterocolitica*	Intestinal and extraintestinal yersiniosis: hemorrhagic enterocolitis, terminal ileitis, mesenteric lymphadenitis (pseudo-appendicular syndrome), septicemia, and focal infections; postinfectious arthritis in adolescents and young adults. Associated with contaminated blood transfusion products.	Fecal-oral; ingestion of contaminated food (often, milk or pork) or water; contact with infected animals.
		Y. pestis (fka *Pasteurella pestis*)	Bubonic plague: fever, chills, malaise, myalgia, nausea, sore throat, and headache, lymphadenitis that results in swelling, inflammation, tenderness, and lesions (buboes); progresses to bloodstream dissemination, septicemia, and pneumonia. **Category A bioterrorism agent**.	Rat flea bites; handling of tissues of infected animals.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
			Pneumonic plague: secondary infection of the lungs resulting in pneumonia, mediastinitis, or pleural effusion. Localized outbreaks or devastating epidemics. **Category A bioterrorism agent.**	Droplet; also present in animals, including domestic pets (cats).
			Septicemic plague: direct inoculation of the bloodstream without localization in regional lymph nodes.	Rat flea bites; handling of tissues of infected animals
	Found in rodents, rabbits, deer, and birds.	*Y. pseudotuberculosis*	Self-limiting infection similar to *Y. enterocolitica,* although abdominal pain is more common and active diarrhea is less common; mesenteric lymphadenitis; erythema nodosum; reactive arthritis; nephritis.	Fecal-oral; ingestion of contaminated food or water; contact with infected animals.

REFERENCES

Association for Professionals in Infection Control and Epidemiology. *APIC Text Online.* 2017. http://text.apic.org.

Bateman AC, Butler-Wu SM. The brief case: bacteremia caused by Helicobacter cinaedi. *J Clin Microbiol.* 2017;55(1):5–9. doi:10.1128/JCM.02936-15J.

Bennett JE, Dolin R, Blaser MJ. *Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases*. 8th ed. Philadelphia, PA: Saunders; 2015.

Carroll K, Morse SA, Mietzner T, et al. *Jawetz, Melnick, and Adelberg's Medical Microbiology*. 27th ed. New York: McGraw-Hill Education; 2016.

Gilbert DN, Chambers HF, Eliopoulos GM, Saag MS, Pavia AT. *The Sanford Guide to Antimicrobial Therapy 2017*. 47th ed. Sperryville, VA: Antimicrobial Therapy; 2017.

Heymann DL, ed. *Control of Communicable Diseases Manual*. 20th ed. Baltimore, MD: American Public Health Association; 2014.

Jorgensen JH, Pfaller MA, Carroll KC, et al, eds. *Manual of Clinical Microbiology*. 11th ed. Washington, DC: American Society of Microbiology Press; 2015.

Kimberlin DW, Brady MT, Jackson MA, Long SS, eds. *2015 Red Book: Report of the Committee on Infectious Diseases*. 30th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2015.

Li H, Jiang JF, Liu W, et al. Human infection with *Candidatus Neoehrlichia mikurensis*, China. *Emerg Infect Dis.* 2012;18(10): 1636–1639. doi:10.3201/eid1810.120594.

Mahon CR, Lehman DC, Manuselis G, eds. *Textbook of Diagnostic Microbiology*. 5th ed. St. Louis, MO: Elsevier; 2015.

Porter RS, Kaplan, JL, eds. *The Merck Manual of Diagnosis and Therapy*. 19th ed. Whitehouse Station, NJ: Merck; 2011.

Ryan K, Ray G. *Sherris Medical Microbiology*. 6th ed. New York: McGraw-Hill Education; 2014.

Tille PM, ed. *Bailey & Scott's Diagnostic Microbiology*. 14th ed. St. Louis, MO: Mosby; 2017.

Tortora GJ, Funke BR, Case CL, eds. *Microbiology: An Introduction*. 12th ed. Boston: Pearson; 2016.

ADDITIONAL RESOURCES

American Society for Microbiology. http://www.asm.org.

Centers for Disease Control and Prevention. http://www.cdc.gov.

Centers for Disease Control and Prevention. Healthcare-Associated Infections. http://www.cdc.gov/hai.

Lee E. Microbial pathogenicity and host response. In: *APIC Text Online.* 2014. http://text.apic.org/toc/microbiology-and-risk-factors-for-transmission/microbial-pathogenicity-and-host-response.

National Institutes of Health. Understanding Emerging and Re-emerging Infectious Diseases. Bethesda, MD: National Institutes of Health; 2007. https://www.ncbi.nlm.nih.gov/books/NBK20370/#top.

World Health Organization. http://www.who.int.

CHAPTER 2

Common Commensals

An estimated 500 to 1,000 different bacterial species residing on or in the human body are considered **normal flora**, microbes that normally live in and on the body without causing infection or disease to the host. Normal flora is divided into two types: resident and transient. **Resident flora** is always present on the skin and throughout the body. It includes the body's colonizing bacteria, which multiply and live on and in the body without invading the tissues. **Transient flora** colonize the skin and mucosa temporarily, without invading tissues, when humans come into direct contact with the environment containing these organisms. Resident and transient floras vary by anatomical site and location; collectively, they make up the human microbiota.

The following three relationships exist between the human host and normal flora:

- **Commensal**, in which normal flora neither harm nor benefit the host (e.g., microbes on the skin)
- **Mutual**, in which both flora and host benefit (e.g., *Escherichia coli,* a normal gastrointestinal [GI] flora, synthesizes vitamin K)
- **Pathogenic**, in which the microbes cause harm to the host (e.g., normal flora is disturbed and host defenses are decreased, resulting in microbes becoming opportunistic and invading tissue leading to infections and disease states)

Common commensals rarely cause infection, but infection can occur after a breakdown in skin or mucosal barriers. Common commensals can become pathogenic for immunocompromised individuals.

Because resident and transient floras are shed by the host with the secretion of body oils and mucus and the shedding of the outer layer of dead skin cells, common commensals become a transmission concern when individuals do not follow the hand hygiene practices recommended by the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) Five Moments for Hand Hygiene strategy.

NORMAL FLORA BY THE FOUR MAJOR BODY SITES

SKIN

The common commensals of the skin include the *Staphylococcus* species, *Streptococcus* species, *Micrococcus* species, *Corynebacterium* species, and *Propionibacterium* species, as well as Gram-negative

organisms, often as transient flora, in the more common moist areas (e.g., *Escherichia coli* and *Pseudomonas* species).

- Moist areas of axilla, perineum, and toe webs promote dense bacterial colonization.
- Drier areas comprising the bulk of the skin surfaces promote less-dense bacterial colonization.

RESPIRATORY TRACT

The common commensals along the respiratory tract vary from the nares to the lung tissues. They can include, but are not limited to, *Staphylococcus* species, viridans group *Streptococcus*, *Corynebacterium* species, *Moraxella* species, *Neisseria* species, and a mix of anaerobic organisms (e.g., *Lactobacillus* species, *Propionibacterium* species, *Prevotella* species, *Fusobacterium* species).

Staphylococcus aureus, Streptococcus pyogenes, other beta-hemolytic *Streptococcus* species, *Neisseria meningitidis,* and *Haemophilus* species can colonize the respiratory tract without causing infection. In the noninfectious state, they are considered transient flora. However, they are typically pathogenic organisms, causing infection in the host individual.

- The upper respiratory tract includes the nares, nasopharyngeal area, epiglottis, and throat. In contrast to other parts of the upper respiratory tract, the sinuses are considered a sterile site.
- The lower respiratory tract includes the trachea, bronchi, and lung tissues; these sites are considered sterile.

GASTROINTESTINAL TRACT

The GI tract is home to most of the common commensals present in the human body, with the greatest concentration of bacteria located in the large intestine. The bacteria normally present in the GI tract significantly change along the tract from the oral cavity to the small and large intestines. The wide range of bacteria within the GI tract includes a large variety of aerobic and anaerobic Gram-positive cocci, Gram-positive bacilli, and Gram-negative bacilli. The common commensals present in the GI tract are beneficial to the host individual, contributing to digestion, vitamin synthesis, and immunologic protective mechanisms.

- The oral cavity has more than 700 bacterial species, with the most common being *Streptococcus* species, *Lactobacillus* species, *Corynebacterium* species, and anaerobic organisms.
- Common commensals in the upper esophagus consist of viridans group *Streptococcus* organisms and transient organisms from the respiratory tract and oral cavity.
- Flora suspected to be in the lower esophagus include a variety of viridans group *Streptococcus* species and anaerobic organisms such as *Bacteroides* species.
- Because of the high acidity of stomach acid, few bacterial organisms are found in the stomach. Those capable of surviving the highly acidic environment are transient residents.

- The small intestine flora consists of *Lactobacillus* species, *Streptococcus* species, the *Enterobacteriaceae*, and mixed anaerobic organisms.
- The large intestine is the organ with the densest flora present in the body, with predominantly anaerobic organisms (*Bacteroides*, *Clostridia*, *Bifidobacteria,* and anaerobic *Streptococcus* species) as well as *Enterobacteriaceae*.

GENITOURINARY TRACT

The genitourinary (GU) tract is made up of the kidneys, bladder, ureters, urethra, external genitalia (penis or vagina), and, in females, the cervix and uterus. The kidneys, bladder, ureters, and urethra are all considered sterile sites. The common commensals of the vagina are predominately *Lactobacillus* species but also include *Corynebacterium* species, *Staphylococcus* species, *Streptococcus* species, and the occasional transient species of *Escherichia coli* and yeast (*Candida* species). The common commensals of the vagina vary greatly depending on the age of the female, menses, pH, and hormone levels. Additionally, flora of the external genitalia includes skin and large intestine flora (*E. coli; Staphylococcus, Enterococcus, Corynebacterium,* and *Proteus* species).

- The kidney, bladder, and ureters do not normally contain microbes.
- The external genitalia contain mixed skin flora from the surrounding skin. Flora from the colon are found in the vagina.
- The microbes in the internal vaginal lining and cervix are predominately *Lactobacillus* species.
- The uterus was previously thought to be sterile. However, healthy uterus flora has been identified and includes *Lactobacillus* species, *Bacteroides* species, and low numbers of *Prevotella* species.

TABLE

The table presents basic concepts for an understanding of normal flora per body site and addresses special considerations for specimen collection.

BODY SITE	NORMAL FLORA	SPECIAL CONSIDERATIONS FOR SPECIMEN COLLECTION
Skin (including nails and hair)	Coagulase-negative *Staphylococcus*, *Corynebacterium, Micrococcus, Peptostreptococcus, Propionibacterium, Staphylococcus aureus, Staphylococcus epidermidis, Staphylococcus saprophyticus, Streptococcus pyogenes*	Skin bacterial cultures: Wipe skin with sterile water or sterile normal saline prior to specimen collection. Fungal cultures of skin and nail scrapings: Wipe nails or skin with 70% alcohol; use clippings of affected nail area; scrape skin at leading edge of lesion. Hair samples: Collect intact shaft.

BODY SITE	NORMAL FLORA	SPECIAL CONSIDERATIONS FOR SPECIMEN COLLECTION
Blood	None	Draw two sets of cultures from two separate sites when patient is febrile and prior to beginning antibiotic treatment. Do *not* draw blood cultures from or above the intravenous site. Using an approved antiseptic, clean the venipuncture site to prevent the introduction of contaminants into the individual or the blood culture. Following manufacturers' recommendations, disinfect the stopper on the top of the blood culture bottles. For adults, draw 10 to 20 mL blood and divide the sample between the aerobic and anaerobic bottles. For infants and children, draw 1 to 5 mL blood and place it in a pediatric blood culture bottle. For patients with a central line, draw one set of cultures from the central line and the other set from a venipuncture. **Probable contaminants**: *Bacillus* species, *Corynebacterium* species, *Propionibacterium acnes, Micrococcus* species, viridans group *Streptococcus,* or coagulase-negative *Staphylococcus* present in one bottle; mixed-microbial isolates reported from one or more bottles. **Probable pathogens**: Identification of a single organism from multiple bottles, multiple sites, and with different collection times. *Staphylococcus* species, *Streptococcus* species, *Enterococcus* species, *Enterobacteriaceae* members, and Gram-negative organisms.
EYES		
Ocular surface (conjunctiva and cornea)	Coagulase-negative *Staphylococcus, Micrococcus* species, *Streptococcus* species, *Corynebacterium* species, *Propionibacterium* species, *Moraxella* species, *Neisseria* species, and fungal isolates	Conjunctiva cultures: Using a sterile flexible swab, touch the swab to the eye drainage or the conjunctiva and send for culture. **Probable pathogens**: *Staphylococcus aureus, Streptococcus pneumoniae,* beta-hemolytic *Streptococcus, Haemophilus influenzae, Neisseria* species, *Moraxella* species, *Pseudomonas* species, *Acinetobacter* species, *Enterobacteriaceae*, and fungal isolates (*Candida* species, *Aspergillus* species, and others).
Vitreous cavity	None	Endophthalmitis culture requires a sterile invasive procedure such as a vitreous washing, needle aspirate, and, in extreme cases, a vitrectomy.

BODY SITE	NORMAL FLORA	SPECIAL CONSIDERATIONS FOR SPECIMEN COLLECTION
		EARS
External ear	Reflective of normal skin flora: coagulase-negative *Staphylococcus, Micrococcus* species, *Lactobacillus* species, *Corynebacterium* species, *Propionibacterium acnes, Candida* species	Moisten sterile swab with sterile water; use it to remove crusts, and then discard it. Firmly rotate a new sterile swab in external canal; place swab in appropriate transport medium and submit for culture.
Middle and inner ear	None	Clean external ear with mild soap solution; aspirate fluid from middle ear and submit for culture. If eardrum is ruptured, collect fluid with sterile flexible swab.
		CENTRAL NERVOUS SYSTEM
Cerebrospinal fluid	None	Determine the volume of cerebrospinal fluid needed for all testing prior to collection. Disinfect the selected site with an approved antiseptic prior to aspiration. Once collected, transport the specimen without delay to the laboratory. Never refrigerate cerebrospinal fluid prior to microbial testing. Collection of cerebrospinal fluid should occur before antibiotics are started. **Probable contaminants**: Common skin flora (coagulase-negative *Staphylococcus, Corynebacterium* species, *Micrococcus* species). However, clinical correlation with the identified organism is crucial for final diagnosis. **Probable pathogens**: *Streptococcus pneumoniae, Neisseria meningitidis, Haemophilus influenzae, Listeria monocytogenes, Escherichia coli,* and other *Enterobacteriaceae*, *Pseudomonas aeruginosa,* and *Treponema pallidum* (syphilis). Additionally, a number of other bacteria, fungi, viruses, and parasites can be the cause of meningitis, aseptic meningitis, encephalitis, and meningoencephalitis.
		RESPIRATORY TRACT
Sinuses	None	Aseptic aspiration performed by the provider, submitted in the appropriate culture medium, and transported to the laboratory in a timely manner for cultures. **Probable pathogens**: *Staphylococcus aureus, Streptococcus pneumoniae,* beta *Streptococcus* species, *Haemophilus* species, *Neisseria meningitidis, Moraxella catarrhalis,* rhinovirus, and fungal pathogens.

BODY SITE	NORMAL FLORA	SPECIAL CONSIDERATIONS FOR SPECIMEN COLLECTION
Pharynx	*Actinomyces* species, *Bifidobacterium* species, *Corynebacterium* species, *Eubacterium* species, *Fusobacterium* species, *Moraxella* species, *Lactobacillus* species, *Peptostreptococcus* species, *Porphyromonas* species, *Prevotella* species, *Propionibacterium* species, *Staphylococcus aureus,* coagulase-negative *Staphylococcus*, *Streptococcus* species, and *Veillonella* species	Specimen collection techniques include nasopharynx washings and swabs, and throat and tonsils swabs submitted in the appropriate culture medium. Culture results depend on the quality of specimen collected. **Probable pathogens**: beta *Streptococcus* species, *Streptococcus pneumoniae, Neisseria gonorrhoeae, Neisseria meningitidis, Corynebacterium* species, *Haemophilus* species, *Bordetella pertussis* and other *Bordetella* species, and multiple viruses.
Bronchi	None	The following collection methods are recommended to prevent contamination from the upper respiratory flora: Bronchioalveolar lavage: During a bronchoscopy procedure, a defined amount of sterile saline is used to irrigate the bronchial lining to obtain cells, protein, and potential microbes of the pulmonary interstitial and alveolar spaces. Quantitative testing is performed, providing a quantitated number of organisms per milliliter of saline. Bronchial washing: During the bronchoscopy, sterile saline is used to wash the bronchial lining of secretions to collect cells, protein, and microbes present. Bronchial brushing: During the bronchoscopy, a protected catheter bronchial brush is used to obtain a semiquantitative specimen. Colony counts of identified organisms greater than or equal to 1,000 organisms per milliliter are considered pathogenic. Submit the specimen immediately to the laboratory for testing. Specimens submitted for microbial testing must be in saline. Specimens transferred into preservative (10% formalin or alcohol preservative) will be rejected for culture. **Probable pathogens**: *Streptococcus pneumoniae, Haemophilus influenzae, Moraxella catarrhalis, Neisseria meningitidis, Corynebacterium diphtheriae, Bordetella pertussis, Bordetella parapertussis, Mycoplasma pneumoniae, Chlamydia pneumoniae, Legionella* species, *Mycobacterium tuberculosis* and other *Mycobacterium* species, *Enterobacteriaceae*, *Pseudomonas aeruginosa* and other *Pseudomonas* species; multidrug-resistant Gram-negative organisms; and multiple anaerobic, viral, parasitic, and fungal organisms.

BODY SITE	NORMAL FLORA	SPECIAL CONSIDERATIONS FOR SPECIMEN COLLECTION
Lower respiratory tract	None	Expectorated sputum collection is required to identify lower respiratory tract infections. Quality of the specimen is important for identifying pathogens. Induced sputum is collected following percussive stimulation or ultrasonic nebulization by a respiratory therapist. Endotracheal aspirate is the produced secretions suctioned and collected in a Lukens trap. Gastric aspirate is collected early in the morning specifically to test respiratory drainage in the stomach for acid-fast bacilli (AFB) from patients unable to produce sputum. AFB are capable of surviving the gastric acidity for a limited time. **Probable pathogens**: *Corynebacterium diphtheriae, Bordetella pertussis, Bordetella parapertussis, Mycoplasma pneumoniae, Chlamydia pneumoniae, Mycobacterium tuberculosis,* nontuberculosis *Mycobacterium* species, *Enterobacteriaceae*, *Pseudomonas aeruginosa* and other *Pseudomonas* species, and multiple viruses, parasites, and fungal organisms.
GASTROINTESTINAL TRACT		
Oral cavity	*Staphylococcus aureus, Streptococcus* species, viridans group *Streptococcus*, *Actinobacillus* species, *Actinomyces* species, *Cardiobacterium* species, *Kingella* species, *Bifidobacterium* species, *Eikenella corrodens, Gemella* species, *Enterobacteriaceae*, and mixed anaerobic organisms (*Veillonella* species, *Peptostreptococcus* species, *Prevotella* species, *Peptostreptococcus* species, *Porphyromonas* species, and *Fusobacterium* species)	Oral bacterial cultures are not typically performed. Cultures would be obtained for the following infections: chronic oral lesions or ulcers, thrush, periodontal abscesses and parotitis. **Probable pathogens**: *Actinobacillus* species, *Actinomyces* species, *Cardiobacterium* species, *Kingella* species, *Bifidobacterium* species, *Eikenella corrodens, Gemella* species, *Enterobacteriaceae*, mixed anaerobic organisms (*Veillonella* species, *Peptostreptococcus* species, *Prevotella* species, *Peptostreptococcus* species, *Porphyromonas* species and *Fusobacterium* species), and multiple viruses and fungal organisms.
Esophagus	Transient flora from oral and upper respiratory drainage	Endoscopic biopsy and brushings typically reveal few organisms on smears and fungal and viral cultures. **Probable pathogens**: Rare bacterial pathogens, *Candida albicans,* herpes simplex virus, and cytomegalovirus.

BODY SITE	NORMAL FLORA	SPECIAL CONSIDERATIONS FOR SPECIMEN COLLECTION
Stomach	Transient flora that survive the gastric acidity	Gastric aspirate or endoscopic biopsy may reveal *Helicobacter pylori* and *Mycobacterium* species.
Small intestine	Mostly transient flora: *Streptococcus* species, *Enterococcus* species, *Lactobacillus* species, enteric bacteria, *Bacteroides* species, and some *Bifidobacterium* species (located at the ileocecal junction)	
Large intestine	*Bacteroides* species, *Bifidobacterium* species, *Enterococcus* species, *Staphylococcus* species, *Lactobacillus* species, *Clostridium* species, *Escherichia coli,* and other enteric organisms	Stool culture: For routine culture, collect at least a pea-sized specimen for formed stool or 5 mL for liquid stool. Stool should *never* be retrieved from the toilet. For viral testing, place specimen in appropriate viral media and transport to the laboratory within 2 hours. To collect a stool specimen from a diaper, line clean diaper with plastic wrap, and then use aseptic technique with a swab or sterile tongue depressor to obtain specimen. Rectal swab, which is used to identify enteric pathogens, should be inserted 2.5 cm past the anal sphincter. Collection of a stool specimen for ova and parasitic testing should occur before the start of antiparasitic treatment or the administration of barium, iron, metronidazole, tetracycline, Kaopectate, Milk of Magnesia, or Pepto-Bismol, or wait 7 to 10 days before initiating testing. **Probable pathogens**: *Staphylococcus aureus, Bacillus cereus, Clostridium perfringens, Salmonella* species, *Vibrio* species, *Shigella* species, *E. coli, Yersinia enterocolitica, Listeria monocytogenes, Clostridium botulinum, Aeromonas* species, *Plesiomonas shigelloides*, and multiple parasites and viruses. *Clostridium difficile* infection is both community and healthcare associated; it is most often seen following antibiotic treatment although it can be acquired through exposure to organism spores in the environment.
URINARY TRACT		
Kidneys	None	
Ureters	None	

BODY SITE	NORMAL FLORA	SPECIAL CONSIDERATIONS FOR SPECIMEN COLLECTION
Bladder	None	Suprapubic bladder aspiration is warranted to reduce potential contamination. Disinfect the skin with an approved disinfectant. Using a sterile needle and syringe, aspirate urine for culture.
Urethra (distal)	*Corynebacterium* species, *Staphylococcus* species, *Enterococcus* species, *Lactobacillus* species	Remove exudate from urethral opening with a sterile swab. Insert a new sterile flexible swab 2 to 4 cm and rotate for 2 seconds.
Urine	None	Take care to prevent contamination of the specimen by normal flora of vagina, perineum, and anterior urethra. Clean-catch midstream: For females, separate the labia, wipe front to back with provided wipe or soap and water, follow with a water rinse; while keeping the labia separated, begin voiding into the toilet; then collect urine in the provided sterile urine container. For males, retract foreskin and clean glans with provided wipe or soap and water; follow with a rinse; while retracting foreskin, begin voiding in the toilet; then collect urine in the provided sterile urine container. Straight catheter (in and out): Appropriately disinfect the insertion site and insert the catheter into the bladder. Discard the first 15 mL urine; collect the remainder. Foley catheter: Avoid collecting urine directly from the Foley bag. Access the catheter collection port; after disinfecting it with 70% alcohol, aspirate 5 to 10 mL urine; submit specimen for testing. Pediatric urine collection: A collection bag may be applied using aseptic technique and monitored until approximately 5 mL urine are obtained; submit specimen for testing.
FEMALE REPRODUCTIVE TRACT		
External genitalia	*Staphylococcus* species, *Enterococcus* species, *Corynebacterium* species, viridans group *Streptococcus*, *Kingella* species, *Peptostreptococcus* species, *Prevotella* species, *Bacteroides* species, *Escherichia coli,* and *Proteus* species	Genital lesions: Clean with sterile saline; remove lesion surface with sterile scalpel blade, and collect specimen with sterile swab at the base of the lesion.

BODY SITE	NORMAL FLORA	SPECIAL CONSIDERATIONS FOR SPECIMEN COLLECTION
Vagina/cervix	*Staphylococcus aureus,* coagulase-negative *Staphylococcus*, *Enterococcus* species, *Corynebacterium* species, viridans group *Streptococcus*, *Kingella* species, *Eubacterium* species, *Veillonella* species, *Lactobacillus* species, *Peptostreptococcus* species, *Prevotella* species, *Bacteroides* species, *Escherichia coli,* and *Proteus* species	Remove exudate and excess mucous secretions using sterile water or sterile normal saline. Obtain specimen from mucosal membrane of vaginal vault with sterile swab. Bartholin cyst: Clean the skin with an approved antiseptic; aspirate fluid from cyst with sterile needle and syringe. **Probable pathogens**: *Chlamydia trachomatis, Neisseria gonorrhoeae, Gardnerella vaginalis*, herpes simplex virus, and *Trichomonas vaginalis* (parasite).
Uterus	None	Without using lubricant on speculum, first remove the excess mucus from the vagina and cervix. Using a sterile, flexible swab, insert swab into the endocervical canal.
MALE REPRODUCTIVE TRACT		
External genitalia	Coagulase-negative *Staphylococcus, Corynebacterium* species, and anaerobic organisms	Remove exudate; then insert a sterile, flexible minitip swab 2 to 4 cm into urethra, rotating swab for 2 seconds. **Probable pathogens**: *Chlamydia trachomatis, Neisseria gonorrhoeae, Gardnerella vaginalis,* herpes simplex virus, and *Trichomonas vaginalis* (parasite).
WOUNDS		
Decubiti	Skin flora as defined above	Tissue biopsy and aspirated specimens are acceptable for aerobic and anaerobic cultures.
Burns	Skin flora as defined above	Tissue biopsy and aspirated specimens are acceptable for aerobic and anaerobic cultures.
Abscesses (lesions, pustules, ulcers, surgical wounds)	Skin flora as defined above	Superficial: Clean area with sterile water, and swab along edge of wound.

BODY SITE	NORMAL FLORA	SPECIAL CONSIDERATIONS FOR SPECIMEN COLLECTION
OTHER SITES		
Body fluids (amniotic, abdominal, synovial, pericardial, pleural)	None	Prepare the skin with an approved antiseptic at the aspiration site. Collect fluid with sterile needle and syringe; 1 to 5 mL of fluid is adequate for culture, and 5 to 10 mL is ideal.
Bone	None	Bone biopsy: Perform under sterile conditions.
Bone marrow	None	Must be collected by licensed independent providers.
Vascular catheter tip	None	Clean catheter site with 70% alcohol. Remove catheter using aseptic technique and cut 5 cm of distal catheter tip. Place tip in sterile container and transport immediately. Quantitative culture is obtained by rolling catheter tip across sheep blood agar with sterile forceps. Report of greater than or equal to 15 colonies is clinically significant.
Deep tissue/ organ space	None	Clean area with sterile saline or water; aspirate exudate, pus, or material from wall or excise tissue. Send immediately for aerobic and anaerobic culture.

REFERENCES

Aas JA, Paster BJ, Stokes LN, Olsen I, Dewhirst FE. Defining the normal bacterial flora of the oral cavity. *J Clin Microbiol.* 2005;43(11):5721–5732. doi:10.1128/JCM.43.11.5721-5732.2005.

Association for Professionals in Infection Control and Epidemiology. *APIC Text Online*. 2017. http://text.apic.org.

Bennett JE, Dolin R, Blaser MJ. *Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases*. 8th ed. Philadelphia, PA: Saunders; 2015.

Carroll K, Morse SA, Mietzner T, et al, eds. *Jawetz, Melnick, and Adelberg's Medical Microbiology*. 27th ed. New York: McGraw-Hill Education; 2016.

Davis CP. Normal flora. In: Baron S, ed. *Medical Microbiology.* 4th ed. Galveston: University of Texas Medical Branch at Galveston; 1996. https://www.ncbi.nlm.nih.gov/books/NBK7617.

Gilbert DN, Chambers HF, Eliopoulos GM, Saag MS, Pavia AT. *The Sanford Guide to Antimicrobial Therapy 2017*. 47th ed. Sperryville, VA: Antimicrobial Therapy; 2017.

Heymann DL, ed. *Control of Communicable Diseases Manual*. 20th ed. Baltimore, MD: American Public Health Association; 2014.

Jorgensen JH, Pfaller MA, Carroll KC, et al, eds. *Manual of Clinical Microbiology*. 11th ed. Washington, DC: American Society for Microbiology Press; 2015.

Kimberlin DW, Brady MT, Jackson MA, Long SS, eds. *2015 Red Book: Report of the Committee on Infectious Diseases*. 30th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2015.

Lu LJ, Liu J. Human microbiota and ophthalmic disease. *Yale J Biol Med.* 2016;89(3):325–330.

Mahon CR, Lehman DC, Manuselis G, eds. *Textbook of Diagnostic Microbiology*. 5th ed. St. Louis, MO: Elsevier; 2015.

Porter RS, Kaplan, JL, eds. *The Merck Manual of Diagnosis and Therapy*. 19th ed. Whitehouse Station, NJ: Merck; 2011.

Sthapit PR, Tuladhar NR. Conjunctival flora of normal human eye. *JSM Ophthalmol.* 2014;2(2):1021. https://www.jscimedcentral.com/Ophthalmology/ophthalmology-2-1021.pdf.

Tille PM, ed. *Bailey & Scott's Diagnostic Microbiology*. 14th ed. St. Louis, MO: Mosby; 2017.

Tortora GJ, Funke BR, Case CL, eds. *Microbiology: An Introduction*. 12th ed. Boston: Pearson; 2016.

Verstraelen H, Vilchez-Vargas R, Desimpel F, et al. Characterisation of the human uterine microbiome in non-pregnant women through deep sequencing of the V1-2 region of the 16S rRNA gene. *PeerJ*. 19;4:e1602. doi:10.7717/peerj.1602.

ADDITIONAL RESOURCES

American Society for Microbiology. http://www.asm.org.

Centers for Disease Control and Prevention. http://www.cdc.gov.

Centers for Disease Control and Prevention. Healthcare-Associated Infections. http://www.cdc.gov/hai.

Lee E. Microbial pathogenicity and host response. In: *APIC Text Online.* 2014. http://text.apic.org/toc/microbiology-and-risk-factors-for-transmission/microbial-pathogenicity-and-host-response.

National Institutes of Health. Understanding Emerging and Re-emerging Infectious Diseases. Bethesda, MD: National Institutes of Health; 2007. https://www.ncbi.nlm.nih.gov/books/NBK20370/#top.

World Health Organization. http://www.who.int.

CHAPTER 3

Fungi

Fungi are widely distributed in nature. Of the more than 100,000 species of fungi, fewer than 500 species are known to cause disease or infections in humans and other animals. Fewer than 50 species have been identified to cause infections in healthy persons. However, fungi are common causes of infection in patients with altered immune systems. **Mycology** is the study of fungi. **Mycosis** refers to infections or diseases caused by fungi.

GROWTH

The two broad groups of fungi are described as yeasts or molds based on the macroscopic appearance of the colonies formed. **Yeasts** are unicellular, round to oval organisms ranging in size from 2 to 60 µm. Yeasts reproduce by budding and the production of spores and produce moist, creamy, opaque, or pasty colonies. Basic structures of **molds** are tube-like projections known as *hyphae* or *pseudohyphae*. Molds reproduce by elongation and fragmentation of their hyphae and produce fluffy, cottony, wooly, or powdery colonies. Several pathogenic species of fungi can grow as both yeast or mold; they are referred to as **dimorphic**, meaning two forms of growth.

TAXONOMY

The term **fungus** refers generically to all members of the kingdom fungi. Clinically significant species include multiple types of yeasts and molds (mildews, rusts, and smuts). Clinically significant fungi require treatment by anti-infective drugs—specifically, antifungals. Antibacterial drugs are not effective in the treatment of fungal infections.

The four major categories of mycosis are as follows:

- **Superficial or cutaneous mycoses**: Infections or diseases that involve hair, skin or nails without direct invasion of deeper tissues. This category includes infections caused by dermatophytes, a group of three genera of fungi, *Epidermophyton, Trichophyton,* and *Microsporum,* that commonly cause skin disease in people or animals.
- **Subcutaneous mycoses**: Infections or diseases (chromoblastomycosis and mycetoma) that involve cutaneous and subcutaneous tissues.

- **Systemic mycoses**: Infections or diseases that affect a specific body system, usually the lungs although any organ system may be involved. This category includes infections caused by *Blastomyces, Coccidioides, Histoplasma,* and *Paracoccidioides* species and *Penicillium marneffei.*
- **Opportunistic mycoses**: Systemic mycoses that occur primarily in patients whose immune status is altered either by underlying disease or use of immunosuppressive agents. This category includes infections caused by *Aspergillus, Candida,* and *Cryptococcus.*

TABLE

The following table will help guide the user through an understanding of fungi. Note that the table

- lists the fungi by genus;
- describes the fungi, including their reservoirs and locations where they are normally found;
- lists the names and formerly known as (fka) names, if applicable; and
- describes infections and the mode of transmission.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Acremonium (fka *Cephalosporium*)	Mold; found in soil, decaying plants; worldwide; common in Asia, Oceania, Europe, and North, South, and Central America.	*A. kiliense* *A. potronii* *A. recifei*	Skin and nail infections; corneal ulcers; meningitis; endocarditis; endophthalmitis; osteomyelitis; peritonitis. Opportunistic infections in immunocompromised patients.	Traumatic inoculation.
Alternaria	Mold; found in tomatoes, plants, food stuffs, soil; most commonly found in outdoor air; common in tropics and subtropics.	*A. alternata* *A. infectoria*	Sinusitis; keratitis; nail infections; keratomycosis; subcutaneous, cutaneous, and invasive infections; otitis media; osteomyelitis. Opportunistic infections in bone marrow transplant patients.	Contact; inhalation.
Apophysomyces	Mold; found in tropic and subtropical soil.	*A. elegans*	Skin and soft tissue infections; necrotizing fasciitis; osteomyelitis; bladder and renal infections; mucormycosis; systemic zygomycosis (rare cause of infections).	Traumatic injury to skin, such as insect bites or surgical and burn wounds; inhalation.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Arthrographis	Mold; found in soil and compost; worldwide.	*A. kalrae*	Nail infections; opportunistic infections.	Contact; trauma; inhalation.
Aspergillus	Mold; found in soil, natural debris, air-handling systems, indoor and outdoor air; worldwide.	*A. flavus* *A. fumigatus* *A. lentulus* *A. nidulans* *A. niger* *A. terreus*	Invasive pulmonary aspergillosis; otomycosis; opportunistic infections; aspergilloma; toxicosis; allergic reactions; sarcoidosis. Secondary colonizers after *Candida.*	Contact; trauma; inhalation; ingestion.
Aureobasidium	Yeast-like mold; found in plant debris, soil, wood, textiles, and indoor air environment; worldwide.	*A. pullulans*	Rare infections; phaeohyphomycosis; keratomycosis; pulmonary mycosis with sepsis; cutaneous mycoses; other opportunistic infections. Catheter-associated septicemia; peritonitis; "humidifier lung."	Contact.
Basidiobolus	Mold; found in decaying vegetables and plants, debris, dung, soil; worldwide; more abundant in Indonesia, Uganda, Nigeria, tropical regions.	*B. ranarum*	Subcutaneous chronic infections, mostly in male children; basidiobolomycosis; rare gastrointestinal (GI) infections.	Inhalation; trauma.
Beauveria	Mold; found in decaying vegetable matter, soil; worldwide.	*B. bassiana*	Rare mycotic keratitis; pneumonia in immunocompromised patients.	Contact; inhalation.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Bipolaris	Mold; found in soil, plants; worldwide.	*B. australiensis* *B. hawaiiensis* *B. spicifera*	Meningitis; sinusitis; peritonitis; keratitis; cutaneous and pulmonary infections; fungemia; otitis media in farm workers.	Contact; inhalation.
Blastomyces	Mold to yeast phases under appropriate conditions of temperature and nutrition; found in soil; common in states surrounding the Ohio and Mississippi Rivers, and in the Great Lakes region and Southeast and South Central United States. Associated with beaver dams.	*B. dermatitidis*	Blastomycosis; self-limited or asymptomatic localized pulmonary lesions; cutaneous and disseminated and systemic mycoses in immunocompromised patients; chronic infections of skin, genitourinary (GU) tract, bone, and kidney.	Inhalation; contact.
Blastoschizomyces	Yeast and mold phases; normal skin flora, ubiquitous worldwide in nature, soil, sand, poultry feces.	*B. capitatus* (fka *Trichosporon capitatum; Geotrichum capitatum*)	Invasive disease in leukemia patients; fungemia; disseminated infections in lung, kidney, spleen, brain, endocardium, bone; meningitis; encephalitis; urinary tract infection (UTI); skin infections; nail infections.	Contact; inhalation; endogenous.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Candida	Yeast; normal GI, oral, skin flora; worldwide.	*C. africana* (common) *C. albicans* (common) *C. catenulata* (medically important [MI]) *C. ciferrii* (MI) *C. dubliniensis* (common) *C. glabrata* (common) *C. guilliermondii* (MI) *C. haemulonii* (MI) *C. krusei* (emerging) *C. lipolytica* (emerging) *C. lusitaniae* (emerging) *C. parapsilosis* (common) *C. rugosa* (MI) *C. tropicalis* (common) *C. utilis* (MI)	Opportunistic infections; candidiasis; intravenous (IV) and central line infections (superficial to systemic); thrush; vaginitis; skin and nail infections; pulmonary disease; enteritis; esophagitis; endocarditis (may be chronic in IV drug users); meningitis; brain abscess; pyelonephritis; cystitis; surgical site infections; fungemia.	Contact; endogenous.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
		C. auris	Mostly healthcare-associated infections (HAI) isolated from central lines: bloodstream infections, UTI, wounds, and otitis. Demonstrates resistance to all 3 main classes of antifungals.	Mode of transmission is unclear. HAI may involve environmental contact, contaminated medical instruments and equipment, or person-to-person contact. Prevention includes strict adherence to hand hygiene and Contact Precautions (gown, gloves).
Chaetomium	Mold; found in soil, air, plant debris; all types of climates from extremes of Himalayas to deserts.	*C. atrobrunneum* *C. globosum* *C. perlucidum*	Contaminant. Cutaneous infections; brain abscesses; peritonitis; nail infections.	Contact.
Chrysosporium	Mold; found in soil, plant material, dung, and birds; lives on remains of hairs and feathers in soil; worldwide; common in North America, Europe, Iran.	*C. zonatum*	Skin and nail infections. Systemic infections in bone marrow transplant recipients and in patients with chronic granulomatous disease.	Contact; inhalation.
Cladophialophora	Mold; found in soil, air, plant debris; worldwide; most cases of infection in subtropical regions of Americas and Africa.	*C. bantiana* *C. carrionii*	Chromoblastomycosis; skin infections; brain abscesses; skin lesions.	Contact.
Cladosporium	Mold; found in soil, plants, organic material, surface of fiberglass duct liners, paints, textiles; worldwide.	*C. cladosporioides* *C. oxysporum*	Common contaminant. Skin, nail, and pulmonary infections; keratitis.	Contact; trauma; inhalation.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Coccidioides	Mold (environment and culture) and yeast (mature states) phases; found in soil; endemic in Southwest United States, extending into Mexico and Central and South America.	*C. immitis* *C. posadasii*	Coccidioidomycosis; transient and chronic pulmonary infections. Systemic mycosis begins in respiratory tract and disseminates to meninges, bone, skin, joints, lymph nodes, and subcutaneous tissue. Immunosuppressed patients are at increased risk.	Inhalation.
Conidiobolus	Mold; found in soil in tropical and subtropical Africa and Southeast Asia.	*C. coronatus* *C. incongruus*	Chronic granulomatous diseases, commonly involving nose and face in men and in outdoor workers.	Inhalation; trauma.
Cryptococcus	Yeast; found in soil, decaying vegetables, dung, bird feces, eucalyptus trees; worldwide; common in tropics, southern hemisphere, U.S. Pacific Northwest.	*C. gattii* *C. luteolus* *C. neoformans* *C. terreus* *C. uniguttulatus*	Cryptococcosis; opportunistic infections; acute and chronic pulmonary infections; disseminated central nervous system, cutaneous, eye, sinus, ear, and other organ infections.	Contact; inhalation.
Cunninghamella	Mold; found in Mediterranean and subtropical soil.	*C. bertholletiae*	Rare infections; mucormycosis; disseminated zygomycosis; rhinocerebral, pulmonary, and cutaneous infections. Opportunistic infections in immunocompromised patients.	Inhalation; trauma.
Curvularia	Mold; found in soil, decaying vegetation, plant material; worldwide.	*C. geniculata* *C. lunata*	Common contaminant. Wound, skin, and nail infections; keratitis; sinusitis; cerebral abscesses; pneumonia; dialysis-associated infections. Opportunistic infections in immunocompromised patients.	Inhalation; contact.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Epidermophyton	Mold; found in moist showers and gyms; worldwide.	*E. floccosum*	Dermatophytoses; superficial, cutaneous mycosis: ringworm of the foot, body, groin, and nails.	Contact.
Exophiala	Mold; found worldwide in decaying wood, soil, plant debris, fruits, vegetables; common skin colonization in irritated, excoriated skin and eczema.	*E. dermatitidis* (fka *Wangiella dermatitidis*) *E. jeanselmei*	Cutaneous, subcutaneous, mucosal, systemic disease; granuloma; skin infections; chromoblastomycosis, intramuscular abscess with fistula formation; endocarditis, septic arthritis, cerebral infections; may be fatal in immunocompromised patients.	Contact; trauma.
Exserohilum	Mold; found in plant material, particularly grasses, and soil; common in warm, humid climates.	*E. rostratum*	Rare infections; phaeohyphomycosis characterized by lesions mimicking hemorrhagic herpes zoster; keratitis.	Contact.
Fonsecaea	Mold; found in soil, wood; common in Central and South America.	*F. monophora* *F. pedrosoi*	Chromoblastomycosis.	Environmental contact; trauma.
Fusarium	Mold; found worldwide in soil, plants, grains, humidifiers.	*F. chlamydosporum* *F. falciforme* (fka *Acremonium falciforme*) *F. moniliforme* *F. oxysporum* *F. solani*	Keratitis; subcutaneous diseases; nail infections. Systemic, invasive diseases; can be devastating to burn and bone marrow transplant patients.	Inhalation; contact; trauma; ingestion.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Histoplasma	Mold (environment) and yeast (culture) phases; found in soil contaminated with bird and bat feces; worldwide; common endemic mycosis in states surrounding the Mississippi and Ohio Rivers, and in Africa, Australia, and Eastern Asia.	*H. capsulatum* var. *capsulatum* *H. capsulatum* var. *duboisii*	Acute pulmonary histoplasmosis, often self-limited. Chronic and cavitary histoplasmosis in individuals with underlying lung disease. Disseminated/systemic mycosis in immunocompromised patients and older adults; may be fatal. *H. capsulatum* is associated with North American histoplasmosis (pulmonary and disseminated). *H. duboisii* is associated with African histoplasmosis (skin and bone).	Inhalation; contact.
Hortaea	Mold; found in soil, particularly in tropical and subtropical climates.	*H. werneckii* (fka *Exophiala werneckii*)	Tinea nigra: superficial infection of stratum corneum (usually, palms and soles of feet).	Direct inoculation onto skin; contact.
Lacazia	Yeast-like mold; found in tropical zone waters; restricted to South America.	*L. loboi* (fka *Loboa loboi*)	Lobomycosis: a tropical mycosis characterized by mucocutaneous lesions, usually nodular, vegetating, verrucose, cauliflower-like, and hyper- or hypopigmented.	Cutaneous trauma; insect bite; skin wound via contact with infected surrounding, such as dolphins.
Leptosphaeria	Mold; found in soil, organic debris; West Africa, India.	*L. senegalensis*	Skin infections; black piedra: infection of the hair and scalp common in the tropics, rarely involves axillary or pubic hair.	Contact; trauma.
Lichtheimia	Mold; found in soil, compost, decaying vegetation, rotten fruits and breads, indoor air; worldwide.	*L. corymbifera* (fka *Absidia corymbifera*)	Opportunistic infections in immunocompromised patients. Pulmonary, rhinocerebral, cutaneous, GI, renal, and meningeal infections, which may disseminate; mucormycosis; zygomycosis.	Direct inoculation (wounds); inhalation; IV drug use.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Madurella	Mold; found in soil, decaying vegetation; common in the tropics, India, Africa, South America, Middle East.	*M. grisea* *M. mycetomatis*	Subcutaneous infection from traumatic foreign bodies, rare destruction of bone; human pathogen (rarely seen in the United States); Madura foot; mycetoma.	Contact; trauma.
Malassezia (fka *Pityrosporum*)	Yeast; found in soil, animals; worldwide.	*M. furfur* *M. globosa* *M. restricta* *M. slooffiae* *M. sympodialis*	Tinea versicolor: superficial mycosis (skin, hair). Rare disseminated infection in patients receiving high-dose lipid replacements; colonization of IV catheters.	Contact.
Microascus	Mold; found worldwide in soil, plant material, feathers, dung, insects.	*M. cinereus* *M. cirrosus* *M. manginii* *M. trigonosporus*	Significant invasive infections in immunocompromised patients. Nail infections; maxillary sinusitis; suppurative cutaneous granulomata; endocarditis; brain abscess.	Contact.
Microsporum	Mold; found worldwide in soil, humans, animals.	*M. audouinii* *M. canis* *M. ferrugineum* *M. gypseum* *M. praecox* *M. racemosum*	Dermatophytosis; superficial, cutaneous mycosis: ringworm of the foot, scalp, nail, body, groin, beard, hand (tinea pedis, capitis, unguium, corporis).	Direct and indirect skin contact with skin and fomites (barber clippers, clothing, contaminated shower surfaces).

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Mucor	Mold; found worldwide in soil, plants, food products.	*M. circinelloides* *M. indicus* *M. racemosus* *M. ramosissimus*	Mucormycosis; zygomycosis with tissue necrosis, vascular invasion, thrombosis. Severe opportunistic infections in immunocompromised patients; mucocutaneous, rhinocerebral, septic arthritis, and dialysis-associated infections.	Inhalation or ingestion of spores; contact.
Neotestudina	Yeast; found in soil in tropical areas, Central Africa.	*N. rosatii*	White-grain mycetoma: chronic subcutaneous infection that can lead to abscesses with possible osteomyelitis.	Traumatic implantation into the subcutaneous tissue via contact with soil.
Paecilomyces	Mold; found worldwide in soil, plants, animals.	*P. lilacinus* *P. variotii*	Keratomycosis; endocarditis; sinusitis; cellulitis; subcutaneous, cutaneous, and disseminated pulmonary infections; toxicosis.	Contact; trauma; inhalation.
Paracoccidioides	Mold (room temperature) and yeast (under appropriate conditions of nutrition and temperature) phases; found in soil, dust, wood; South and Central America.	*P. brasiliensis*	Paracoccidioimycosis; oral ulcerative, cutaneous, and subcutaneous lesions; lymphadenopathy; pulmonary and systemic mycoses. Emerging endemic public health problem among human immunodeficiency virus (HIV) population in Southeast Asia.	Inhalation; contact; trauma; ingestion of contaminated soil or dust.
Penicillium	Mold (room temperature) and yeast (body temperature) phases; found in soil, plant material, indoor air; Southeast Asia and China; more than 30 species.	*P. marneffei*	Keratitis; endocarditis; pulmonary and skin infections; external otomycosis; peritonitis; systemic disease. Opportunistic infection in HIV population in Southeast Asia.	Contact; soil exposure; trauma; inhalation.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Phialophora	Mold; found in water, soil, decaying vegetation; tropical and subtropical regions.	*P. americana* *P. europaea* *P. verrucosa*	Chromoblastomycosis, mycosis of the skin and subcutaneous tissues (usually lower extremities); keratitis; granulomas.	Contact; trauma.
Pichia	Yeast; found in decaying plants; skin colonizer; common in temperate and tropical regions.	*P. angusta* *P. anomala*	Generally considered a contaminant. Rare and emerging opportunistic mycoses in immunocompromised patients (e.g., those born prematurely or with low birth weight; those with lengthy hospital stays). UTI; peritonitis; prosthetic valve endocarditis; fungemia.	Contact.
Piedraia	Mold; found in soil and fomites; common in tropical climates of Central and South America, Southeast Asia, and the South Pacific islands.	*P. hortae*	Black piedra.	Direct skin-to-skin contact; indirect contact with contaminated barber clippers, hats, combs.
Pneumocystis	Yeast; formerly classified as a tissue protozoon (single-cell); worldwide.	*P. carinii* *P. jirovecii*	Asymptomatic to mildly symptomatic. Pneumonitis and interstitial pneumonia in immunocompromised patients; multiple extrapulmonary sites are associated with a rapidly fatal outcome.	Possible modes: (1) airborne; (2) acquired early in life; (3) person-to-person transmission; (4) short periods of exposure with small inoculum.
Pseudallescheria	Mold; found in soil, decaying vegetation; worldwide; most common in North and South America.	*P. boydii* (fka *Petrilidium boydii;* asexual form is *Scedosporium apiospermum*)	Skin infections; suppuration of subcutaneous tissue with sinus tracts (feet, lower leg, hand, shoulders, back, nasal sinuses); meningitis; arthritis; endocarditis; keratitis; external otomycosis; brain abscesses; pulmonary infections.	Contact; trauma.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Pyrenochaeta	Mold; found in soil, decaying vegetation; arid subtropics, Central and South America.	*P. mackinnonii* *P. romeroi*	Skin infections; suppuration of subcutaneous tissue with formation of sinus tracts (foot, lower leg, hand, shoulder, and back).	Contact; trauma.
Pythium	Mold; found in soil and plants; worldwide; more common in tropical and subtropical regions.	*P. insidiosum*	Rare infections; keratitis; cutaneous and subcutaneous infections.	Trauma; contact; ingestion.
Rhinosporidium	Mold (soil and water) and yeast (living tissue) phases; endemic in India, Sri Lanka; may occur in the Americas, Europe, Africa; more common in tropical regions.	*R. seeberi*	Nasal, conjunctiva, urethral infections; chronic granulomatous disease; rhinosporidiosis.	Contact; inhalation.
Rhizomucor	Mold; found in soil, composting or fermenting organic matter; common throughout temperate regions of the world.	*R. miehei* *R. pusillus* (fka *Mucor pusillus*) *R. variabilis*	Mucormycosis; zygomycosis in immunocompromised individuals.	Inhalation.
Rhizopus	Mold; found in soil, air, compost, wood products; worldwide.	*R. microsporus* *R. oryzae* *R. schipperae*	Mucormycosis; zygomycosis. Rhino-facial-cranial infections seen in patients who have diabetes or burns and those who are malnourished or immunocompromised.	Inhalation.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Rhodotorula	Yeast; found in soil, water, food, plants, moist skin, shower curtains, air, associated with dialysis, IV catheters, solutions, and respiratory equipment; worldwide.	*R. glutinis* *R. minuta* *R. mucilaginosa* (fka *R. rubra*)	*R. glutinis* and *R. mucilaginosa* are the most common pathogens. Meningitis; fungemia; endocarditis; chronic skin diseases; dialysis-associated peritonitis.	Contact; inhalation.
Saccharomyces	Yeast; brewer's yeast; found in beer, wine yeast, plants, animals, environment; common in wine-producing regions of the world.	*S. cerevisiae*	Thrush; UTI; empyema; fungemia.	Person to person; contact; contaminated foods.
Saksenaea	Mold; found worldwide in forest soil.	*S. vasiformis*	Rare infections; invasive lesions.	Traumatic implantation into the subcutaneous tissue via contact with soil.
Scedosporium	Mold; found worldwide in soil and plants.	*S. apiospermum* (sexual form is *Pseudallescheria boydii*)	Subcutaneous infections; keratitis; septic arthritis; osteomyelitis.	Trauma; inhalation.
Scopulariopsis	Mold; found worldwide in soil, old carpet, wallpaper.	*S. brevicaulis*	Contaminant. Nail infections (usually toenails). Skin, soft tissue, bone, and pulmonary infections in immunocompromised patients; skin infection can disseminate. Occupational allergy in tobacco industry.	Contact.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Sporobolomyces	Yeast; found in air, tree leaves, and orange peels; natural habitats are humans, mammals, birds, the environment, and plants.	*S. holsaticus* *S. roseus* *S. salmonicolor*	Lymphadenitis in patients with acquired immunodeficiency syndrome (AIDS); dermatitis; cerebral infection; fungemia.	Contact; inhalation.
Sporothrix (fka *Sporotrichum*)	Mold and yeast phases; found in soil, wood, plants; worldwide; widespread in temperate and tropical zones.	*S. brasiliensis* *S. globosa* *S. schenckii*	Cutaneous, osteoarticular, pulmonary, disseminated, and meningeal infections.	Contact; trauma.
Stachybotrys	Mold; found in water-damaged cellulose, sheetrock, paper, ceiling tiles, insulation backing and wallpaper; worldwide.	*S. chartarum*	Pulmonary hemosiderosis; produces extremely toxic mycotoxins; symptoms: dermatitis, cough, rhinitis, nose bleeds, burning sensation in the mouth and nasal passage, headache, general malaise, and fever.	Inhalation of toxins; ingestion; dermal exposure.
Trichoderma	Mold; found in soil, plant materials; prefers climates with moderate temperatures.	*T. citrinoviride* *T. longibrachiatum*	Lung infections.	Inhalation.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Trichophyton	Mold; found in soil, wet areas in gyms and showers; worldwide in warm regions; native to Mediterranean region.	*T. concentricum* *T. megninii* *T. mentagrophytes* *T. rubrum* *T. schoenleinii* *T. soudanense* *T. tonsurans* *T. verrucosum* *T. violaceum*	Dermatophytoses; superficial, cutaneous mycoses; ringworm (skin, hair, nail infections); onychomycosis; tinea pedis (athlete's foot), tinea barbae, tinea capitis, tinea corporis, tinea cruris (jock itch), tinea unguium.	Contact.
Trichosporon	Yeast; normal flora of the mouth, skin, nails, and GI tract; found in soil, water, vegetables, mammals, birds; common in South America, Africa, and Asia; sporadic infections in North America and Europe.	*T. asahii* *T. asteroides* *T. beigelii* *T. cutaneum* *T. inkin* *T. loubieri* *T. ovoides*	Opportunistic pathogen. Superficial (white piedra; nail infections; otomycosis) and invasive infections in immunocompromised patients; neutropenia is most important predisposing factor.	Contact.

REFERENCES

Association for Professionals in Infection Control and Epidemiology. *APIC Text Online*. 2017. http://text.apic.org.

Bennett JE, Dolin R, Blaser MJ. *Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases*. 8th ed. Philadelphia, PA: Saunders; 2015.

Carroll K, Morse SA, Mietzner T, et al, eds. *Jawetz, Melnick, and Adelberg's Medical Microbiology*. 27th ed. New York: McGraw-Hill Education; 2016.

Centers for Disease Control and Prevention. Fungal Diseases: *Candida auris*. https://www.cdc.gov/fungal/diseases/candidiasis/candida-auris.html.

Diep BA, Chan L, Tattevin P, et al. Polymorphonuclear leukocytes mediate *Staphylococcus aureus* Panton-Valentine leukocidin-induced lung inflammation and injury. *Proc Natl Acad Sci U S A.* 2010;107(12):5587–5592. doi:10.1073/pnas.0912403107.

Gilbert DN, Chambers HF, Eliopoulos GM, Saag MS, Pavia AT. *The Sanford Guide to Antimicrobial Therapy 2017*. 47th ed. Sperryville, VA: Antimicrobial Therapy; 2017.

Heymann DL, ed. *Control of Communicable Diseases Manual*. 20th ed. Baltimore, MD: American Public Health Association; 2014.

Jorgensen JH, Pfaller MA, Carroll KC, et al, eds. *Manual of Clinical Microbiology.* 11th ed. Washington, DC: American Society of Microbiology Press; 2015.

Kimberlin DW, Brady MT, Jackson MA, Long SS, eds. *2015 Red Book: Report of the Committee on Infectious Diseases*. 30th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2015.

Mahon CR, Lehman DC, Manuselis G, eds. *Textbook of Diagnostic Microbiology*. 5th ed. St. Louis, MO: Elsevier; 2015.

Perdomo H, Sutton DA, García D, et al. Spectrum of clinically relevant *Acremonium* species in the United States. *J Clin Microbiol.* 2011;49(1): 243–256.

Porter RS, Kaplan, JL, eds. *The Merck Manual of Diagnosis and Therapy*. 19th ed. Whitehouse Station, NJ: Merck; 2011.

Tille PM, ed. *Bailey & Scott's Diagnostic Microbiology*. 14th ed. St. Louis, MO: Mosby; 2017.

Tortora GJ, Funke BR, Case CL, eds. *Microbiology: An Introduction*. 12th ed. Boston: Pearson; 2016.

ADDITIONAL RESOURCES

American Society for Microbiology. http://www.asm.org.

Centers for Disease Control and Prevention. http://www.cdc.gov.

Centers for Disease Control and Prevention. Healthcare-Associated Infections. http://www.cdc.gov/hai.

University of Adelaide. Mycology Online. http://www.mycology.adelaide.edu.au.

World Health Organization. http://www.who.

CHAPTER 4

Parasites

A **parasite** is a single-celled organism that lives on or within another organism and obtains an advantage at the expense of the host. Humans play host to far more than 100 different parasites, some of which we share with other species. Usually, when present in low numbers, parasites exist benignly. Sometimes, however, they can be the cause of significant morbidity and mortality.

GROWTH AND STAGES

Human parasites range in size and complexity from microscopic, intracellular single-cell organisms to worms of up to 50 feet in length. Most protozoan parasites can exist in two different forms or stages:

- **Trophozoite stage**: The parasite feeds, metabolizes, and produces effects in the host characteristic of a disease associated with that organism.
- **Cyst stage**: The parasite is essentially dormant, more refractile, and stable in the environment outside of the host; this is the stage most responsible for transmission of the parasite between hosts.

Some parasites require one or more specific species to host a sexual, asexual, or developmental stage of their complex life cycle. The different hosts might serve as nutritional sources or possibly as vectors to the next host in the cycle.

TAXONOMY

The human parasites are classified into four major groups:

- **Protozoa** are the simplest life forms and include amoebas, flagellates, ciliates, and nonmotile tissue-dwelling organisms. The amoeba group can exist in the cyst form or the trophozoite form. They reproduce either sexually or asexually. Protozoa that are pathogenic to humans are classified into the following four groups based on the mode of movement:
  - Sarcodina (amoebas; e.g., *Entamoeba* species)
  - Mastigophora (flagellates; e.g., *Giardia, Leishmania* species)
  - Ciliophora (ciliates; e.g., *Balantidium* species)
  - Sporozoa (organisms whose adult stage is not motile; e.g., *Plasmodium, Cryptosporidium* species)
- **Helminths** are large, multicellular organisms whose adult stages are generally visible to the naked eye. Infection is the result of eggs that hatch into larvae in the jejunum and small intestine of humans. In

adult form, helminths cannot multiply in humans. The following are the three main groups of helminths (worms) that cause infections in humans:

- Flat worms (platyhelminths), including trematodes (flukes) and cestodes (tapeworms)
- Thorny-headed worms (acanthocephalans), whose adult forms reside in gastrointestinal (GI) tract
- Roundworms (nematodes), whose adult forms can reside in GI tract, blood, lymphatic system, or subcutaneous tissues. Larval states can also cause infection in various body tissues.

- **Microfilaria** are microscopic filarial worms transmitted by mosquitoes that can cause lymphatic filariasis in humans. The following are the three principal microfilarial worms that cause disease in humans:
  - *Wuchereria bancrofti,* which have worldwide distribution
  - *Brugia malayi,* which are distributed in Asian countries
  - *Brugia timori,* which are distributed in Asian countries

- **Arthropods** live on the outside of their hosts and transmit parasitic, viral, bacterial, and rickettsial diseases while ingesting a blood meal. The following are examples of arthropods:
  - Ticks
  - Fleas
  - Mites
  - Mosquitoes

TABLE

The following table will help guide the user through an understanding of parasites. Note that the table

- lists the parasites by genus;
- provides a description of the parasite as well as reservoirs or locations where it is normally found;
- lists the names and formerly known as (fka) names;
- describes infections and syndromes; and
- lists the mode(s) of transmission.

Parasites that are considered bioterrorism agents are denoted in the "Infections" column. For special considerations regarding bioterrorism agents, refer to Chapter 6.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Acanthamoeba	Free-living amoeba; found in freshwater and soil, contaminated water sources (e.g., pools, hot tubs, drinking water systems), sewage systems, air (e.g., cooling towers, heating and air ventilation systems); worldwide.	*A. castellanii* *A. culbertsoni*	Cutaneous infections; chronic granulomatous amoebic encephalitis; keratitis due to contaminated contact lens solution; sinusitis; infection of connective tissue around bone. Disseminated infection in immunocompromised patients.	Contact with contaminated water or soil.
Ancylostoma	Nematode (roundworm); hookworm; worldwide; prevalent in Asia and sub-Saharan Africa.	*A. duodenale*	Can be asymptomatic. Severe infections: anemia, diarrhea, fatigue, weight loss. "Ground itch," pruritus, rash at skin penetration site.	Skin penetration; ingestion.
Anisakis	Nematode (roundworm); parasite of marine mammals that can also infect humans.	*A. simplex*	Accidental infection with larval form and intestinal penetration (most common); gastric penetration and resulting complications.	Ingestion of raw or undercooked infected fish (e.g., sushi or sashimi).
Ascaris	Intestinal nematode (roundworm); worldwide; most common in tropical and subtropical areas. Reservoir: humans, pigs.	*A. lumbricoides*	Can be asymptomatic. Severe infections: impaired digestion or absorption of dietary proteins, cramping, vomiting, obstruction (especially in children); pulmonary disease.	Fecal-oral; ingestion of food or water containing worm eggs originating from contaminated soil.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Babesia	Protozoan (single-cell); parasite in blood of cattle that can also infect humans; worldwide. Reservoir: deer mice, other small mammals; outbreaks in U.S. Northeast, Midwest, and West Coast, as well as Europe and Japan.	*B. divergens*	Babesiosis resembles malaria; hemolytic anemia; fever and hepatosplenomegaly; hemoglobinuria and renal insufficiency in severe cases. Disease reported only in splenectomized patients.	Bite of an infected *Ixodes scapularis* tick.
	Protozoan (single-cell); parasite in blood of rodents that can also infect humans.	*B. microti*	Resembles malaria; hemolytic anemia; fever and hepatosplenomegaly; hemoglobinuria and renal insufficiency in severe cases. Severest cases in splenectomized patients.	Bite of an infected *Ixodes scapularis* tick.
Balamuthia	Free-living amoeba; found worldwide in soil and possibly freshwater.	*B. mandrillaris*	Central nervous system (CNS) infections; cutaneous infections; rare, often fatal granulomatous amoebic encephalitis.	Contaminated soil contact with skin wounds and cuts; dust inhalation.
Balantidium	Intestinal ciliated protozoan (single-cell); parasite of swine that can also infect primates and humans; worldwide.	*B. coli*	Invasion of the colon; possible appendicitis or dysenteric syndrome with rectosigmoid ulceration; lower abdominal pain, vomiting, cramping, diarrhea.	Fecal-oral; associated with infected swine or primates; ingestion of food or water contaminated with organism cysts.
Blastocystis	Intestinal protozoan (single-cell); parasite associated with diarrhea in swine; worldwide. Reservoir: humans and animals.	*B. hominis*	Recurrent diarrhea with fever, vomiting, intense abdominal discomfort. Symptoms more pronounced in immunocompromised patients.	Fecal-oral; ingestion of food or water containing organism cysts.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Brugia	Tissue nematode (roundworm) of primates and felines that can also infect humans; tropics and subtropics.	*B. malayi* *B. timori*	Malayan filariasis: acute lymphatic inflammation or obstruction such as hydrocele, elephantiasis (lymphatic filariasis), and chyluria.	Bite of infected mosquito (various species).
Capillaria	Intestinal nematode (roundworm); endemic in Philippines, Thailand; rare cases in other countries.	*C. philippinensis*	Relatively rare. Capillariasis: abdominal pain, flatulence, intermittent diarrhea, vomiting, weight loss, anorexia, muscle wasting, generalized massive edema.	Ingestion of raw (fresh or brackish water) fish infected with the larval stages.
Chilomastix	Intestinal flagellated protozoan (single-cell); worldwide.	*C. mesnili*	Nonpathogenic; presence may suggest poor sanitation or compromised hygiene.	Fecal-oral; ingestion of food or water containing organism cysts.
Clonorchis	Intestinal trematode (fluke); the Oriental or Chinese liver fluke; parasite of fish-eating mammals that can also infect humans; common in Asia.	*C. sinensis*	Asymptomatic infections; severe infections: cholangitis, cholangiohepatitis.	Ingestion of infected raw or undercooked fish.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Cryptosporidium	Intestinal protozoan (single-cell); associated with diarrhea, especially in domesticated livestock; can also infect humans; worldwide. Reservoir: humans, cattle, contaminated water. (recreational water parks and swimming pools). Implicated in outbreaks in developing countries; occurs mostly in children under 5 years of age.	*C. parvum* *C. hominis*	Self-limiting cryptosporidiosis: watery diarrhea with abdominal cramps, fever and nausea; intestinal, biliary, respiratory tract infections. Common in immunocompromised patients. Chronic (weeks to years) profuse watery diarrhea in patients with acquired immunodeficiency syndrome (AIDS). **Category B bioterrorism agent**.	Fecal-oral, ingestion of contaminated fruits, vegetables, shellfish, water; direct contact with infected animal or human.
Cyclospora	Intestinal protozoan (single-cell); worldwide; endemic in Central and South America, Caribbean, Mexico, Asia (India, Indonesia, Nepal), Africa; common in Southern Europe, Middle East.	*C. cayetanensis*	Often asymptomatic. Prolonged, relapsing, watery diarrhea; weight loss; abdominal pain, nausea, vomiting; fever.	Fecal-oral; associated with ingestion of fresh raspberries, strawberries, or other fruits and vegetables from Central America.
Cystoisospora	Intestinal protozoan (single-cell); worldwide, mainly tropical and subtropical areas.	*C. belli* (fka *Isopora belli*)	Can be asymptomatic. Watery diarrhea, abdominal cramps, flatulence, nausea, vomiting, signs of malabsorption. Severe in infants and young children; frequent, severe, and sometimes fatal in immunocompromised patients.	Fecal-oral; ingestion of food or water contaminated with organism cysts.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Dientamoeba	Intestinal flagellated protozoan (single-cell) having no cyst stage; worldwide; high prevalence in missionaries, Native Americans in Arizona, and institutionalized persons.	*D. fragilis*	Diarrheal disease, especially in children; nausea, vomiting, and weight loss; noninvasive diarrheal illness.	Fecal-oral; ingestion of contaminated food or water.
Diphyllobothrium	Intestinal cestode (tapeworm or segmented worm); the fish tapeworm; longest intestinal parasite of humans; worldwide; common in Scandinavian Lake areas, Northern Europe, and North and South America.	*D. latum*	Can be asymptomatic. Severe infections lead to competition with host for vitamins, such as B_{12} and folate, resulting in deficiency, megaloblastic anemia, and neurologic symptoms.	Ingestion of infected raw or undercooked fish (pike, burbot, perch, ruffe, turbot).
Dirofilaria	Tissue nematode (roundworm); the dog heartworm, which can infect humans; common in the United States along Gulf and Atlantic coasts, Mississippi River. Hosts: dogs, foxes, bears.	*D. immitis*	Usually asymptomatic. Pulmonary dirofilariasis: pulmonary embolism evoking granulomatous response producing "coin lesions," cough, chest pain, hemoptysis.	Bite of an infected mosquito.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Dracunculus	Tissue nematode (guinea worm); found in remote, impoverished areas of Africa that lack safe drinking water. In dry regions, infections occur during the rainy season, when stagnant surface water is available; in wet regions, infections occur during the dry season, when surface water becomes stagnant.	*D. medinensis*	Infected blisters; inflammation; tissue damage; lesions occur mainly on lower extremities but may occur anywhere in the body.	Ingestion of unfiltered water from ponds and other stagnant surface-water sources.
Echinococcus	Tissue cestode (tapeworm or segmented worm); the dog tapeworm or hydatid tapeworm; worldwide.	*E. granulosus* *E. multilocularis*	Hydatid, fluid-filled cysts, usually in the liver and/or lungs but can affect other organs.	Ingestion of food or water contaminated with worm eggs in dog feces; hand-to-mouth from fomites.
Endolimax	Intestinal amoebic protozoan (single-cell).	*E. nana*	Nonpathogenic; presence may suggest poor sanitary conditions or compromised hygiene.	Fecal-oral; ingestion of food or water containing organism cysts.
Entamoeba	Intestinal amoebic protozoan (single-cell); worldwide; higher prevalence in areas with poor sanitation.	*E. coli*	Nonpathogenic; presence may suggest poor sanitary conditions or compromised hygiene.	Fecal-oral; ingestion of food or water containing organism cysts.
		E. dispar	Nonpathogenic; physically indistinguishable from *E. histolytica.*	Fecal-oral; ingestion of food or water containing organism cysts.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
		E. hartmanni	Nonpathogenic; presence may suggest poor sanitary conditions or compromised hygiene.	Fecal-oral; ingestion of food or water containing organism cysts.
	Worldwide; tropical and subtropical regions. Reservoir: humans.	*E. histolytica*	Colonic irritation; amoebic dysentery; toxic megacolon; ameboma; chronic irritable bowel syndrome; cutaneous amebiasis; amoebic liver disease; invasive intestinal and extraintestinal amebiasis.	Fecal-oral; ingestion of food or water containing organism cysts; oral-anal sexual contact.
	Associated with pigs; most common intestinal parasite in Papua New Guinea.	*E. polecki*	Diarrheal disease.	Fecal-oral; ingestion of food or water containing organism cysts.
Enterobius	Intestinal nematode (roundworm); pinworm; worldwide; more common in children.	*E. vermicularis*	Can be asymptomatic. Nocturnal perianal pruritus; occasional ectopic disease such as appendicitis, salpingitis, or ulcerative bowel lesions.	Fecal-oral; ingestion of worm eggs via contact with fomites or airborne.
Fasciola	Intestinal trematode (fluke); the sheep fluke, or liver or common liver fluke; worldwide.	*F. hepatica*	Liver enlargement; bile duct obstruction; biliary cirrhosis.	Ingestion of plants or food contaminated with soil containing infective forms.
Fasciolopsis	Intestinal fluke; the large intestinal or giant fluke; primarily in Southeast Asia.	*F. buski*	Mostly asymptomatic. Severe infections involve diarrhea, abdominal pain, and malabsorption.	Ingestion of plants or food contaminated with soil containing infective forms.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Giardia	Intestinal flagellated protozoan (single-cell); worldwide. Reservoir: humans and many animal species. Most common cause of intestinal parasitosis worldwide; common in developing countries, daycare centers, immunocompromised patients, hikers.	*G. duodenalis* *G. intestinalis* *G. lamblia*	Giardiasis can be asymptomatic. Traveler's diarrhea; acute diarrhea, abdominal cramps, bloating, flatulence. May become chronic; can cause failure to thrive in children.	Fecal-oral; ingestion of cysts in contaminated water or food; inoculum of only 10 to 100 cysts sufficient for infection.
Gnathostoma	Intestinal nematode; most commonly found in Southeast Asia, South and Central America, and in some areas of Africa; a variety of mammals are hosts.	*G. doloresi* *G. hispidum* *G. nipponicum* *G. spinigerum*	Dermatologic manifestations of gnathostomiasis; panniculitis, creeping eruptions, pseudofurunculosis. Eye involvement may result in vision loss or blindness. CNS involvement may result in nerve pain, paralysis, coma and death. Any visceral organ may be affected. Considered a subtype of visceral larva migrans.	Ingestion of raw or undercooked freshwater fish, eels, frogs, birds, and reptiles.
Hymenolepis	Intestinal cestode (tapeworm or segmented worm); smallest intestinal tapeworm of humans; a parasite of mice; most common tapeworm that can infect humans; worldwide.	*H. diminuta* (aka rat tapeworm) *H. nana* (aka dwarf tapeworm)	Can be asymptomatic. Abdominal cramps; diarrhea. Severe infections: neurotoxic worm products lead to dizziness and seizures; possible autoinfection.	Ingestion of worm eggs; hatching larvae from eggs of infecting worms (autoinfection).

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Leishmania	Tissue protozoan (single-cell) of small carnivores that can infect humans; worldwide. Reservoir: humans, many animal species, including wild and domestic dogs, foxes, and some marsupials.	*L. braziliensis* *L. major*	Cutaneous disease with chronic, latent, and metastatic mucosal membrane involvement. Most cases of leishmaniasis occur in Afghanistan, Algeria, Iran, Iraq, Saudi Arabia, Syria. Mucocutaneous disease (mainly seen in Bolivia, Brazil, Peru). Opportunistic infections in immunocompromised patients.	Sand fly bite.
		L. donovani	Visceral disease, known as kala-azar (black fever) in India: subacute or chronic course with fever, hepatosplenomegaly, anemia, progressive emaciation.	Sand fly bite.
		L. mexicana	Cutaneous disease resembling that caused by *L. tropica.*	Sand fly bite.
		L. tropica	"Oriental sore": cutaneous disease seen in tropical and subtropical Africa and Asia; resembles syphilis, leprosy, or cutaneous tuberculosis.	Sand fly bite.
Loa	Tissue nematode (African eye roundworm); rainforests of West and Central Africa.	*L. loa*	Infections of the subconjunctiva; migration through connective tissues; subcutaneous edema called "Calabar swellings" around wrist or knee joints.	Tabanid fly (deerfly) bite.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Naegleria	Free-living amoeba found worldwide in freshwater, sewage, sludge, and soil.	*N. fowleri*	Acute and fulminating primary amoebic meningoencephalitis (rare, severe brain infection).	Contaminated water from small, freshwater lakes or swimming pools forced under pressure (during swimming, diving, or skiing) through the nasal mucosa covering the cribriform plate to the meninges.
Necator	Nematode (roundworm); hookworm; worldwide.	*N. americanus*	Can be asymptomatic. Severe infections: anemia, diarrhea, fatigue, weight loss; "ground itch," pruritus, rash at skin penetration site.	Skin penetration.
Onchocerca	Tissue nematode (roundworm); tropical areas in equatorial and Sahara Africa, Yemen, Central and South America.	*O. volvulus*	Infections involve debilitating itching or nodules under the skin, lymph nodes, and eyes. Worldwide, onchocerciasis (river blindness) is second only to trachoma as an infectious cause of blindness.	Black fly bite.
Paragonimus	Tissue trematode (fluke); Oriental lung fluke (eggs found in sputum); worldwide; common in China, Southeast Asia.	*P. westermani*	Can be asymptomatic. Chest pain, hemoptysis, chronic bronchitis or bronchiectasis, pleuritic chest pain, lung abscess.	Ingestion of infected crawfish or freshwater crab.
Parastrongylus	Tissue nematode (roundworm); worldwide; public health threat in Southeast Asia and Asian Pacific Islands. Hosts: variety of rodents.	*P. cantonensis* (fka *Angiostrongylus cantonensis*)	Meningitis; meningoencephalitis; eye infection with retinal detachment and blindness; pulmonary disease.	Ingestion of infected mollusk or infected paratenic hosts (e.g., shrimp, crabs, fish, frogs).

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Plasmodium	Tissue protozoan (single-cell); tropical and subtropical areas. Reservoir: humans, possibly other primates.	*P. falciparum*	Malignant malaria: anemia, undulating high fever, chills, acute renal failure, cerebral dysfunction.	Infected *Anopheles* mosquito bite; transfusion with infected blood.
	Host: infected pigtailed macaques.	*P. knowlesi*	Malaria seen in Southeast Asia.	Infected *Anopheles* mosquito bite.
		P. malariae *P. ovale* *P. vivax*	Malaria: similar to disease caused by *P. falciparum* but less severe.	Infected *Anopheles* mosquito bite; transfusion with infected blood.
Schistosoma	Tissue trematode (fluke); the blood or snail flukes; eggs found in stool; common in tropical regions; snail is intermediate host.		Intestinal schistosomiasis.	Penetration of infectious worm stage through skin.
	Eggs found in urine; common in Africa.	*S. haematobium*	Genitourinary schistosomiasis.	Penetration of infectious worm stage through skin.
	Common in Africa.	*S. intercalatum*	Rectal schistosomiasis.	Penetration of infectious worm stage through skin.
	Eggs found in stool; common in Indonesia, China, Philippines. *S. mekongi* found in Laos and Cambodia.	*S. japonicum* *S. mekongi*	Same as for *S. mansoni,* but acute disease is more pronounced due to heavy volume of egg production. Egg embolism possible in chronic disease.	Penetration of infectious worm stage through skin.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
	Common in Africa, Caribbean, South America.	*S. mansoni*	Dermatitis ("swimmer's itch") at worm entry through skin; acute schistosomiasis (Katayama fever): serum sickness–like syndrome; chronic disease.	Penetration of infectious worm stage through skin.
Strongyloides	Intestinal nematode (roundworm); exists on all continents except Antarctica; most common in regions with warm temperatures; found more frequently in areas inhabited with socioeconomically disadvantaged, or institutionalized populations, and in rural areas.	*S. stercoralis*	Chronic infections. Can be asymptomatic. Burning or colicky abdominal pain with diarrhea and mucus, nausea, vomiting, weight loss. Lethal autoinfection in immunocompromised patients.	Penetration of infectious worm stage through skin; hatching larvae from eggs of infecting worms (autoinfection).
Taenia	Intestinal cestode (tapeworm or segmented worm); the beef tapeworm; worldwide.	*T. saginata*	Can be asymptomatic. Diarrhea; abdominal cramps; rare intestinal obstruction.	Ingestion of raw or undercooked, infected beef.
	The pork tapeworm; endemic in all parts of developing world where pigs are raised.	*T. solium*	Same as for *T. saginata*; neurocysticercosis: worms encysted in almost any tissue if eggs are consumed.	Ingestion of raw or undercooked, infected pork; ingestion of worm eggs.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Toxocara	Tissue nematode (roundworm); found worldwide in soil.	*T. canis* *T. cati*	One of the most common helminthic infections. Subclinical; severe forms involve eyes, heart, brain, or other vital organs; toxocariasis in pregnant women may result in miscarriage. Infection rates are higher among people living in poverty.	Direct contact with contaminated soil or sand (e.g., in a sandbox) or infected feces of dogs *(T. canis)* or cats *(T. cati)*; ingestion of raw or undercooked meat (raw lamb or calf's liver).
Toxoplasma	Obligate intracellular protozoan (single-cell); parasite of animals that can also infect humans; worldwide. Important reservoir: cats become infected after eating small animals and birds.	*T. gondii*	Toxoplasmosis is one of the most common parasitic infections. Can be asymptomatic or mild disease; chronic or latent. Tissue cysts in brain, heart, skeletal muscle; encephalitis, myocarditis, pneumonitis in immunocompromised patients. Birth defects or serious infections (chorioretinitis) in infants of mothers who were infected during last trimester of pregnancy.	Major modes: oral and congenital; ingestion of tissue cysts in undercooked, contaminated meat; ingestion of infectious forms originating from cat feces; organ transplantation; blood transfusion; transplacental transmission.
Trichinella	Tissue nematode (roundworm); worldwide.	*T. spiralis*	Trichinosis: encysted worm larvae in skeletal muscle; early disease: diarrhea, abdominal pain, vomiting; late disease: fever, periorbital edema, myositis, weakness. Can be asymptomatic.	Ingestion of raw or undercooked, infected pork.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
Trichomonas	Tissue flagellated protozoan (single-cell) having no cyst stage; worldwide.	*T. vaginalis*	Vaginal and exocervical inflammation with hemorrhage, ulceration, and foul-smelling discharge; urethritis in males; neonatal pneumonia. Often as copathogen with other venereal disease agents; presence in minors may suggest abuse.	Sexually transmitted; genital secretions via fomites.
Trichuris	Intestinal nematode (roundworm); the whipworm; worldwide; most associated with children in tropical and subtropical regions.	*T. trichiura*	Can be asymptomatic. Severe infections: mild anemia, bloody stools and possible rectal prolapse. Growth in children with serious infection may be retarded by chronic malnutrition and anemia.	Ingestion of worm eggs.
Trypanosoma	Tissue protozoan (single-cell) of small carnivores that can infect humans; primarily confined to Africa. Reservoir: humans; possibly, domestic and wild animals.	*T. brucei gambiense*	West African (Gambian) trypanosomiasis: sleeping sickness, systemic inflammation due to buildup of immune complexes; chronic illness.	Bite of tsetse fly.
	Primarily confined to Central Africa.	*T. brucei rhodesiense*	East African (Rhodesian) trypanosomiasis: same as West African trypanosomiasis but more severe and with rash; acute morbidity and mortality.	Bite of tsetse fly.
	Confined to Central and South America, California, Louisiana, and Texas.	*T. cruzi*	American trypanosomiasis (Chagas disease): periocular edema (Romaña's sign), fever, anorexia, edema of face and lower extremities; severe myocarditis.	Feces of reduviid bug scratched into skin; blood transfusion; organ transplantation; congenital.

GENUS	DESCRIPTION	NAME(S)	INFECTIONS	MODE(S) OF TRANSMISSION
	Africa, Asia, Central and South America; hosts: animals (buffalo, camels, cattle, horses, rats).	*T. evansi*	Transient fevers, sensory disorders.	Bite of bloodsucking insects (e.g., stable flies or horseflies).
	Present only in Central and South America. Reservoir: animals (dogs, cats, armadillos, raccoons, rodents, opossums).	*T. rangeli*	Asymptomatic infection.	Bite of infected triatomine bugs.
Wuchereria	Tissue nematode (roundworm); tropics and subtropics. Reservoir: humans.	*W. bancrofti*	Bancroftian filariasis: acute lymphatic inflammation or obstruction, such as hydrocele or elephantiasis (lymphatic filariasis); chyluria.	Bite of infected mosquito (various species).

REFERENCES

Association for Professionals in Infection Control and Epidemiology. *APIC Text Online*. 2017. http://text.apic.org.

Bennett JE, Dolin R, Blaser MJ. *Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases*. 8th ed. Philadelphia, PA: Saunders; 2015.

Carroll KC, Morse SA, Mietzner T, et al, eds. *Jawetz, Melnick, and Adelberg's Medical Microbiology*. 27th ed. New York: McGraw-Hill Education; 2016.

Gilbert DN, Chambers HF, Eliopoulos GM, Saag MS, Pavia AT. *The Sanford Guide to Antimicrobial Therapy 2017*. 47th ed. Sperryville, VA: Antimicrobial Therapy; 2017.

Heymann DL, ed. *Control of Communicable Diseases Manual*. 20th ed. Baltimore, MD: American Public Health Association; 2014.

Jorgensen JH, Pfaller MA, Carroll KC, et al, eds. *Manual of Clinical Microbiology*. 11th ed. Washington, DC: American Society of Microbiology Press; 2015.

Kimberlin DW, Brady MT, Jackson MA, Long SS, eds. *2015 Red Book: Report of the Committee on Infectious Diseases*. 30th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2015.

Mahon CR, Lehman DC, Manuselis G. *Textbook of Diagnostic Microbiology*. 5th ed., St. Louis, MO: Saunders Elsevier; 2015.

Porter RS, Kaplan JL, eds. *The Merck Manual of Diagnosis and Therapy*, 19th ed. Whitehouse Station, NJ: Merck; 2011.

Roberts LS, Janovy J, Nadler S, eds. *Foundations of Parasitology.* 9th ed. New York: McGraw-Hill; 2013.

Tille PM, ed. *Bailey & Scott's Diagnostic Microbiology*. 14th ed. St. Louis, MO: Mosby; 2017.

Tortora GJ, Funke BR, Case CL, eds. *Microbiology: An Introduction*. 12th ed. Boston: Pearson; 2016.

ADDITIONAL RESOURCES

American Society for Microbiology. http://www.asm.org.

Centers for Disease Control and Prevention. http://www.cdc.gov.

Centers for Disease Control and Prevention. About Parasites. https://www.cdc.gov/parasites/about.html.

Centers for Disease Control and Prevention. Healthcare-Associated Infections. http://www.cdc.gov/hai.

Hubálek Z. Emerging human infectious diseases: anthroponoses, zoonoses, and sapronoses. *Emerg Infect Dis.* 2003;9(3):403–404. doi:10.3201/eid0903.020208.

Lee E. Microbial pathogenicity and host response. In: *APIC Text Online.* 2014. http://text.apic.org/toc/microbiology-and-risk-factors-for-transmission/microbial-pathogenicity-and-host-response.

Lienau J. Parasites. In: *APIC Text Online*. 2014. http://text.apic.org/toc/healthcare-associated-pathogens-and-diseases/parasites.

World Health Organization. http://www.who.int.

CHAPTER 5

Viruses

Viral agents play a major role in infectious diseases throughout the world, affecting humans as well as plants and other animals.

GROWTH

Viruses are obligate intracellular parasites that require living host cells to grow and reproduce. Intact viral particles, called *virions,* are made up of nucleic acid (either ribonucleic acid [RNA] or deoxyribonucleic acid [DNA]), a protein coat (capsid), and possibly an envelope composed of viral proteins and host cell lipids. Virions are taken in by living host cells, where they modify the cell metabolism to produce a new nucleic acid and protein coat. The virus particles are assembled and released by the cell to invade other host cells. The release process may cause host cell damage that leads to pathology and signs and symptoms of infection. Some viruses will lie dormant in the host cell for months or years. After this latent period, the virus forms new virus particles and damages the host cell.

TAXONOMY

The nomenclature of viral agents is more confusing and less standardized than that of bacteria, fungi, and parasites. Instead of genus and species names, viruses are often referred to by "common names" derived from the organ system involved (e.g., *hand, foot, and mouth disease*), the disease produced (e.g., *hepatitis virus*), or the location in which the disease was first seen (e.g., *Norwalk virus*). The taxonomy of the viruses is generally based on the following:

- Whether the virus contains DNA or RNA
- Whether the virus is single- or double-stranded
- The size and shape of the virus
- The structure of the protein coat
- The presence or absence of an envelope
- The mode of replication

VACCINES

The terms *immunization* and *vaccination* are used interchangeably. Immunization can be active or passive. In cases of **active immunity**, a person is exposed to the organism either by vaccination or by direct exposure. When the immune person comes into contact with the organism in the future, the immune system will remember it and trigger an immune response. Immunity is acquired over time. In cases of **passive immunity**, the person is given antibodies for a specific

disease and immunity is immediate. Another example of passive immunity is when a mother passes immunity to the newborn by way of placental transfer. Administration of certain blood products can also provide passive immunity to many organisms.

Because viral particles contain protein coats that possess "good" antigens, viruses are often made into safe and efficacious vaccines. Virus vaccines are either live, attenuated vaccines that are "weakened" from their wild types or inactivated vaccines that are heated or chemically treated.

Vaccines for prevention of viral diseases include, but are not limited to, poliomyelitis, measles, mumps, rubella, varicella, hepatitis A, hepatitis B, and influenza.

PANDEMIC INFLUENZA CONCERNS

There are three types of influenza virus: A, B, and C.

- **Influenza type A viruses** can infect people, birds, pigs, horses, dogs, marine mammals, and other animals. Subtypes of Influenza type A are based on two proteins on the surface of the virus: **hemagglutinin** (HA) and **neuraminidase** (NA). For example, H5N1 (Avian flu) contains subtype 5 of the HA protein and subtype of the NA protein on the virus surface. There are 16 known HA subtypes and 9 known NA subtypes. Influenza A viruses have been the predominant cause of worldwide pandemics. In 2009, influenza H1N1 type virus with genes from viruses previously associated with swine, avian, and human sources (antigenic shift) caused the first flu pandemic in more than 40 years.
- **Influenza type B virus** can result in epidemics with milder clinical illnesses than those caused by type A influenza.
- **Influenza type C virus** has not been associated with large epidemics and is less common than types A and B. Clinical illness resembles the common cold.

See Appendix D for additional information about seasonal influenza.

PRIONS

Prions can be described as infectious particles of abnormally folded proteins that do not contain DNA or RNA. They are associated with spongiform encephalopathies, which are rare neurodegenerative disorders that have incubation periods of months to years. Infected human tissue is usually the reservoir for prion diseases. Prion diseases are acquired through contact with infected tissue, such as transplanted organs, cerebral spinal fluid, or neurologic matter. They can be transmitted via use of contaminated medical devices and surgical equipment. Prions are abnormally resistant to normal sterilization procedures; therefore, instruments used on patients with suspected prion diseases require special care and alternative protocols when handling. Prion diseases progress rapidly and are fatal. Some prion diseases such as Kuru can also be acquired through the ingestion of the contaminated neurologic tissue of animals. This happened in Papua New Guinea.

Human prion diseases include the following:

- Creutzfeldt-Jakob disease (CJD)
- Variant Creutzfeldt-Jakob disease (vCJD)
- Fatal familial insomnia (FFI)
- Gerstmann-Straussler-Scheinker syndrome (GSS)
- Kuru

TABLE

The following table will help guide the user through an understanding of viruses.

Note that the table

- lists the viruses alphabetically by common name(s);
- notes acronyms and associated "also known as" (aka) names for the virus, if applicable;
- provides a description (RNA or DNA genome) of the virus as well as its reservoirs and geographic distribution;
- lists family and genus; and
- describes infections and syndromes, transmission, incubation, and vaccines, if applicable.

Viruses that are considered bioterrorism agents are denoted in the "Infections and Syndromes" column. For special considerations regarding bioterrorism agents, refer to Chapter 6.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Adenovirus	DNA genome; approximately 52 serotypes of Adenoviridae are associated with human disease. Adenoviridae is divided into 7 species, A through G. Species B is divided into 2 subspecies.	Adenoviridae/ *Mastadenovirus*	The most common clinical manifestations associated with Adenoviridae are respiratory and gastrointestinal (GI) infections. GI infections primarily affect infants and young children in daycare, orphanages, and hospitals.	Direct and indirect contact. Incubation period for respiratory disease is 2 to 14 days. Incubation for GI disease is 3 to 10 days.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
BK virus (BKV)	DNA genome; reservoir: humans; worldwide.	Papovaviridae/ *Polyomavirus*	Generally asymptomatic or minimally symptomatic; mild upper respiratory tract symptoms. Occur mostly in immunocompromised adults. Rare cases of progressive multifocal leukoencephalopathy (PML); polyomavirus-associated nephropathy; hemorrhagic cystitis; urethral stenosis; and hematuria; potential cause of cancer.	Little is known about transmission or events during primary infection; no definitive evidence of perinatal transmission with maternal viruria.
Borna virus	RNA genome. Reservoir: rodents; worldwide.	Bornaviridae/ *Bornavirus*	Neuropsychiatric disorders.	Secretions. Incubation: variable.
California encephalitis virus	RNA genome. Reservoir: *Aedes* mosquito egg.	Bunyaviridae/ *Bunyavirus*	Encephalitis.	Infected mosquito bite. Incubation: usually 5 to 15 days.
Chikungunya virus	RNA genome. Reservoir: primates; worldwide.	Togaviridae/ *Alphavirus*	Fever, joint pain and swelling, muscle pain, headache; possible rash.	Bite from infected mosquitoes (*Aedes aegypti* and *A. albopictus*). Incubation: 3 to 7 days.
Colorado tick fever virus (CTFV)	RNA genome. Reservoir: wood tick.	Reoviridae/ *Coltivirus*	Sudden onset of "saddleback" fever: retro-orbital pain, myalgia of legs and back, and leukopenia.	Bite of infected tick. Incubation: 4 days.
Coronavirus	RNA genome. Reservoir: humans.	Coronaviridae/ *Coronavirus*	Common cold; rare: pneumonia and bronchitis; gastroenteritis. See also SARS-associated coronavirus (SARS-CoV).	Aerosol of respiratory secretions. Incubation: 2 to 5 days.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Cowpox virus	DNA genome. Reservoir: humans, cats, cattle, rodents.	Poxviridae (subfamily Chordopoxvirinae)/ *Orthopoxvirus*	Fever and flu-like symptoms; painful papules evolve to crusts, usually located on hands or face; cutaneous lesions heal in 3 to 4 weeks, up to 12 weeks with scarring is common.	Infected animals (usually cats). Incubation: 7 days.
Coxsackievirus	RNA genomes; group A: serotypes 1–24. Reservoir: humans; worldwide; frequent outbreaks in childcare centers.	Picornaviridae/ *Enterovirus*	Febrile illness, aseptic meningitis, encephalitis, herpangina (vesicular pharyngitis; A2–6, 8, 10, 22); hand-foot-mouth disease (vesicular stomatitis; A5, 7, 9, 10, 16); lymphonodular pharyngitis (A10); epidemic hemorrhagic conjunctivitis (A24); exanthems.	Direct contact with secretions; fecal-oral; inhalation of aerosols. Incubation: 3 to 5 days.
	RNA genomes; group B: serotypes 1–6. Reservoir: humans; worldwide; frequent outbreaks in childcare centers.		Pleurodynia (Bornholm disease or devil's grip), pericarditis, myocarditis, generalized disease of the newborn, aseptic meningitis.	Direct contact with secretions; fecal-oral; inhalation of aerosols. Incubation: 3 to 5 days.
Crimean-Congo hemorrhagic fever (aka Central Asian hemorrhagic fever; Congo fever)	RNA genome; Eastern and Southern Europe, Mediterranean region, northwestern China, Central Asia, Africa, Middle East; Indian subcontinent.	Bunyaviridae/ *Nairovirus*	Sudden severe headache, chills, fever, vomiting and pain in lower back and upper abdomen muscles. Petechial hemorrhages seen 3 to 5 days after initial symptoms. **Category C bioterrorism agent**.	Bites of hard-bodied Ixodid ticks; infected animal blood; improper sterilization of medical equipment; reuse of needles; contamination of medical supplies. Incubation: 2 to 7 days.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Cytomegalovirus (CMV; aka human herpesvirus 5)	DNA genome. Reservoir: humans; worldwide.	Herpesviridae (subfamily Betaherpesvirinae)/ *Cytomegalovirus*	Infectious mononucleosis syndrome, congenital cytomegalic inclusion disease, retinitis. Associated with hepatitis, pneumonitis, encephalitis, colitis, meningoencephalitis, myocarditis, interstitial pneumonitis, Guillain-Barré syndrome. In individuals with human immunodeficiency virus (HIV): retinitis, polyradiculopathy, mononeuritis multiplex, peripheral neuropathy, esophagitis, colitis, pancreatitis, cholecystitis.	Perinatal; blood products and post open heart surgery; intimate exposure by mucosal contact with infected tissues, excretions, and secretions (excreted in urine, saliva, breast milk, cervical secretions, and semen). Incubation: 3 to 8 weeks posttransfusion or transplant; and 3 to 12 weeks postdelivery.
Dengue virus (aka breakbone fever; dandy fever; dengue hemorrhagic fever [DHF]; dengue shock syndrome [DSS]; seven-day fever)	RNA genomes; serotypes 1–4. Reservoir: humans (and, possibly, monkeys in West Africa and Southeast Asia).	Flaviviridae/ *Flavivirus*	Sudden onset of fever; severe headache; retro-orbital pain; anorexia; nausea and vomiting; rash; myalgias and arthralgias; leukopenia, thrombocytopenia, and hemorrhagic manifestations. Severe and fatal disease in children younger than 15 years.	*Aedes aegypti or A. albopictus* mosquito bite. Incubation: 3 to 10 days.
Eastern equine encephalitis virus (EEEV)	RNA genome. Reservoir: birds, bats, possibly rodents and *Aedes* mosquitoes; widely distributed in the Americas.	Togaviridae/ *Alphavirus*	Fever, headache, irritability, restlessness, drowsiness, anorexia, vomiting, diarrhea, cyanosis, convulsions, and coma; encephalomyelitis. **Category B bioterrorism agent**.	Mosquito bite. Incubation: 5 to 15 days.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Ebola virus (aka African hemorrhagic fever; Ebola disease; Ebola hemorrhagic fever)	RNA genome. Reservoir: bats suspected; antibodies found in domestic guinea pigs; Western, Central, and Southern Africa.	Filoviridae/*Filovirus*	Acute infection: sudden onset with high fever, malaise, myalgia, vomiting, diarrhea, maculopapular rash, renal/hepatic involvement and hemorrhagic diathesis. Involvement of liver, pancreas, kidney, and, to a much less degree, the central nervous system (CNS) and heart. **Category A bioterrorism agent**.	Direct contact of broken skin and mucous membranes with infected blood, organs, or secretions (including urine, saliva, sweat, feces, vomit, breast milk, semen); aerosols; sexual contact; contaminated syringes and needles. Incubation: 2 to 21 days.
Enterovirus	RNA genomes; serotypes 68–71. Reservoir: humans; worldwide; outbreaks in eye clinics and tropical areas.	Picornaviridae/*Enterovirus*	Acute hemorrhagic conjunctivitis (Enterovirus 70); aseptic meningitis, respiratory illness, encephalitis, hand-foot-mouth disease (rare; Enterovirus 71); myopathy, exanthems.	Person to person by direct contact; Fomites. Incubation: 12 hours to 3 days.
Epstein-Barr virus (EBV; aka human herpesvirus 4; kissing disease)	DNA genome. Reservoir: humans; worldwide.	Herpesviridae (subfamily Gammaherpesvirinae)/*Lymphocryptovirus*	Infectious mononucleosis, hepatitis, pneumonitis, myopericarditis, encephalitis, myelitis. Associated with chronic fatigue syndrome, African-type Burkitt lymphoma, nasopharyngeal carcinoma, CNS lymphoma, other lymphomas, leiomyosarcoma. In HIV patients: interstitial pneumonia, hairy leukoplakia, B-cell tumors.	Person-to-person contact, usually via saliva (e.g., kissing); blood products; after open heart surgery; perinatal. Incubation: 4 to 6 weeks.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Hantavirus (aka Four Corners virus; Hantaan-Korean hemorrhagic fever; hantavirus hemorrhagic fever; hantavirus respiratory distress syndrome)	RNA genome. Reservoir: rodents.	Bunyaviridae/ *Hantavirus*	Hemorrhagic fever with renal syndrome; hantavirus pulmonary syndrome. **Category C bioterrorism agent**.	Inhalation of aerosolized rodent urine and feces. Incubation: usually 5 to 15 days.
Hepatitis A virus (HAV; aka Enterovirus 72; infectious hepatitis)	RNA genome. Reservoir: humans, chimpanzees (rare); worldwide with sporadic and epidemic cycles.	Picornaviridae/ *Hepatovirus*	Fever, malaise, anorexia, nausea, abdominal pain, jaundice.	Fecal-oral; ingestion of contaminated food (e.g., oysters) and water; blood transfusions (very rare); direct transmission among men who have sex with men. Incubation: 15 to 50 days (dose related).
Hepatitis B virus (HBV; aka serum hepatitis)	DNA genome. Reservoir: humans; worldwide.	Hepadnaviridae/ *Hepadnavirus*	Primary hepatitis B infection: anorexia, abdominal discomfort, nausea and vomiting, arthralgias, rash, jaundice. Can result in chronic HBsAg carrier state; leads to hepatocellular carcinoma and cirrhosis.	Intimate contact; body excretions and secretions (e.g., blood- or serum-derived fluids, saliva, semen, vaginal fluids); percutaneous and permucosal exposure; indirect contact with contaminated inanimate surface (nonintact skin; sharing of shaving razors or toothbrushes); blood products; perinatal transmission. Incubation: 45 to 180 days (usually 60 to 90 days).
Hepatitis C virus (HCV; originally called non-A, non-B hepatitis)	RNA genome. Reservoir: humans; worldwide.	Flaviviridae/ *Hepacivirus*	Initial, acute hepatitis C infection: anorexia, abdominal discomfort, nausea and vomiting. Leads to chronic infection, hepatocellular carcinoma, cirrhosis.	Percutaneous; parenteral; sexual contact. Incubation: 2 weeks to 6 months.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Hepatitis D virus (HDV; aka delta agent hepatitis; delta-associated hepatitis; delta hepatitis; hepatitis delta virus)	Defective RNA genome; requires coinfection (HBV) for viral replication. Reservoir: humans; worldwide.	Hepadnaviridae/ *Deltavirus*	Acute infection: only in persons with acute or chronic HBV; onset is abrupt with symptoms resembling HBV; may be self-limiting or progress to chronic hepatitis; coinfection or superinfection. Can convert asymptomatic or mild chronic HBV infection into fulminant, severe, or rapidly progressive disease.	Exposure to blood and serous body fluids; contaminated needles, syringes, and plasma derivatives; sexual transmission; transmission from mother to newborn. Incubation: 2 to 12 weeks, shorter in HBV carriers.
Hepatitis E virus (HEV; aka enterically transmitted non-A, non-B hepatitis [ET-NANB]; epidemic non-A, non-B hepatitis)	RNA genome. Reservoir: unknown; found primarily in countries with inadequate sanitation.	Hepeviridae/ *Orthohepevirus*	Acute infection: abrupt onset fever, malaise, anorexia, nausea, abdominal discomfort; followed in a few days by jaundice.	Fecal-oral; ingestion of contaminated food and water. Incubation: 3 to 8 weeks.
Herpes B virus (aka B virus; cercopithicine herpesvirus 1; herpesvirus simiae; simian virus)	DNA genome; alphaherpesvirus related to herpes simplex virus. Reservoir: Asian monkeys (rhesus and cynomolgus).	Herpesviridae (subfamily Alpha-herpesvirinae)/ *Simplexvirus*	Myelitis; hemorrhagic encephalitis; highly fatal.	Bites or scratches from infected monkeys. Incubation: 3 to 7 days.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Herpes simplex virus (HSV)	DNA genome; types 1 and 2. Reservoir: humans; worldwide.	Herpesviridae (subfamily Alpha-herpesvirinae)/ *Simplexvirus*	Gingivostomatitis; pharyngitis; herpes labialis; keratoconjunctivitis; encephalitis; cutaneous and genital lesions; esophagitis; pneumonitis; hepatitis; neonatal infection; retinitis; myelitis; erythema multiforme; urethritis; endometritis; salpingitis; prostatitis; proctitis; herpetic whitlow; herpes gladiatorum.	Perinatal; close contact (mucosal surfaces or openings in skin) with a person shedding the virus from a peripheral site or mucosal surface, or in genital or oral secretions; autoinoculation. Incubation: 2 to 12 days.
Human herpesvirus 6 (HHV-6; aka roseola infantum; sixth disease)	DNA genome; type 6; clinical relevance still being defined. Reservoir: humans.	Herpesviridae (subfamily) Betaherpesvirinae)/ *Roseolovirus*	Exanthem subitum: maculopapular rash, high fever, hepatitis; encephalitis.	Saliva; infects nearly all humans by age 5 years. Incubation: 5 to 15 days.
Human herpesvirus 7 (HHV-7; aka roseola infantum)	DNA genome; type 7. Reservoir: humans.	Herpesviridae (subfamily Betaherpesvirinae)/ *Roseolovirus*	Causes 5% of roseola cases. Typically milder than HHV-6 infection): fever and maculopapular rash; childhood febrile illnesses.	Saliva. Incubation: unknown, occurs after primary infection with HHV-6.
Human herpesvirus 8 (HHV-8; aka Kaposi's sarcoma–associated herpesvirus)	DNA genome; type 8; similar to EBV. Reservoir: humans.	Herpesviridae (subfamily Gammaherpesvirus)/ *Rhadinovirus*	Kaposi's sarcoma: skin lesions and tumors; multicentric Castleman disease; primary effusion lymphoma.	Likely sexually transmitted; virus isolated in saliva, semen, leukocytes. Incubation period unknown.
Human immunode-ficiency virus (HIV)	RNA genome. Reservoir: humans; worldwide.	Retroviridae (subfamily Lentivirinae)/ *Lentivirus*	Acquired immunodeficiency syndrome (AIDS). HIV-2: an AIDS-related disease syndrome primarily found in West Africa.	Sexual contact with or exposure to blood and body fluids. Incubation: variable, generally 1 to 3 months.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Human metapneumovirus	RNA genome. Reservoir: humans; worldwide.	Paramyxoviridae/ *Paramyxovirus*	Upper and lower respiratory infections, including pneumonia. More severe illness in young children, people with specific comorbidities, and older adults.	Close personal contact and contact with infected secretions. Incubation: 3 to 6 days; most active in the winter and early spring.
Human papillomavirus (HPV)	DNA genome. Reservoir: humans; worldwide.	Papovaviridae/ *Alphapapillomavirus*	Infects cutaneous and mucosal epithelium of skin, oral cavity, conjunctiva, anus, genital tract. HPV16 and HPV18 are the most common types in invasive cancers. HPV6 is associated with verrucous carcinoma; cutaneous warts (deep plantar, common, plane, or flat warts); epidermodysplasia verruciformis may resemble flat warts or lesions of pityriasis versicolor covering the torso and upper extremities; anogenital warts are flesh- to gray-colored, hyperkeratotic, exophytic papules; may indicate the existence of cervical HPV squamous epithelial lesions, including cervical intraepithelial neoplasia.; infection of the vulva may appear as white patches; most are asymptomatic, frequent itching, burning, pain and tenderness. Recurrent respiratory papillomatosis causes hoarseness, respiratory distress; may spread to trachea and lungs.	Close person-to-person contact; anogenital warts are sexually transmitted; recurrent respiratory papillomatosis in young children acquired by passage through an infected birth canal or in utero; in adults, infection is associated with a high number of sexual partners and with oral-genital contact. Incubation: 2to 3 months (range 1 to 20 months). HPV vaccine available.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Human parechovirus (aka echovirus)	RNA genomes; serotypes 1–34 reservoir: humans; worldwide. "Echo" in "echovirus" is acronym for "enteric, cytopathic, human, orphan."	Picornaviridae/ *Enterovirus*	Aseptic meningitis, muscle weakness and paralysis, pericarditis, myocarditis, common cold, conjunctivitis, infantile diarrhea and exanthem, chronic meningitis.	Fecal-oral; person to person. Incubation: 2 to 14 days.
Human parvovirus B19 (aka erythema infectiosum; fifth disease; slapped cheek disease)	Smallest DNA genome. Reservoir: humans; worldwide; temperate climates.	Parvoviridae/ *Erythrovirus*	Rash, arthropathy, aplastic crisis, hydrops fetalis. Common in young children.	Droplet; congenital; blood transfusions from viremic donor (rare). Incubation: 4 to 20 days.
Human T-cell lymphotropic virus (HTLV)	RNA genome; types 1, 2 (3, 4 recently identified). Reservoir: infected humans.	Retroviridae/ *Deltaretrovirus*	HTLV 1: T-cell lymphomas and leukemias; HTLV-associated myelopathy/ tropical spastic paraparesis. HTLV 2 is rarely associated with neurologic disease.	Breast milk; sexual contact; intravenous (IV) drug use; transplants; transfusions. Incubation period is variable (perhaps up to 40 years; data are limited).
Influenza virus	RNA genomes; types A, B, and C. Type A reservoir: humans, swine, horses, birds, and marine mammals; type B reservoir: humans; type C reservoir: humans, swine; worldwide.	Orthomyxoviridae/ *Influenza virus*	Systemic symptoms: fever/chills, headache, myalgia, malaise, anorexia; respiratory symptoms: dry cough, severe pharyngeal pain, nasal obstruction, discharge. Type A: large pandemics with significant mortality in young people. Type B: severe disease in older adults, no pandemics. Type C: mild disease without seasonality.	Aerosol droplets; person-to-person direct contact; indirect contact with articles recently contaminated by infective nasopharyngeal secretions. Incubation: abrupt onset of symptoms within 1 to 2 days of infection. Annual influenza vaccine consists of three inactivated virus strains (two type A strains and one type B).

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Influenza A/H1N1/ H3N2/H1N2 virus (aka swine flu)	RNA genomes; type A. Reservoir: swine.	Orthomyxoviridae/ *Influenza virus*	Significant febrile respiratory illnesses. **Category C bioterrorism agent**.	Aerosol droplets; person-to-person direct contact; indirect contact with articles recently contaminated by infective nasopharyngeal secretions. Incubation: abrupt onset of symptoms within 1 to 2 days of infection. Annual influenza vaccine includes protection against H1N1.
Influenza A, Avian/ H5N1 virus (aka avian flu; bird flu)	Avian influenza A virus of the H5 and H7 subtypes able to cross the species barrier; H5N1 subtype is of the greatest concern. Distribution: evolving issue; refer to World Health Organization (WHO) and Centers for Disease Control and Protection (CDC) websites.	Orthomyxoviridae/ *Influenza Virus*	High fever, flu-like symptoms. Diarrhea, vomiting, abdominal pain; chest pain; bleeding from nose and gums; respiratory distress, hoarseness, pneumonia. **Category C bioterrorism agent**.	Principle mode of transmission: close contact with dead or sick birds; no efficient human-to-human transmission. Incubation: 2 to 8 days (can be up to 17 days); evolving issue, refer to CDC and WHO websites.
Japanese encephalitis virus (JEV)	RNA genome. Reservoir: pigs and birds; associated with rice paddies and pig farms; widespread in Asia, occurs in New Guinea and Australia.	Flaviviridae/ *Flavivirus*	Acute encephalitis can progress to paralysis, seizures, coma and death. Most infections are subclinical; aggressive encephalitis may have a prodrome of 2 to 4 days.	*Culex tritaeniorhynchus, C. annulirostris,* or *C. vishnui* mosquito bite. Incubation: 4 to 21 days. Inactivated JEV vaccine available.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
John Cunningham virus (JCV; JC virus)	DNA genome. Reservoir: humans; worldwide.	Papovaviridae/ *Polyomavirus*	Primary infection does not exhibit clinical illness. Progressive multifocal leukoencephalopathy (PML): rapidly progressive focal neurologic deficits, hemiparesis, visual field deficits, cognitive impairment, aphasia, ataxia, cranial nerve deficits; later cortical blindness, quadriparesis, profound dementia, and coma; rapid deterioration and death within 6 months. PML is the most common manifestation of JCV in HIV/AIDS patients.	Little is known about transmission or events during primary infection; transmission probably requires sustained close contact; no definitive evidence of perinatal transmission with maternal viruria. Can be reactivated in HIV/AIDS patients.
Junin virus (aka Argentine hemorrhagic fever)	RNA genome. Reservoir: rodents; limited to agricultural areas in Argentina.	Arenaviridae/ *Arenavirus*	Slow onset with fever, malaise, headache, and muscular pains; petechiae on the upper body and bleeding from the nose and gums. Disease progresses to the hemorrhagic phase. **Category A bioterrorism agent**.	Carried by local rodents (*Calomys laucha* and *C. musculinus*); sharp seasonal pattern of occurrence between February and August; seen in farmhands who inhale virus secreted in urine or droppings as the soil is disturbed. Incubation: 7 to 14 days.
Klassevirus	RNA genome. Reservoir: humans; newly identified in 2009.	Picornaviridae/ *Picornavirus*	Diarrhea; gastroenteritis.	Stool and sewerage. Incubation: unknown.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Kyasanur Forest disease (KFD) virus	RNA genome. Reservoir: infected monkeys; limited to Karnataka state, India.	Flaviviridae/ *Flavivirus*	Symptoms of KFD begin suddenly with fever, headache, severe muscle pain, cough, dehydration, GI symptoms, and bleeding; abnormally low blood pressure, low platelet, red blood cell, and white blood cell counts. After 1 to 2 weeks of symptoms, illness is biphasic; second wave of symptoms experienced at the beginning of the third week: fever and signs of encephalitis. **Category C bioterrorism agent**.	Tick bite or contact with an infected animal, such as sick or recently dead monkey, shrew, or bat. Incubation period: 3 to 8 days.
La Crosse virus (LACV)	RNA genome. Reservoir: unknown.	Bunyaviridae/ *Bunyavirus*	Usually asymptomatic or mild illness with fever, headache, nausea, vomiting, and fatigue. Rare cause of aseptic meningitis, encephalitis, flaccid paralysis.	Infected mosquito bite. Incubation: usually 5 to 15 days.
Lassa virus (aka Lassa fever)	RNA genome. Reservoir: rodents; West Africa, rare cases in Europe, Japan, and United States.	Arenaviridae/ *Arenavirus*	Initially, sore throat; lower back pain; conjunctivitis; fever, headache, myalgia, cough, vomiting, retrosternal pain, lymphopenia, thrombocytopenia, mucosal hemorrhage, multisystem failure. Duration of illness is 2 to 21 days. **Category A bioterrorism agent**.	Ingestion of contaminated food or infected rodents; direct contact with infected rodent droppings; inhalation of aerosolized urine and drippings. Incubation: 6 to 21 days.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Machupo virus (aka Bolivian hemorrhagic fever [BHF])	RNA genome. Reservoir: rodents; occurs sporadically and/or as epidemics in small villages of rural northeast Bolivia.	Arenaviridae/ *Arenavirus*	Fever, headache, myalgia, cough, vomiting, retrosternal pain, lymphopenia, thrombocytopenia, mucosal hemorrhage, multisystem failure. Chronic: deafness, spontaneous abortion, loss of coordination, hair loss. **Category A bioterrorism agent**.	Ingestion of contaminated food or infected rodents; direct contact with infected rodent droppings; inhalation of aerosolized urine and droppings. Incubation: 7 to 14 days.
Marburg virus (aka Marburg hemorrhagic fever)	RNA genome. Reservoir: unknown (monkeys and African fruit bats are susceptible, incidental hosts).	Filoviridae/ *Marburgvirus*	Acute infection: sudden onset high fever, malaise, myalgia, vomiting, diarrhea, maculopapular rash, hemorrhagic diathesis, involvement of liver, pancreas, kidney, CNS, and heart; leukopenia, thrombocytopenia. **Category A bioterrorism agent**.	Direct contact with infected blood, secretions, organs, or semen; aerosol; contaminated syringes and needles. Incubation: 2 to 21 days.
Molluscum contagiosum virus (MCV)	DNA genome. Reservoir: humans; worldwide.	Poxviridae/ (subfamily Chordopoxvirinae)/ *Molluscipoxvirus*	Children/adolescents: molluscum contagiosum lesions (small, firm, umbilicate papule with a smooth, waxy surface) appear on face, trunk, and limbs with ocular involvement. Adolescents and adults: lesions appear on lower abdomen, pubis area, inner thighs, and genitalia; 10 to 20 lesions may be present for months. Spontaneously resolves (average 2 months, as long as 4 years).	Skin-to-skin contact in children; sexual transmission; autoinoculation; contact with fomites. Incubation: 1 week to several months.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Monkeypox virus	DNA genome. Reservoir: humans, rodents; West Africa.	Poxviridae (subfamily Chordopoxvirinae)/ *Orthopoxvirus*	Similar to, but much less serious than smallpox, except for greater tendency of monkey pox to produce both lymphadenopathy and skin lesions that occur in "crops."	Person to person. Smallpox vaccination is protective. Incubation: 7 to 14 days.
Mumps virus (aka infectious parotitis)	RNA genome. Reservoir: humans; worldwide.	Paramyxoviridae/ *Rubulavirus*	Presents with mild symptoms: slight fever; headache, muscle aches, fatigue, loss of appetite, enlarged parotid glands. Complications: orchitis, oophoritis, polyarthritis, pancreatitis, meningoencephalitis.	Airborne; droplet; direct contact with saliva of infected person. Incubation: 16 to 18 days. Preventable with measles-mumps-rubella (MMR) vaccine.
Murray Valley encephalitis virus (aka Australian X disease)	RNA genome. Reservoir: birds, rabbits, kangaroos; Australia, Papua New Guinea.	Flaviviridae/ *Flavivirus*	Usually asymptomatic or mild illness with headache. Rare cause of aseptic meningitis, encephalitis, flaccid paralysis.	Mosquito *(Culex annulirostris)* bite. Incubation: 5 to 15 days.
Newcastle virus (aka Newcastle disease virus [NDV])	RNA genome. Reservoir: birds; worldwide.	Paramyxoviridae/ *Avulavirus*	Conjunctivitis.	Direct contact with secretions, feces.
Nipah virus (NiV; aka Nipah virus encephalitis)	RNA genome. Reservoir: fruit bats; swine can be an intermediate host; Malaysia.	Paramyxoviridae/ *Henipavirus*	Fever, headache; myalgia; sore throat; thrombocytopenia; encephalitis; seizures; coma. **Category C bioterrorism agent**.	Close contact with infected pigs. Incubation: 4 to 18 days.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Norovirus (aka Norwalk-like virus [NLV])	RNA genome. Reservoir: humans; worldwide. Outbreaks in close-quarter settings; food outbreaks in nursing homes and cruise ships.	Caliciviridae/ *Norovirus*	Acute onset gastroenteritis: vomiting, watery nonbloody diarrhea, abdominal cramps, myalgia, malaise, headache, dehydration. Symptoms last 24 to 60 hours.	Fecal-oral; direct person-to-person contact, contact with feces-contaminated food or water; droplets from vomitus. Incubation: 12 to 48 hours.
Norwalk virus (aka Norwalk agent; winter vomiting disease)	RNA genome. Reservoir: humans; worldwide.	Caliciviridae/ *Norovirus*	Acute gastroenteritis: self-limited, mild to moderate disease with clinical symptoms of nausea, vomiting, diarrhea, abdominal pain, myalgia, headache, malaise, low-grade fever; GI symptoms generally last 24 to 48 hours.	Fecal-oral; contact; airborne transmission from fomite suggested to explain outbreaks; ingestion of raw shellfish and contaminated vegetables. Incubation: 10 to 50 hours (usually 24 to 48 hours).
Omsk hemorrhagic fever virus (OHFV)	RNA genome. Reservoir: muskrats and voles; western Siberia.	Flaviviridae/ *Flavivirus*	Sudden onset of fever, headache, severe muscle pain, cough dehydration, GI symptoms and bleeding; abnormally low blood pressure; low platelet, red blood cell, and white blood cell counts. Illness is biphasic, with second wave of symptoms at beginning of third week: fever, encephalitis. **Category C bioterrorism agent**.	Tick bite or direct contact with an infected muskrat or vole; milk of infected goats or sheep. Incubation period: 3 to 8 days.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Orf virus (aka contagious pustular dermatosis; ecthyma contagiosum; infectious pustular dermatitis; scabby mouth; sore mouth)	DNA genome. Reservoir: humans, sheep, goats.	Poxviridae (subfamily Chordopoxvirinae)/ *Parapoxvirus*	Presents with 1 to 4 papules on hands; progresses through 6 stages, each lasting about 6 days. Typically, leaves no scars; lesions are painless and persist for approximately 6 weeks. Autoinoculation of the eye may lead to serious sequelae.	Bite from or other direct contact with by infected animals (e.g., bottle/tube feeding, shearing wool); handling infected equipment. Incubation: 3 to 7 days.
Parainfluenza virus (type 1; aka Sendai virus)	RNA genomes; serotypes 1–4. Reservoir: humans, pigs, mice, other animals; worldwide.	Paramyxoviridae/ *Respirovirus*	Croup, common cold syndrome, laryngotracheobronchitis, bronchiolitis, pneumonia.	Droplet. Incubation: 1 to 4 days.
Poliovirus (aka Heine-Medin disease; infantile paralysis)	RNA genomes; serotypes 1–3. Reservoir: humans.	Picornaviridae/ *Enterovirus*	Poliomyelitis, aseptic meningitis, encephalitis, paralytic syndrome, post-poliomyelitis syndrome, vaccine-associated paralytic poliomyelitis.	Fecal-oral (direct); saliva, feces, contaminated sewage and water (indirect). Incubation: 9 to 10 days (range 5 to 35 days). Vaccine preventable.
Powassan virus	RNA genome. Reservoir: rodents, wild mammals; Russia, Canada, United States.	Flaviviridae/ *Flavivirus*	Encephalitis with fever and nonspecific neurologic sequelae.	Infected deer tick bite. Incubation: 1 week to 1 month.
Pseudocowpox virus (aka bovine papular stomatitis, milker's virus nodules, paravaccinia virus)	DNA genome. Reservoir: humans and cattle.	Poxviridae (subfamily Chordopoxvirinae)/ *Parapoxvirus*	Symptoms include skin nodules.	Infected lesions on teats of cattle. Incubation: 3 to 7 days.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Rabies virus	RNA genome. Reservoir: animals; worldwide.	Rhabdoviridae/ *Lyssavirus*	Virus replicates at site of bite and then infects CNS; fever, excitation, dilated pupils, excessive lacrimation, salivation, hydrophobia due to spasms of throat muscles; eventually, death.	Bite or wound infected with saliva from rabid animal. Incubation: 3 to 8 weeks. Vaccine available for both animals and humans.
Respiratory syncytial virus (RSV)	RNA genome. Reservoir: humans; worldwide. Crowded conditions, such as at schools and daycare centers, increase infection rate.	Paramyxoviridae/ *Pneumovirus*	Bronchiolitis in infants and young children; pneumonia and tracheobronchitis.	Droplet; direct contact with infectious secretions and fomites. Incubation: 2 to 8 days (median 4.4 days); individuals can be contagious for as long as 4 weeks.
Rhinovirus	Small RNA genomes; more than 120 serotypes. Reservoir: humans; seasonal worldwide distribution.	Picornaviridae/ *Enterovirus*	Common cold, laryngitis, tracheitis, and bronchitis. May have role in acute sinus infections, otitis media, asthma, and chronic bronchitis.	Direct close contact; airborne droplets; fomites; self-inoculation (finger to nose, finger to eye). Incubation: 1 to 4 days.
Rift Valley fever virus (RVFV)	RNA genome. Reservoir: unknown; Eastern and Southern Africa.	Bunyaviridae/ *Phlebovirus*	Fever; encephalitis; hemorrhagic fever; blindness; hemorrhagic hepatitis.	Mosquito bite; direct exposure to infected animals. Incubation: usually 2 to 14 days.
Rotavirus	RNA genome. Reservoir: humans, zoonotic; worldwide.	Reoviridae/ *Rotavirus*	Occurs mostly in infants and young children. Gastroenteritis; vomiting, followed by severe diarrhea, which can last 3 to 8 days.	Fecal-oral; possibly airborne; may be present in contaminated water. Incubation: 24 to 72 hours.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Rubella virus (aka German measles; three-day measles)	RNA genome. Reservoir: humans; worldwide.	Togaviridae/ *Rubivirus*	Mild febrile infectious disease with diffuse macular rash; congenital rubella syndrome.	Contact with nasopharyngeal secretions of infected person; droplet; congenital. Incubation: 14to 17 days (range 12 to 23 days). Preventable with MMR vaccine.
Rubeola virus (aka red measles)	RNA genome. Reservoir: humans; worldwide.	Paramyxoviridae/ *Morbillivirus*	Coryza, conjunctivitis, red maculopapular rash (Koplik spots). Complications: bronchopneumonia.	Airborne; droplets; contaminated fomites. Incubation from exposure to prodrome: 10 to 12 days. Preventable with MMR vaccine.
SARS-associated coronavirus (SARS-CoV)	RNA genome. Reservoir: bats; major outbreaks: Canada, China, Singapore, Vietnam.	Coronaviridae/ *Coronavirus*	Severe acute respiratory syndrome (SARS): severe lower respiratory illness, fever, chills, rigors, myalgia, headache, shortness of breath, dry cough.	Direct contact; respiratory droplets, indirect contact with fomites (contaminated surfaces or objects). Incubation: 2 to 10 days (mean 5 days).
Severe fever with thrombocytopenia syndrome virus (SFTSV)	RNA genome. Reservoir: ticks; newly identified virus in 2009 in China.	Bunyaviridae/ *Phlebovirus*	Fever, thrombocytopenia, leukocytopenia, and elevated serum enzyme levels. High fatality rate.	Tick-borne; person-to-person transmission through contaminated blood. Incubation: unknown.
Sindbis virus (aka Babanki virus; Karelian fever virus; Ockelbo virus; Pogosta virus)	RNA genome. Reservoir: birds; Africa, India, Southeast Asia, Europe, Philippines, Australia, Russia.	Togaviridae/ *Alphavirus*	Fever, arthritis, rash, malaise.	Mosquito bite. Incubation: 3 to 21 days.
St. Louis encephalitis virus (SLEV)	RNA genome. Reservoir: birds; present only in the Americas.	Flaviviridae/ *Flavivirus*	Flu-like symptoms. Individuals older than 60 years are at higher risk of developing encephalitis; eighth cranial nerve is affected.	Mosquito bite: *Culex nigripalpus* (Florida), *C. tarsalis* (western United States), *C. pipicus* (Midwest). Incubation: 4 to 21 days.

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Tick-borne encephalitis virus (TBEV)	RNA genome. Three subtypes: European; Far Eastern; Siberian. Reservoir: ticks; endemic in temperate regions of Europe and Asia.	Flaviviridae/ *Flavivirus*	Approximately two-thirds of infections are asymptomatic. First phase: nonspecific febrile illness with headache, myalgia, and fatigue; usually lasts for several days; followed by an afebrile and relatively asymptomatic period. Second phase: CNS involvement resulting in aseptic meningitis, encephalitis, or myelitis; cranial nerve involvement (bulbar syndrome), and acute flaccid paralysis of the upper extremities. European subtype: associated with milder disease, a case-fatality ratio of less than 2%, and neurologic sequelae in 30% of patients. Far Eastern subtype: associated with a more severe disease course, including a case-fatality ratio of 20% to 40% and higher rates of severe neurologic sequelae. Siberian subtype: associated with chronic or progressive disease and has a case-fatality ratio of 2% to 3%. **Category C bioterrorism agent**.	Bite of an infected *Ixodes* species tick; ingestion of unpasteurized dairy products (such as milk and cheese) from infected goats, sheep, or cows. Incubation: 4 to 28 days (milk-borne exposure is usually shorter: 3 to 4 days).

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Varicella-zoster virus (VZV; aka human herpesvirus 3; herpes zoster [shingles]; varicella virus [chickenpox])	DNA genome. Reservoir: humans; worldwide.	Herpesviridae (subfamily Alpha-herpesvirinae)/ *Varicellovirus*	Chickenpox (varicella); shingles (dermatomal zoster, zoster); disseminated infection, perinatal varicella, cerebellar ataxia, encephalitis, cerebral vasculitis after herpes zoster ophthalmicus, meningitis, transverse myelitis, varicella pneumonitis, myositis, myocarditis, nephritis, hepatitis. Associated with Guillain-Barré syndrome, Reye syndrome.	Perinatal; direct person-to-person contact; droplet or airborne spread of vesicle fluids or respiratory secretions of chickenpox patients; direct contact of vesicle fluids of zoster patients; indirect contact with articles soiled with discharges from vesicles and mucous membranes of persons with chickenpox. Incubation: 2 to 3 weeks (usually 14 to 16 days). Chickenpox and shingles are vaccine preventable.
Variola virus (aka smallpox)	DNA genome. Reservoir: humans; global eradication, 1979.	Poxviridae (subfamily Chordopoxvirinae)/ *Orthopoxvirus*	Fever, malaise, backache; exanthem appears within 2 to 4 days and evolves from macules to pustules to crusts; lesions begin on face and extremities; scarring may be severe. Mortality: 30% to 50%. **Category A bioterrorism agent**.	Direct person-to-person contact; droplet or airborne spread of vesicle fluids or respiratory secretions; indirect contact with articles soiled with discharges from vesicles and mucous membranes of persons with smallpox. Incubation: 7 to 19 days with prodrome at 2 to 4 days. Vaccine available from CDC on limited basis.
Venezuelan equine encephalitis virus (VEEV; aka Everglades virus; Mucambo virus; Tonate virus)	RNA genome. Reservoir: rodents; found in the Americas.	Togaviridae/ *Alphavirus*	Fever, severe headache, back pain, myalgia, prostration, chills, nausea, vomiting, and weakness; may progress from encephalitis to death; encephalomyelitis. **Category B bioterrorism agent**.	Mosquito bite. Incubation: 2 to 6 days.
Vesiculovirus (aka vesicular stomatitis diseases)	RNA genome. Reservoir: sand fly.	Rhabdoviridae/ *Vesiculovirus*	High fever, malaise, retrobulbar pain on motion of eyes; oral mucosal vesicular lesions; meningoencephalitis.	Sand fly bite. Incubation: up to 6 days (usually 3 to 4 days).

NAME(S)	DESCRIPTION	FAMILY/*GENUS*	INFECTIONS AND SYNDROMES	TRANSMISSION AND INCUBATION
Western equine encephalitis virus (WEEV)	RNA genome. Reservoir: birds; found in the Americas.	Togaviridae/ *Alphavirus*	Fever, severe headache, back pain, myalgia, prostration, chills, nausea, vomiting, and weakness; may progress from encephalitis to death; encephalomyelitis. **Category B bioterrorism agent**.	Mosquito bite. Incubation: 5 to 15 days.
West Nile virus	RNA genome. Reservoir: birds; worldwide.	Flaviviridae/ *Flavivirus*	Fever, arthralgia, rash, encephalitis. In less than 15% of cases, acute aseptic meningitis or encephalitis; flaccid paralysis, hepatitis, pancreatitis, myocarditis, chorioretinitis. Older adults are at greatest risk of severe disease.	*Culex* species mosquito bite. Incubation: 3 to 12 days.
Yellow fever virus (YF)	RNA genome. Reservoir: humans, monkeys; tropical Central and South America (south of Panama Canal), sub-Saharan/ tropical Africa.	Flaviviridae/ *Flavivirus*	Sudden onset of fever, slow pulse, headache. Severe cases: intense albuminuria, jaundice, hemorrhage, hematemesis; hemorrhagic fever, hepatitis, nephritis; often fatal. **Category C bioterrorism agent**.	*Aedes* species mosquito bite. Incubation: 2 to 5 days. Immunization available and required by many countries.
Zika virus	South America, Central America, Puerto Rico, North America.	Flaviviridae/ *Flavivirus*	During pregnancy: birth defects, spontaneous abortion; fever, rash, headache, joint pain, red eyes, muscle pain.	*Aedes* species mosquito bite; sexual contact; intrauterine, intrapartum, or sexual routes. Incubation: 3 to 14 days.

REFERENCES

Association for Professionals in Infection Control and Epidemiology. *APIC Text Online.* 2017. http://text.apic.org.

Bag AK, Curé JK, Chapman PR, Roberson GH, Shah R. JC virus infection of the brain. *Am J Neuroradiol*. 2010;31(9):1564-1576. doi:10.3174/ajnr.A2035.

Bennett JE, Dolin R, Blaser MJ. *Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases*. 8th ed. Philadelphia, PA: Saunders; 2015.

Carroll K, Morse SA, Mietzner T, et al, eds. *Jawetz, Melnick, and Adelberg's Medical Microbiology*. 27th ed. New York: McGraw-Hill Education; 2016.

Charrel RN, Fagbo S, Moureau G, Alqahtani MH, Temmam S, Lamballerie XD. Alkhurma hemorrhagic fever virus in *Ornithodoros savignyi* ticks. *Emerg Infect Dis*. 2007;13(1):153–155. doi:10.3201/eid1301.061094.

Gilbert DN, Chambers HF, Eliopoulos GM, Saag MS, Pavia AT. *The Sanford Guide to Antimicrobial Therapy 2017*. 47th ed. Sperryville, VA: Antimicrobial Therapy; 2017.

Greninger AL, Holtz L, Kang G, Ganem D, Wang D, DeRisi JL. Serological evidence of human klassevirus infection. *Clin Vaccine Immunol.* 2010;17(10):1584-1588.

Heymann DL, ed. *Control of Communicable Diseases Manual*. 20th ed. Baltimore, MD: American Public Health Association; 2014.

Jorgensen JH, Pfaller MA, Carroll KC, et al, eds. *Manual of Clinical Microbiology*. 11th ed. Washington, DC: American Society for Microbiology Press; 2015.

Kimberlin DW, Brady MT, Jackson MA, Long SS, eds. *2015 Red Book: Report of the Committee on Infectious Diseases*. 30th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2015.

Krow-Lucal ER, Biggerstaff BJ, Staples J. Estimated incubation period for zika virus disease. *Emerg Infect Dis*. 2017;23(5):841–845. doi:10.3201/eid2305.161715.

Liu Y, Li Q, Hu W, et al. Person-to-person transmission of severe fever with thrombocytopenia syndrome virus. *Vector Borne Zoonotic Dis*. 2012;12(2):156–160.

Mahon CR, Lehman DC, Manuselis G, eds. *Textbook of Diagnostic Microbiology*. 5th ed. St. Louis, MO: Elsevier; 2015.

Porter RS, Kaplan, JL, eds. *The Merck Manual of Diagnosis and Therapy*. 19th ed. Whitehouse Station, NJ: Merck; 2011.

ScienceDirect. Pseudocowpox. http://www.sciencedirect.com/topics/neuroscience/pseudocowpox.

Southern PM, Smith JW, Luby JP, Barnett JA, Sanford JP. Clinical and laboratory features of epidemic St. Louis encephalitis. *Ann Intern Med*. 1969;71:681–689. doi:10.7326/0003-4819-71-4-681.

Tille PM, ed. *Bailey & Scott's Diagnostic Microbiology*. 14th ed. St. Louis, MO: Mosby; 2017.

Tortora GJ, Funke BR, Case CL, eds. *Microbiology: An Introduction*. 12th ed. Boston: Pearson; 2016.

Yu XJ, Liang MF, Zhang SY, et al. Fever with thrombocytopenia associated with a novel bunyavirus in China. *N Engl J Med.* 2011;364:1523–1532.

ADDITIONAL RESOURCES

American Society for Microbiology. http://www.asm.org.

Babcock H. Influenza. In: *APIC Text Online*. 2014. http://text.apic.org/toc/healthcare-associated-pathogens-and-diseases/influenza.

Centers for Disease Control and Prevention. http://www.cdc.gov.

Centers for Disease Control and Prevention. Crimean-Congo Hemorrhagic Fever (CCHF). May 9, 2014. https://www.cdc.gov/vhf/crimean-congo/index.html.

Centers for Disease Control and Prevention. Crisis and Emergency Risk Communication (CERC). April 27, 2017, https://emergency.cdc.gov/cerc.

Centers for Disease Control and Prevention. Healthcare-Associated Infections. http://www.cdc.gov/hai.

Centers for Disease Control and Prevention. Human Metapneumovirus (HMPV) Clinical Features. August 19, 2016. https://www.cdc.gov/surveillance/nrevss/hmpv/clinical.html.

Centers for Disease Control and Prevention. Influenza. December 22, 2017. https://www.cdc.gov/flu/index.htm.

Centers for Disease Control and Prevention. Kyasanur Forest Disease. January 6, 2014. https://www.cdc.gov/vhf/kyasanur.

Centers for Disease Control and Prevention. Omsk Hemorrhagic Fever (OHF). December 9, 2013. https://www.cdc.gov/vhf/omsk/index.html.

Centers for Disease Control and Prevention. Rift Valley Fever (RVF). October 19, 2016. https://www.cdc.gov/vhf/rvf/index.html

Centers for Disease Control and Prevention. Tick-borne Encephalitis (TBE). March 31, 2014. https://www.cdc.gov/vhf/tbe.

Centers for Disease Control and Prevention. Viral Hemorrhagic Fevers (VHFs). January 29, 2014. https://www.cdc.gov/vhf.

Centers for Disease Control and Prevention. Viral Hemorrhagic Fevers: *Arenaviridae*. June 18, 2013. https://www.cdc.gov/vhf/virus-families/arenaviridae.html.

Centers for Disease Control and Prevention. Yellow Fever. July 12, 2016. https://www.cdc.gov/yellowfever.

Garry Lab. The Big Picture Book of Viruses. 2007. http://www.virology.net/Big_Virology/BVHomePage.html.

Lee E. Microbial pathogenicity and host response. In: *APIC Text Online.* 2014. http://text.apic.org/toc/microbiology-and-risk-factors-for-transmission/microbial-pathogenicity-and-host-response.

Midgley CM, Baber JK, Biggs HM. Notes from the field: severe human metapneumovirus infections—North Dakota, 2016. *MMWR Morb Mortal Wkly Rep*. 2017;66(18):486488. doi:10.15585/mmwr.mm6618a7.

ScienceDirect. Togaviridae. http://www.sciencedirect.com/topics/neuroscience/togaviridae.

World Health Organization. http://www.who.int.

World Health Organization. Haemorrhagic Fevers, Viral. http://www.who.int/topics/haemorrhagic_fevers_viral/en.

World Health Organization. Nipah Virus (NiV) Infection. http://www.who.int/csr/disease/nipah/en.

World Health Organization. Yellow Fever (fact sheet). May 2016. http://www.who.int/mediacentre/factsheets/fs100/en.

Yun SM, Lee WG, Ryou J, et al. Severe fever with thrombocytopenia syndrome virus in ticks collected from humans, South Korea, 2013. *Emerg Infect Dis*. 2014;20(8):1358–1361. doi:10.3201/eid2008.131857.

CHAPTER 6

Bioterrorism Agents

Bioterrorism is defined as the unlawful use or threatened use of bacteria, viruses, or toxins to produce disease or death in humans. The act is intended to create fear and to intimidate. Biological warfare agents have been used for more than 2,000 years.

- During the sixth century B.C., Assyrians poisoned enemy wells with fungus.
- In 1346, the Tartar army hurled bodies of soldiers who died during plague outbreaks over city walls, beginning the "Black Death" pandemic in Europe.
- In 1756, the English provided smallpox-laden blankets to Native Americans who were loyal to the French during the French-Indian War.
- In 1937, Japan used human test subjects in occupied China. Seven hundred and thirty-one out of 1,000 autopsies revealed death by aerosolized anthrax.
- In 1940, Japanese planes dropped pots containing plague-infected fleas over China.
- In 2001, bioterrorism attacks using anthrax-laden letters occurred in the United States.

The Centers for Disease Control and Prevention (CDC) categorize bioterrorism agents according to priority, as follows:

Category A bioterrorism agents are biological agents that have high potential for an adverse public health impact, increased risk to national security, serious potential for large-scale dissemination, potential for public panic and social disruption, and high mortality rates. Category A bioterrorism agents include the following:

- Anthrax *(Bacillus anthracis)*
- Botulism (*Clostridium botulinum* toxin)
- Plague *(Yersinia pestis)*
- Smallpox *(Variola major)*
- Tularemia *(Francisella tularensis)*
- Viral hemorrhagic fevers
  - Filoviruses
    - Ebola hemorrhagic fever (Ebola virus)
    - Marburg hemorrhagic fever (Marburg virus)

- Arenaviruses
  - Argentinian hemorrhagic fever (Junin virus)
  - Bolivian hemorrhagic fever (Machupo virus)
  - Lassa fever (Lassa virus)

Category B bioterrorism agents are moderately easy to disseminate and have specific requirements for disease surveillance, moderate morbidity rates, and low mortality rates. Category B bioterrorism agents include the following:

- Alpha viruses, such as Eastern equine encephalitis, Venezuelan equine encephalitis, and Western equine encephalitis viruses
- Brucellosis (*Brucella* species)
- Epsilon toxin of *Clostridium perfringens*
- Glanders *(Burkholderia mallei)*
- Melioidosis *(Burkholderia pseudomallei)*
- Psittacosis *(Chlamydia psittaci)*
- Q fever *(Coxiella burnetii)*
- Ricin toxin from *Ricinus communis* (castor beans)
- Staphylococcal enterotoxin B
- Typhus *(Rickettsia prowazekii)*
- West Nile virus
- A subset of Category B agents includes foodborne or waterborne pathogens, such as the following:
  - *Cryptosporidium parvum*
  - *Escherichia coli* O157:H7
  - *Salmonella* species
  - *Shigella dysenteriae*
  - *Vibrio cholera*

Category C bioterrorism agents are emerging infectious diseases and pathogens that potentially could be engineered for mass dissemination due to availability or ease of production and would have a major health impact, with potential for high morbidity or mortality rates. Category C agents include the following:

- Chikungunya virus
- Dengue virus
- Hantavirus
- Influenza, pandemic
- Nipah virus
- SARS (severe acute respiratory syndrome)–associated coronavirus (SARS-CoV)
- Tick-borne encephalitis viruses: flaviviruses
- Tick-borne hemorrhagic fever viruses
  - Bunyaviruses
  - Omsk hemorrhagic fever virus
  - Kyasanur Forest virus

- Tuberculosis, multidrug-resistant
- Yellow fever

TABLE

The following table provides basic concepts regarding prevention of healthcare-associated infections (HAIs) once an outbreak related to a bioterrorism agent has been identified.

The table includes

- microbes (bacteria, parasites, and viruses) that are considered bioterrorism agents, including the CDC category;
- disease or common names of the bioterrorism agents; and
- precautions and treatment to prevent HAIs once an outbreak has been identified.

Information regarding genus, description, name, infections, and modes of transmission is not duplicated in this chapter. Refer to Chapters 1, 3, and 4 or the index for further information.

MICROBE	DISEASE NAME(S)	CDC CAT.	ISSUES RELATED TO NOSOCOMIAL TRANSMISSION	TREATMENT	COMMENTS
BACTERIA					
Bacillus anthracis	Anthrax	A	**Inhalation**: Standard Precautions. Not transmitted person to person. **Cutaneous**: Standard and Contact Precautions with uncontained drainage; direct contact with skin lesions *may* result in cutaneous infection. **Gastrointestinal (GI)**: Standard Precautions. Not transmitted person to person; no restrictions on room placement or transportation. **Injection**: Begins as cutaneous anthrax but spreads throughout the body and is difficult to recognize; associated with intravenous (IV) drug use.	Vaccine used in U.S. military, not offered to general public. Ciprofloxacin is drug of choice; doxycycline and/or penicillin may also be used; antitoxin in conjunction with other treatment options is recommended by the Centers for Disease Control and Prevention (CDC).	Spores can be bioterrorism agent when weaponized into powder for inhalation.

MICROBE	DISEASE NAME(S)	CDC CAT.	ISSUES RELATED TO NOSOCOMIAL TRANSMISSION	TREATMENT	COMMENTS
Burkholderia mallei	Glanders	B	Standard and Contact Precautions. Private room; limit movement from room to essential purposes only.	Limited information on antibiotic treatment exists. Sulfadiazine, tetracycline, ciprofloxacin, streptomycin, gentamycin, novobiocin, imipenem, ceftazidime, and sulfonamides may be used.	Exists only in infected susceptible hosts (horses, mules, donkeys); endemic in Africa, Asia, Middle East, and Central and South America.
Burkholderia pseudomallei	Melioidosis	B	Standard and Contact Precautions.	Limited information on antibiotic treatment exists. Ceftazidime, meropenem, and doxycycline cotrimoxazole may be used.	Widely distributed in soil and water of the tropics; endemic in Southeast Asia and Northern Australia.
Brucella species	Brucellosis, "Malta fever," undulant fever	B	Standard and Contact Precautions. Private room; limit movement from room to essential purposes only.	Rifampin, doxycycline.	Most cases are from ingestion of unpasteurized dairy products.
Chlamydia psittaci	Psittacosis	B	Standard Precautions. No restrictions regarding room placement or movement within the hospital.	Tetracycline.	Widespread dissemination possible to people who have pet birds, visit pet shops, and/or care for birds.
Clostridium botulinum toxin	Botulism	A	Standard Precautions. Not transmitted by person-to-person contact; no restrictions on room placement or movement within the hospital.	CDC currently investigating use of 7 different botulism toxins for vaccination. Supportive treatment, antitoxin, and ventilatory support; avoid clindamycin and aminoglycosides.	One of the deadliest toxins known; characterized by the 4 "Ds": diplopia, dysarthria, dysphonia, and dysphagia.

MICROBE	DISEASE NAME(S)	CDC CAT.	ISSUES RELATED TO NOSOCOMIAL TRANSMISSION	TREATMENT	COMMENTS
Clostridium perfringens	Epsilon toxin	B	Standard and Contact Precautions. Private room.	Fluid and electrolyte replacement.	Spores germinate and multiply in foods prepared in large quantities (e.g., banquets, school lunches, camp meals, catered or restaurant food) and kept warm for prolonged periods; epsilon toxin produced by spores in lower intestines cause symptoms.
Coxiella burnetii	Q fever	B	Standard Precautions. No restrictions regarding room placement or movement within the hospital.	Doxycycline.	Major manifestations of chronic disease are endocarditis and hepatitis. Mortality rate for patients with endocarditis is 30% to 60%.
Escherichia coli	*E. coli* 0157:H7	B	Standard Precautions. Contact Precautions for diapered or incontinent children younger than 6 years. Private room.	Fluid and electrolyte replacement; transfusions and hemodialysis may be necessary. Role of antibiotic therapy is uncertain.	Hemolytic uremic syndrome (HUS): triad of microangiopathic hemolytic anemia, thrombocytopenia, acute renal dysfunction; HUS frequency: 5% to 10%.
Francisella tularensis	Tularemia	A	Standard Precautions. Not transmitted by person-to-person contact; no restrictions on room placement or movement within hospital.	Streptomycin or gentamicin. Postexposure treatment: doxycycline or ciprofloxacin. No vaccine available.	Because of highly infective nature and ease of aerosolization, can be widely produced as bioterrorism agent. Generally nonlethal; severely incapacitating.

MICROBE	DISEASE NAME(S)	CDC CAT.	ISSUES RELATED TO NOSOCOMIAL TRANSMISSION	TREATMENT	COMMENTS
Mycobacterium tuberculosis	Multidrug-resistant tuberculosis (MDR-TB)	C	Airborne Precautions. N95 respirator required for all entering the room; private and negative pressure room; limit movement from room to essential purposes only; during transport, place mask on patient.	Complex and challenging, constantly evolving treatment protocols. Estimated percentage of patients with MDR-TB who are cured is 69% or less, even when directly observed treatment lasts more than 18 months.	MDR-TB is resistant to isoniazid and rifampin, with or without resistance to other drugs. Extremely resistant tuberculosis is resistant to isoniazid and rifampin, all fluoroquinolones, and at least one second-line injectable drug (amikacin, capreomycin, or kanamycin).
Rickettsia prowazekii	Typhus	B	Standard Precautions. No restrictions regarding room placement or movement within the hospital.	Doxycycline, tetracycline, chloramphenicol.	Cream and gel pediculicides (pyrethrins, lindane) for delousing. Excessive doses of topical lindane can cause seizures in children.
Salmonella species	Salmonellosis	B	Standard Precautions. Contact Precautions for diapered or incontinent children younger than 6 years; private room.	Fluid and electrolyte replacement; see CDC guidelines for additional treatment options.	*Salmonella* species were discovered by American scientist named Salmon. Known to cause illness for more than 100 years.
Salmonella typhi	Typhoid fever	B	Standard Precautions. Contact Precautions for diapered or incontinent children younger than 6 years; private room.	Supportive care; see CDC guidelines for treatment options.	Typhoid vaccine available from CDC.
Shigella dysenteriae	Shigellosis; dysentery	B	Standard Precautions. Contact Precautions for diapered or incontinent children younger than 6 years; private room.	Fluid and electrolyte replacement; antibiotic treatment depends on culture and sensitivity of organism.	HUS; colonic perforation; fulminant toxic encephalopathy (Ekiri syndrome) can be lethal within 48 hours of onset. Rare in United States; widespread in Africa and Indian subcontinent.

MICROBE	DISEASE NAME(S)	CDC CAT.	ISSUES RELATED TO NOSOCOMIAL TRANSMISSION	TREATMENT	COMMENTS
Staphylococcus aureus	Enterotoxin B	B	Standard Precautions.	Fluid and electrolyte replacement. Use of antibiotics is case specific.	Toxic shock syndrome; food poisoning; short incubation period of 30 minutes to 7 hours.
Vibrio cholerae	Cholera	B	Standard Precautions. Contact Precautions for diapered or incontinent children younger than 6 years; private room.	Rapid rehydration and electrolyte replacement; antibiotic therapy only indicated in severe cases and hospitalized patients. See CDC guidelines for further information on treatment options.	Epidemic in Africa, Asia, Latin America. Typical stools are colorless, with small flecks of mucus, called "rice water."
Yersinia pestis	Plague	A	**Pneumonic**: Standard and Droplet Precautions. Mask protection; highly contagious; spreads by respiratory droplets. Private room or cohort with like patient; restrict movement to essential purposes only. **Bubonic**: Standard Precautions.	Streptomycin or gentamicin; fluoroquinolones for plague meningitis. See CDC guidelines for further information on treatment options.	Droplet Precautions mandatory for first 48 hours of antibiotic treatment. Acral gangrene may be late complication of pneumonic plague and may occur in fingers, toes, earlobes, nose, and penis.

MICROBE	DISEASE NAME(S)	CDC CAT.	ISSUES RELATED TO NOSOCOMIAL TRANSMISSION	TREATMENT	COMMENTS
OTHER (NONMICROBE)					
Ricinus communis (castor beans)	Ricin toxin	B	Standard Precautions. Not transmitted by person-to-person contact; no restrictions on room placement or movement within the hospital; intensive care unit (ICU) maybe required for ventilatory support.	Supportive treatment to minimize poison effects; no antidote. Death occurs within 36 to 72 hours, depending on route of exposure (inhalation, ingestion, or injection) and amount of inoculum.	Ricin is part of the waste "mash" produced when castor oil is made. Exposure occurs via ingestion of food, water; inhalation; injection (poison ricin pellet). *Ingestion:* symptoms (vomiting, bloody diarrhea) may occur within 6 hours; leads to multiorgan failure and death. *Inhalation:* symptoms may occur within 8 hours; leads to respiratory failure, multiorgan failure, and death.
PARASITE					
Cryptosporidium parvum	Commonly known as "Crypto"	B	Standard Precautions. Strict hand hygiene.	Prevent dehydration; rapid loss of fluids from diarrhea may be life-threatening to infants. Nitazoxanide has been approved by the Food and Drug Administration for treatment of diarrhea in people with healthy immune systems, but its effectiveness in immunosuppressed individuals is unclear.	Transmitted directly from person-to-person contact, through contact with feces-contaminated objects (e.g., toys), or by swallowing contaminated food or water (drinking and recreational). *Cryptosporidium* is chlorine-resistant and can live for days in chlorine-treated water; therefore, chlorinated recreational water venues (e.g., swimming pool, water park, water play area, splash pad, spray pad) may not provide protection from exposure.

MICROBE	DISEASE NAME(S)	CDC CAT.	ISSUES RELATED TO NOSOCOMIAL TRANSMISSION	TREATMENT	COMMENTS
VIRUSES					
Hantavirus	Four Corners virus, hantavirus hemorrhagic fever, hantavirus pulmonary syndrome	C	Standard Precautions. No restrictions regarding room placement or movement within the hospital.	Supportive treatment for shock and renal failure; prevent overhydration; ribavirin may benefit hemorrhagic fever.	Spread via aerosol transmission from rodent excreta.
Influenza virus	Pandemic influenza	C	Use Isolation Precautions recommended by CDC for pandemic strain in question. Use Standard and Droplet Precautions for influenza types that are not pandemic.	Use of antiviral drugs for treatment and chemoprophylaxis is key; antivirals are used successfully to control outbreaks caused by susceptible strains. See CDC influenza pandemic resources.	During outbreak, reoffer influenza vaccination (if available) to unvaccinated staff and patients. Restrict staff movement between wards or buildings. Restrict contact between ill staff or visitors and patients.
Nipah virus	Nipah virus encephalitis	C	Standard Precautions. No restrictions regarding room placement or movement within the hospital.	Supportive treatment for shock and renal failure; prevent overhydration; ribavirin may benefit hemorrhagic fever.	First isolated in 1999 during an encephalitis and respiratory illness outbreak in men in Malaysia and Singapore.
Variola major virus	Smallpox	A	Standard, Airborne, and Contact Precautions. Highly contagious; patients with smallpox must be isolated immediately in negative pressure room with door closed at all times; N-95 respirators are required for patients and close contacts. If transportation is essential, place mask on patient.	Live-virus vaccination; early vaccination is critical. See CDC guidelines for additional treatment options.	Dangerous due to highly contagious nature of infected persons and their pox. Occurs only in humans; no external hosts or vectors.

MICROBE	DISEASE NAME(S)	CDC CAT.	ISSUES RELATED TO NOSOCOMIAL TRANSMISSION	TREATMENT	COMMENTS
Yellow fever virus	Yellow fever (YF)	C	Standard Precautions. No restrictions regarding room placement or movement within the hospital.	Supportive treatment for symptoms. Vaccination can prevent yellow fever.	Three transmission cycles: (1) Sylvatic (jungle): in tropical rainforests, virus transmitted by mosquitoes from monkeys to humans; most infections occur in young men (loggers) working in the jungle. (2) Savannah (intermediate): in humid or semihumid areas of Africa, virus is transmitted from mosquitoes to humans; most common type of outbreak in Africa. (3) Urban: transmission of virus via *Aedes aegypti* mosquito; virus is brought to urban setting via viremic humans who are infected in the jungle or savannah; cycle results in large, explosive epidemics.
Viral encephalitis viruses					
Eastern equine encephalitis virus	Eastern equine encephalitis (EEE)	B	Standard Precautions. No restrictions regarding room placement or movement within the hospital.	Supportive treatment.	Common in Eastern United States. One of the most severe mosquito-borne viral infections: encephalitic disease rate is greater than 5% and mortality rate is greater than 50%.

MICROBE	DISEASE NAME(S)	CDC CAT.	ISSUES RELATED TO NOSOCOMIAL TRANSMISSION	TREATMENT	COMMENTS
Tick-borne encephalitis virus subtypes: European or Western; Far Eastern; and Siberian	Tick-borne encephalitis (TBE)	C	Standard Precautions. No restrictions regarding room placement or movement within the hospital.	Supportive treatment; anti-inflammatory drugs; ventilatory support may be necessary.	TBE is an important infectious disease in many parts of Europe, Russia, and Asia. Dependent on Ixodid tick reservoir. Between 10% and 20% of infected patients have long-lasting or permanent neuropsychiatric sequelae.
Venezuelan equine encephalitis virus	Venezuelan equine encephalitis (VEE)	B	Standard Precautions. No restrictions regarding room placement or movement within the hospital.	Supportive treatment.	Primarily in South and Central America. Encephalitis rates higher among children.
Western equine encephalitis virus	Western equine encephalitis (WEE)	B	Standard Precautions. No restrictions regarding room placement or movement within the hospital.	Supportive treatment.	Primarily limited to North America. Encephalitis rate is higher in children; increased morbidity mainly confined to infants. Fewer than 700 U.S. cases since 1964.

MICROBE	DISEASE NAME(S)	CDC CAT.	ISSUES RELATED TO NOSOCOMIAL TRANSMISSION	TREATMENT	COMMENTS
Viral hemorrhagic viruses					
Arenaviruses					
Junin virus	Argentinian hemorrhagic fever	A	Standard and Contact Precautions. Private room or cohort with like patients when private room is unavailable.	Supportive treatment; convalescent-phase plasma has been used with success in some patients. Vaccine available.	First reported in 1958; endemic to Argentina. Transmission occurs via small rodents (*Calomys musculinus* and *Calomys laucha*) through their saliva and urine via contact of skin or mucous membranes, or through inhalation of infected particles. Common in people who reside or work in rural areas; 80% of those infected are males between 15 and 60 years of age.
Lassa virus	Lassa fever	A	Highly transmissible via contact and droplet exposure from blood and body fluids. Standard, Airborne, and Contact Precautions. Private room with anteroom preferred or ICU; quarantine required. Personal protective equipment needed: N-95 respirator or powered air-purifying respirators (PAPRs); face shields, double gloves, goggles, impermeable gowns, and shoe covers.	Ribavirin; supportive treatment.	First described in 1950; virus identified in 1969 when 2 missionary nurses died in Lassa, Nigeria. Endemic in Guinea, Liberia, Sierra Leone, parts of Nigeria.

MICROBE	DISEASE NAME(S)	CDC CAT.	ISSUES RELATED TO NOSOCOMIAL TRANSMISSION	TREATMENT	COMMENTS
Machupo virus	Bolivian hemorrhagic fever	A	Standard, Airborne, and Contact Precautions. Highly transmissible via contact and droplet exposure from blood and body fluids. Private room with anteroom preferred or intensive care unit; quarantine required. Personal protective equipment needed: N-95 respirator or PAPRs; face shields, double gloves, goggles, impermeable gowns, and shoe covers.	Ribavirin; supportive treatment. Genetically related Junin virus vaccine may be an effective prophylactic measure.	Also known as *black typhus*. Occurs primarily in Bolivia; first identified in 1959; no cases identified between 1973 and 1994.
Filoviruses					
Ebola virus; subtypes Zaïre, Sudan, Côte d'Ivoire	African hemorrhagic fever; Ebola hemorrhagic fever	A	Standard, Airborne, and Contact Precautions. Highly transmissible via contact and droplet exposure from blood and body fluids. Private room with anteroom preferred or ICU; quarantine required; personal protective equipment needed: N-95 respirator or PAPRs; face shields, double gloves, goggles, impermeable gowns, and shoe covers.	Ribavirin; supportive treatment; fluid replacement; vaccines are in early stages of development.	More than 10 strains; 50% to 90% mortality rate; death results from multiple organ failure and hypovolemic shock.
Marburg virus	Marburg hemorrhagic fever	A	Standard, Airborne, and Contact Precautions. Highly transmissible via contact and droplet exposure from blood and body fluids. Private room with anteroom preferred or ICU; quarantine required. Personal protective equipment needed: N-95 respirator or PAPRs; face shields, double gloves, goggles, impermeable gowns, and shoe covers.	Ribavirin; supportive treatment; fluid replacement. Vaccines in early stages of development.	Discovered in Marburg, Germany; 25% to 100% mortality rate.

MICROBE	DISEASE NAME(S)	CDC CAT.	ISSUES RELATED TO NOSOCOMIAL TRANSMISSION	TREATMENT	COMMENTS
Tick-borne hemorrhagic fever viruses					
Flavivirus—Kyasanur forest disease virus	Kyasanur Forest disease	C	Standard and Contact Precautions.	Supportive treatment; fluid replacement.	Identified in 1957 when isolated from tick-infected monkey from Kyasanur Forest in India. Infections seasonally transmitted in Southern and Central India and Siberia; occurs among villagers and lumbermen with forest contact.
Flavivirus—Omsk hemorrhagic fever virus	Omsk hemorrhagic fever	C	Standard Precautions.	Supportive treatment; fluid replacement.	First described between 1945 and 1947 in Omsk, Russia. Infections seasonally transmitted in Southern and Central India and Siberia via tick-infected muskrats.
Nairovirus	Crimean-Congo hemorrhagic fever	C	Standard, Droplet, and Contact Precautions. Avoid exposure to blood and body fluids.	Supportive care; ribavirin provides some benefit.	First seen in Crimea in 1944; recognized in the Congo in 1969. Nairovirus infection found in Eastern Europe, Mediterranean, Northwestern China, Central Asia, Southern Europe, Africa, Middle East, and India. Transmission occurs via contact with infected animal blood, ticks, improperly sterilized medical equipment, or contaminated medical supplies.

REFERENCES

Association for Professionals in Infection Control and Epidemiology. *APIC Text Online*. 2017. http://text.apic.org.

Carroll K, Morse SA, Mietzner T, et al, eds. *Jawetz, Melnick, and Adelberg's Medical Microbiology*. 27th ed. New York: McGraw-Hill Education; 2016.

Gilbert DN, Chambers HF, Eliopoulos GM, Saag MS, Pavia AT. *The Sanford Guide to Antimicrobial Therapy 2017*. 47th ed. Sperryville, VA: Antimicrobial Therapy; 2017.

Heymann DL, ed. *Control of Communicable Diseases Manual*. 20th ed. Baltimore, MD: American Public Health Association; 2014.

Jorgensen JH, Pfaller MA, Carroll KC, et al, eds. *Manual of Clinical Microbiology*. 11th ed. Washington, DC: American Society of Microbiology Press; 2015.

Kimberlin DW, Brady MT, Jackson MA, Long SS, eds. *2015 Red Book: Report of the Committee on Infectious Diseases*. 30th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2015.

Mahon CR, Lehman DC, Manuselis G, eds. *Textbook of Diagnostic Microbiology*. 5th ed. St. Louis, MO: Elsevier; 2015.

Porter RS, Kaplan, JL, eds. *The Merck Manual of Diagnosis and Therapy*. 19th ed. Whitehouse Station, NJ: Merck; 2011.

Ryan K, Ray G, Ahmed N, Drew W. Plorde J. *Sherris Medical Microbiology*. 6th ed. New York: McGraw-Hill Education; 2014.

Tille PM, ed. *Bailey & Scott's Diagnostic Microbiology*. 14th ed. St. Louis, MO: Mosby; 2017.

Tortora GJ, Funke BR, Case CL, eds. *Microbiology: An Introduction*. 12th ed. Boston: Pearson; 2016.

ADDITIONAL RESOURCES

American Society for Microbiology. http://www.asm.org.

Centers for Disease Control and Prevention. http://www.cdc.gov.

Centers for Disease Control and Prevention. Crimean-Congo Hemorrhagic Fever (CCHF). May 9, 2014. https://www.cdc.gov/vhf/crimean-congo.

Centers for Disease Control and Prevention. Crisis and Emergency Risk Communication (CERC). April 27, 2017. https://emergency.cdc.gov/cerc/index.asp.

Centers for Disease Control and Prevention. Emergency Preparedness and Response: Bioterrorism Agents/Diseases. May 6, 2016. https://emergency.cdc.gov/agent/agentlist.asp.

Centers for Disease Control and Prevention. Emergency Preparedness and Response: Bioterrorism. August 17, 2017. https://emergency.cdc.gov/bioterrorism.

Centers for Disease Control and Prevention. Influenza. December 22, 2017. https://www.cdc.gov/flu/index.htm.

Centers for Disease Control and Prevention. Omsk Hemorrhagic Fever. December 9, 2013. https://www.cdc.gov/vhf/omsk/index.html.

Centers for Disease Control and Prevention. Pandemic Influenza. October 6, 2017. https://www.cdc.gov/flu/pandemic-resources.

Centers for Disease Control and Prevention. Ricin Toxin from *Ricinus communis* (castor beans). November 18, 2015. http://emergency.cdc.gov/agent/ricin/facts.asp.

Centers for Disease Control and Prevention. Viral Hemorrhagic Fevers (VHFs). January 29, 2014. http://www.cdc.gov/vhf/index.html.

Centers for Disease Control and Prevention. Yellow Fever. July 12, 2016. http://www.cdc.gov/yellowfever.

Johns Hopkins Bloomberg School for Public Health. Center for Health Security. Burkholderia Mallei and Pseudomallei (Glanders and Melioidosis). December 1, 2013. http://www.upmchealthsecurity.org/our-work/publications/glanders-and-melioidosis-fact-sheet.

Rebmann T. Infectious disease disasters: bioterrorism, emerging infections, and pandemics. In: APIC Text Online. 2014. http://text.apic.org/toc/community-based-infection-prevention-practices/infectious-disease-disasters-bioterrorism-emerging-infections-and-pandemics.

U.S. Army Medical Research Institute of Infective Diseases. Reference Materials. http://www.usamriid.army.mil/education/instruct.htm.

World Health Organization. http://www.who.int.

World Health Organization. Emergency Preparedness and Response: Yellow Fever. http://www.who.int/csr/disease/yellowfev/en.

World Health Organization. Haemorrhagic Fevers, Viral. http://www.who.int/topics/haemorrhagic_fevers_viral/en/index.html.

World Health Organization. Yellow Fever (fact sheet). May 2016. http://www.who.int/mediacentre/factsheets/fs100/en.

CHAPTER 7

Antimicrobial Therapy

Antimicrobials encompass a wide variety of pharmaceutical agents, including antibacterial, antifungal, antiparasitic, and antiviral drugs. Antimicrobials are categorized as follows:

- **Bactericidal**—causing death and disruption of the bacterial cell. Examples include
  - β-lactams, which primarily act on the cell wall;
  - daptomycin, which acts on the cell membrane;
  - fluoroquinolones, which act on bacterial deoxyribonucleic acid (DNA);
  - aminoglycosides, which inhibit protein synthesis by binding to a ribosomal subunit; and
  - polymyxins, which disrupt the cell membrane.
- **Bacteriostatic**—inhibiting bacterial replication without killing the organism. Examples include
  - sulfonamides;
  - tetracyclines; and
  - macrolides, which inhibit protein synthesis.

Whether an antimicrobial is bactericidal or bacteriostatic depends on the concentration to which the microbe is exposed.

Mechanisms of Antimicrobial Action

MECHANISM	ANTIMICROBIALS
Cell wall or membrane synthesis inhibition	β-lactams (penicillins, cephalosporins, monobactams, carbapenems) glycopeptide (vancomycin) echinocandins (caspofungin) daptomycin colistimethate antifungals (fluconazole)
Protein synthesis in the bacterial ribosome inhibition	aminoglycosides (gentamicin, tobramycin) chloramphenicol glycylglycines (tigecycline) macrolides (azithromycin) tetracyclines oxazolidinones (linezolid)
Essential metabolite production (metabolic pathway) inhibition	trimethoprim-sulfamethoxazole ethambutol
Nucleic acid synthesis inhibition	ansamycins (rifampin) fluoroquinolones (ciprofloxacin, levofloxacin, moxifloxacin) antifungals (flucytosine) antivirals (acyclovir)

SYNERGISTIC ACTIVITY

Synergy is the combined effect of antimicrobials that is greater than the sum of their independent antimicrobial activities when measured separately. For example, the combination of particular β-lactams and aminoglycosides exhibits synergistic activity against a variety of Gram-positive and Gram-negative microbes. Treating endocarditis caused by *Enterococcus* species with a combination of penicillin (which alone is bacteriostatic) and gentamicin (which alone has no significant activity) provides rapid bactericidal synergistic activity. Endocarditis caused by viridans group streptococci can be treated more effectively for 2 weeks with penicillin or ceftriaxone with gentamicin than for 4 weeks of penicillin or ceftriaxone alone.

INDICATIONS FOR ANTIMICROBIAL USE

Antimicrobial therapy can be categorized by type of use, including the following:

- **Microbe (pathogen)-directed therapy**: If the pathogen has been identified by tests, including culture, serology, and polymerase chain reaction (PCR), the narrowest-spectrum antimicrobial is used to decrease emergence of antimicrobial resistance and superinfection.
- **Empirical therapy**: If the gram stain suggests a causative pathogen and the clinical picture—such as site of infection, microbes that colonize the site, prior screening for methicillin-resistant *Staphylococcus aureus* (MRSA), other host factors, and local bacterial resistance patterns or antibiograms—provide an indication of likely pathogens, broad spectrum antimicrobials are used because of the uncertainty about the pathogen.

- **Prophylaxis**: Antimicrobials are used to prevent infection. Surgical antimicrobial prophylaxis is most common. For example, a single dose of a cephalosporin, such as cefazolin, administered within one hour of initial incision targets most likely microbes (skin flora).

ANTIMICROBIAL RESISTANCE

Widespread antimicrobial use is the main selective pressure responsible for increasing resistance in community and healthcare facilities. The end result of widespread use is loss of antibiotic effectiveness. Resistance mechanisms include the following:

- Antimicrobial inactivation:
  - Bacteria produce enzymes that can destroy or inactivate antimicrobials.
  - Bacteria may produce B-lactamase enzymes that destroy penicillins and cephalosporins.
- Target site alteration: The binding site of the antimicrobial on the pathogen is altered.
- Permeability or efflux decrease: Resistance develops due to a change in drug permeability.
- Metabolic pathway bypass: Bacteria develop alternative pathways to bypass the metabolic pathway inhibited by the antimicrobial.
- Point mutations in existing genes: Random errors occur during DNA replication.
- New gene acquisition: Antimicrobial resistance requires complex structural or enzymatic changes resulting in new resistant genes.

COMMON ANTIMICROBIAL MISUSES

Misuses of antimicrobials include the following:

- Prolonged empiric antimicrobial therapy without clear evidence of infection
- Treating a positive clinical culture in the absence of infection
- Failure to narrow the antimicrobial therapy after a causative pathogen is identified
- Prolonged prophylaxis
- Excessive use of certain antimicrobials—for example, widespread use of fluoroquinolones led to the fluoroquinolone-resistant strain of *Clostridium difficile*

TABLE

The following table presents general information for an understanding of the major classifications and broad categories of antimicrobials. Note that the table lists

- antimicrobial classes;
- antimicrobial subclasses;
- representative antimicrobials; and
- effective antimicrobial activity for bacteria, fungi, viruses, parasites.

The reader is encouraged to refer to the most recent edition of *The Sanford Guide to Antimicrobial Therapy* and other credible resources regarding specific antimicrobial therapy per pathogen, body site, and/or infection. Evidence-based practice guidelines for specific infectious disease syndromes and infections caused by specific microbes are available from the Infectious Diseases Society of America website: http://www.idsociety.org/PracticeGuidelines.

CLASS	SUBCLASS	REPRESENTATIVE ANTIMICROBIAL(S)	ANTIMICROBIAL ACTIVITY
ß-LACTAMS			
Penicillins	Natural penicillin	penicillin G	Bactericidal; inhibits cell wall synthesis; Gram-positive bacteria, including enterococci, most streptococci, and oral anaerobic microbes. Drug of choice for group A *Streptococcus* pharyngitis and the organism *Treponema pallidum,* which causes syphilis.
	Aminopenicillins	amoxicillin ampicillin	Inhibits cell wall synthesis; Gram-negative bacteria (*Escherichia coli* and *Haemophilus. influenzae*); retains natural penicillin's antimicrobial activity.
	Penicillinase-resistant penicillins	cloxacillin dicloxacillin nafcillin piperacillin ticarcillin	Inhibits cell wall synthesis; Gram-positive bacteria; Gram-negative bacteria, including *Pseudomonas;* retains natural penicillin's antimicrobial activity.
	Penicillinase-resistant penicillins with β-lactamase inhibitors added	amoxicillin-clavulanate (Augmentin) ampicillin-sulbactam (Unasyn) piperacillin-tazobactam (Zosyn) ticarcillin-clavulanate (Trimentin)	Inhibits β-lactamase enzymes; retains natural penicillin's antimicrobial activity; broadened activity against methicillin-susceptible *Staphylococcus aureus* (MSSA); Gram-negative bacteria other than *Pseudomonas*.

CLASS	SUBCLASS	REPRESENTATIVE ANTIMICROBIAL(S)	ANTIMICROBIAL ACTIVITY
Cephalosporins	First generation	cefazolin (Ancef) cephalexin (Keflex)	Interferes with cell wall synthesis; Gram-positive and Gram-negative bacteria, including most strains of *Escherichia coli, Klebsiella pneumoniae, Proteus mirabilis;* spectrum varies by antimicrobial.
	Second generation	cefotetan cefoxitin (Mefoxin) cefuroxime (Zinacef)	Interferes with cell wall synthesis; Gram-positive and Gram-negative bacteria; increased antimicrobial activity against enteric Gram-negative bacilli, *Neisseria* species, *Haemophilus influenzae;* spectrum varies by antimicrobial.
	Third generation	cefoperazone (Cefobid) cefotaxime (Claforan) ceftazidime (Fortaz) ceftizoxime (Cefizox) ceftriaxone (Rocephin)	Interferes with cell wall synthesis; Gram-positive and Gram-negative bacteria; enhanced antimicrobial activity against Gram-negative bacilli; spectrum varies by antimicrobial, Increase in resistant *Streptococcus pneumoniae* limits empirical therapy.
	Fourth generation	cefepime (Maxipime)	Interferes with cell wall synthesis; broad spectrum antimicrobial activity against Gram-positive bacteria, including *Pseudomonas* species and Gram-negative bacteria. Does not cover methicillin-resistant *Staphylococcus aureus* (MRSA) or anaerobic bacteria lung, abdominal, or soft tissue infections.
		ceftaroline (Teflaro)	Interferes with cell wall synthesis; Gram-positive and Gram-negative bacteria; penicillin-resistant *Streptococcus pneumoniae, Streptococcus pyogenes, Streptococcus agalactiae, Klebsiella* species; *Escherichia coli;* skin, soft tissue infections, community-acquired bacterial pneumonia. Approved for treatment of MRSA.
Other β-lactams	Monobactam	aztreonam	Interferes with cell wall synthesis; limited to aerobic, Gram-negative bacilli, including *Pseudomonas aeruginosa.* Can be given safely to patients with history of serious reactions to penicillins or cephalosporins.

CLASS	SUBCLASS	REPRESENTATIVE ANTIMICROBIAL(S)	ANTIMICROBIAL ACTIVITY
	Carbapenems	doripenem ertapenem imipenem (Primaxin) meropenem	Binds to penicillin-binding proteins of Gram-positive and Gram-negative microbes; broad spectrum. Used for the treatment of infections caused by multidrug-resistant organisms. Resistance is emerging in Gram-negative *Enterobacteriaceae*.
FLUOROQUINOLONES			
	Antipseudomonal	ciprofloxacin (Cipro)	Bactericidal; inhibits deoxyribonucleic acid (DNA) gyrase enzyme; aerobic Gram-negative bacilli; limited antimicrobial activity against *Staphylococcus* species, anaerobes, *Streptococcus* species. Not recommended as first-line treatment of gonococcal infections; used as treatment for postexposure to inhalational *Bacillus anthracis* (anthrax).
	Antistreptococcal	moxifloxacin	Bactericidal; inhibits DNA gyrase enzyme; Gram-negative bacilli; *Streptococcus pneumoniae, Legionella* species, anaerobic bacteria. As a result of resistance, no longer recommended for the treatment of *Neisseria gonorrhoeae* infection.
	Antistreptococcal	levofloxacin	Bactericidal; inhibits DNA gyrase enzyme; Gram-negative bacilli; *Streptococcus pneumoniae, Legionella* species, and *Pseudomonas aeruginosa* (note: resistance is increasing). Not for the treatment of gonococcal infections.
OTHER ANTIBACTERIALS			
	Aminoglycosides	amikacin gentamicin kanamycin streptomycin tobramycin	Inhibits bacterial protein synthesis. Used in combination with other antimicrobials for difficult-to-treat Gram-positive and Gram-negative bacteria; bactericidal against most aerobic Gram-negative bacteria, including *Pseudomonas* species, but not against anaerobic bacteria.

CLASS	SUBCLASS	REPRESENTATIVE ANTIMICROBIAL(S)	ANTIMICROBIAL ACTIVITY
	Chloramphenicol	chloramphenicol	Inhibits protein synthesis; Gram-positive and Gram-negative bacteria. Can be used as an alternative for Doxycycline in the treatment of infections involving *Rickettsia* species.
	Glycopeptide	vancomycin	Inhibits cell wall and cell membrane synthesis; bactericidal for *Streptococcus, Enterococcus, Staphylococcus* species. Commonly used for MRSA.
	Lipopeptide	daptomycin	Disrupts cell membrane; similar to vancomycin for Gram-positive cocci.
	Macrolide-lincosamides	azithromycin (Zithromax) clarithromycin (Biaxin) clindamycin (Cleocin) erythromycin fidaxomicin (Dificid)	Bacteriostatic; inhibits protein synthesis in ribosome. Macrolides (erythromycin, azithromycin, clarithromycin) have limited spectrum for Gram-positive bacteria; atypical bacteria *(Legionella, Mycoplasma, Chlamydia); Helicobacter pylori* gastric/duodenal ulcers; nontuberculosis *Mycobacteria* species. Lincosamide (clindamycin) activity: aerobic Gram-positive, anaerobic Gram-positive, Gram-negative bacteria. Fidaxomicin is used in treatment of *Clostridium difficile;* inhibits bacterial RNA polymerase.
	Nitroimidazole	metronidazole (Flagyl)	Disrupts cell DNA; anaerobic microbes; no activity for aerobic microbes. Used to treat *Clostridium difficile* colitis, parasitic vaginitis *(Trichomonas vaginalis),* and parasitic intestinal infections *(Entamoeba histolytica, Giardia lamblia).*
	Nitrofurantoin	nitrofurantoin (Macrobid, Macrodantin)	Binds ribosomal proteins; Gram-positive and Gram-negative bacteria.
	Oxazolidinones	linezolid (Zyvox)	Inhibits protein synthesis; bacteriostatic for Gram-positive microbes. Primary treatment for vancomycin-resistant enterococci (VRE), MRSA.
	Phosphonic acid derivative	fosfomycin (Monurol)	Bactericidal; inhibits the synthesis of cell wall peptidoglycan. For treatment of complicated and uncomplicated urinary tract infection (UTI).

CLASS	SUBCLASS	REPRESENTATIVE ANTIMICROBIAL(S)	ANTIMICROBIAL ACTIVITY
	Polymyxins	colistimethate sodium colistin sulfate	Targets bacterial cell membrane. Treats infections involving multidrug-resistant microbes: *Pseudomonas aeruginosa, Acinetobacter baumannii.* Resistant to all other antimicrobials, including carbapenems and aminoglycosides.
	Rifampicins	rifabutin rifampin (Rifadin) rifaximin	Interferes with nucleic acid synthesis. Prophylaxis for exposure to *Neisseria meningitidis* meningitis; adjunct therapy for MRSA-infected prosthetic device or mechanical valve. Combination (rifampin/rifabutin) with other antimicrobials for latent or active *Mycobacterium tuberculosis.* Rifaximin used for *Clostridium difficile* colitis
	Streptogramin	quinupristin-dalfopristin (Synercid)	Inhibits bacterial protein synthesis. Synergistic combination for vancomycin-resistant *Enterococcus faecium* (VRE) and vancomycin-resistant *Staphylococcus aureus* (VRSA).
	Sulfonamide-trimethoprim	trimethoprim/ sulfamethoxazole	Synergistic combination; bactericidal; inhibits folate synthesis metabolic pathway. Used for *Pneumocystis jirovecii* pneumonia, *Nocardia* species, multidrug-resistant Gram-negative *Stenotrophomonas maltophilia,* unique strains of MRSA.
	Tetracyclines	doxycycline tetracycline	Inhibits protein synthesis; broad spectrum. Useful in the treatment of syphilis, rickettsial infections, chlamydia, and mycoplasma.
ANTIVIRALS			
Antiretrovirals (HIV treatment)	Nucleoside reverse transcriptase inhibitors	didanosine emtricitabine lamivudine tenofovir zidovudine	Used in highly active antiretroviral therapy (HAART), a combination of various antiretrovirals that suppress viral replication effectively. Commonly used for pre-exposure prophylaxis (PrEP) of healthcare workers exposed to human immunodeficiency virus (HIV); PrEP includes tenofovir and emtricitabine used in combination.

CLASS	SUBCLASS	REPRESENTATIVE ANTIMICROBIAL(S)	ANTIMICROBIAL ACTIVITY
	Nonnucleoside reverse transcriptase inhibitor	delavirdine efavirenz etravirine nevirapine rilpivirine	Used in HAART. Commonly used for PrEP of healthcare workers exposed to HIV.
	Protease inhibitors	atazanavir darunavir fosamprenavir indinavir nelfinavir ritonavir saquinavir tipranavir	Used in HAART. Commonly used in combination with other antiretrovirals for PrEP of healthcare workers exposed to HIV.
	Fusion inhibitor	enfuvirtide	Used in HAART. Commonly used in combination with other antiretrovirals for postexposure prophylaxis of healthcare workers exposed to HIV.
	Entry inhibitor	maraviroc	Used in HAART. Commonly used for PrEP of healthcare workers exposed to HIV; also used for treatment-experienced patients with multiresistant strains.
	Integrase inhibitor	raltegravir	Used in HAART. Commonly used for PrEP of healthcare workers exposed to HIV.

CLASS	SUBCLASS	REPRESENTATIVE ANTIMICROBIAL(S)	ANTIMICROBIAL ACTIVITY
Hepatitis C	Multiple drug classes	elbasvir grazoprevir ledipasvir sofosbuvir velpatasvir	Drugs used in combination with one another for the treatment of hepatitis C.
Herpesviridae	Herpes simplex	acyclovir famciclovir foscarnet valacyclovir	Treatment for herpes zoster; herpes simplex encephalitis. Acyclovir derivatives (valacyclovir and famciclovir) for herpes simplex virus types 1 and 2; foscarnet for acyclovir-resistant herpes simplex virus.
	Cytomegalovirus (CMV)	cidofovir foscarnet ganciclovir valganciclovir	First-line antimicrobials for most CMV infections and for life-threatening pneumonitis in solid organ and bone marrow transplants. The use of hyperimmune globulin in pregnancy is undergoing trials.
Influenza	Influenza A and B	oseltamivir peramivir zanamivir	Do not use amantadine and rimantadine to treat influenza. They are now considered resistant. Zanamivir and oseltamivir (neuraminidase inhibitors) for influenza A and B.
Miscellaneous	Respiratory syncytial virus	ribavirin	Covers wide range of RNA and DNA viruses; not recommended for routine use.

CLASS	SUBCLASS	REPRESENTATIVE ANTIMICROBIAL(S)	ANTIMICROBIAL ACTIVITY
ANTIFUNGALS			
Azoles	Triazole	fluconazole isavuconazole itraconazole (Sporanox)	Candidemia.
		posaconazole voriconazole	Invasive aspergillosis; disseminated candidiasis. Posaconazole also indicated in the treatment of zygomycosis.
Polyenes	Nonlipid formulation	amphotericin B	Weakens fungal cell membrane. Cryptococcosis, histoplasmosis, invasive aspergillosis, other serious yeast or mold infections.
	Lipid formulations	amphotericin B liposomal (Abelcet, AmBisome, Amphotec)	Weaken fungal cell membrane. Fewer renal and hepatic side effects than amphotericin B. Cryptococcosis, histoplasmosis, invasive aspergillosis, other serious yeast or mold infections.
Other	Echinocandin	anidulafungin caspofungin micafungin	Refractory aspergillosis; candidiasis; some invasive candidal infections.
	Nucleoside analogue	flucytosine	Combined with amphotericin for *Candida* species and *Cryptococcus neoformans* infections.

CLASS	SUBCLASS	REPRESENTATIVE ANTIMICROBIAL(S)	ANTIMICROBIAL ACTIVITY
ANTIPARASITICS			
		chloroquine doxycycline mefloquine primaquine quinine	Malaria treatment or prophylaxis.
		praziquantel	Schistosomiasis.
		albendazole ivermectin	Nematodes (roundworms).
		tinidazole	Antiprotozoal; intestinal amebiasis; giardiasis; trichomoniasis.
Antimycobacterials		ethambutol isoniazid pyrazinamide rifampin streptomycin	Agents are usually used in combination therapy and not as a single-agent treatment.

REFERENCES

Bennett JE, Dolin R, Blaser MJ. *Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases*. 8th ed. Philadelphia, PA: Saunders; 2015.

Carroll K, Morse SA, Mietzner T, et al, eds. *Jawetz, Melnick, and Adelberg's Medical Microbiology*. 27th ed. New York: McGraw-Hill Education; 2016.

Carroll KC, Jorgensen JH, Funke G, et al, eds. *Manual of Clinical Microbiology*, 11th ed. Washington, DC: American Society of Microbiology Press; 2015.

Gilbert DN, Chambers HF, Eliopoulos GM, Saag MS, Pavia AT. *The Sanford Guide to Antimicrobial Therapy 2017*. 47th ed. Sperryville, VA: Antimicrobial Therapy; 2017.

Heymann DL, ed. *Control of Communicable Diseases Manual*. 20th ed. Baltimore, MD: American Public Health Association; 2014.

Kimberlin DW, Brady MT, Jackson MA, Long SS, eds. *2015 Red Book: Report of the Committee on Infectious Diseases*. 30th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2015.

Mahon CR, Lehman DC, Manuselis G, eds. *Textbook of Diagnostic Microbiology*. 5th ed. St. Louis, MO: Elsevier; 2015.

Porter RS, Kaplan, JL, eds. *The Merck Manual of Diagnosis and Therapy*. 19th ed. Whitehouse Station, NJ: Merck; 2011.

Tille PM, ed. *Bailey & Scott's Diagnostic Microbiology*. 14th ed. St. Louis, MO: Mosby; 2017.

Tortora GJ, Funke BR, Case CL, eds. *Microbiology: An Introduction*. 12th ed. Boston: Pearson; 2016.

ADDITIONAL RESOURCES

Association for Professionals in Infection Control and Epidemiology. *APIC Text Online*. 2017. http://text.apic.org.

Allegran Inc. Teflaro (product website). https://www.teflaro.com.

American Society for Microbiology. http://www.asm.org.

Arnold FW. Antimicrobials and resistance. In: *APIC Text Online*. November 1, 2017. http://text.apic.org/toc/microbiology-and-risk-factors-for-transmission/antimicrobials-and-resistance.

Centers for Disease Control and Prevention. http://www.cdc.gov.

Centers for Disease Control and Prevention. Healthcare-Associated Infections. http://www.cdc.gov/hai.

Global RPh. Infectious Disease Organisms. Drugs of choice. Antibiotic choices. Empiric therapy. http://www.globalrph.com.

Infectious Diseases Society of America. IDSA Practice Guidelines. http://www.idsociety.org/PracticeGuidelines.

Surbhi L, Terrell CL, Edson RS. General principles of antimicrobial therapy. *Mayo Clin Proc*. 2011;86(2):156–167. doi:10.4065/mcp.2010.0639.

World Health Organization. http://www.who.int.

Quick Facts: Common Bacterial Pathogens by Body Site

Common bacterial pathogens that are known to cause infections in particular human body sites are listed in the table. The table is not meant to cover all pathogens isolated, but it identifies the most common pathogens found in the listed sites. For a more comprehensive review of bacterial pathogens, refer to Chapter 1.

BODY SITE	EXPECTED PATHOGENS
Cutaneous tissue: skin, hair and nails	Methicillin-susceptible *Staphylococcus aureus* (MSSA), methicillin-resistant *Staphylococcus aureus* (MRSA), *Staphylococcus epidermidis, Propionibacterium acnes*
Subcutaneous tissue	MSSA, MRSA, *P. acnes*
Eyes	*Haemophilus influenzae*
Central nervous system	*Neisseria meningitidis, Haemophilus influenzae, Streptococcus pneumoniae*
Ear: middle and internal	*Streptococcus pneumoniae, Haemophilus influenzae, Pseudomonas aeruginosa*
Ear: external	MSSA, MRSA, *Pseudomonas aeruginosa*
Sinuses	MSSA, MRSA, *Streptococcus pneumoniae, Haemophilus influenzae, Neisseria meningitidis*
Oral cavity	*Streptococcus* species, viridans group *Streptococcus,* mixed anaerobic bacterial isolates
Throat	*Streptococcus pyogenes, Moraxella catarrhalis, Neisseria gonorrhoeae*

BODY SITE	EXPECTED PATHOGENS
Respiratory tract: bronchi	*Streptococcus pneumoniae, Haemophilus influenzae*
Respiratory tract: endotracheal tube or sputum	*Klebsiella* species, *Streptococcus pneumoniae, Haemophilus influenzae, Pseudomonas aeruginosa*
Stomach	*Helicobacter pylori*
Intestines	Enterotoxigenic *Escherichia coli,* enterohemorrhagic *E. coli, Aeromonas* species, *Campylobacter jejuni, Salmonella* species, *Shigella* species, *Yersinia enterocolitica, Vibrio cholera*
Female reproductive tract	*Streptococcus agalactiae* (Group B *Streptococcus*), *Chlamydia* species, *Neisseria gonorrhoeae, Treponema pallidum* subspecies *pallidum* (syphilis), *Haemophilus ducreyi, Staphylococcus aureus*
Male reproductive tract	*Chlamydia* species, *Neisseria gonorrhoeae, Treponema pallidum* subspecies *pallidum* (syphilis), *Haemophilus ducreyi*
Urinary tract	*Staphylococcus aureus, Staphylococcus epidermidis, Staphylococcus saprophyticus,* coagulase-negative *Staphylococcus, Aerococcus urinae, Escherichia coli, Klebsiella* species, *Proteus* species
Blood/systemic	MRSA, *Escherichia coli, Haemophilus influenzae, Streptococcus pneumoniae*

REFERENCES

Association for Professionals in Infection Control and Epidemiology. *APIC Text Online*. 2017. http://text.apic.org.

Carroll K, Morse SA, Mietzner T, et al, eds. *Jawetz, Melnick, and Adelberg's Medical Microbiology*. 27th ed. New York: McGraw-Hill Education; 2016.

Tille PM, ed. *Bailey & Scott's Diagnostic Microbiology*. 14th ed. St. Louis, MO: Mosby; 2017.

ADDITIONAL RESOURCES

American Society for Microbiology. http://www.asm.org.

Centers for Disease Control and Prevention. http://www.cdc.gov.

Quick Facts: Methicillin-Resistant *Staphylococcus Aureus* (MRSA)

- MRSA is an aerobic or facultative anaerobic, coagulase-positive organism. It can survive in the presence or absence of atmospheric oxygen.
- MRSA presents a serious threat to patient health and safety across practice settings as well as in the community.
- MRSA is addressed in the U.S. Department of Health and Human Services *National Action Plan to Prevent Health Care-Associated Infections: Road Map to Elimination* (HAI Action Plan). The plan identifies the targets and metrics for national prevention efforts in the United States.
- According to studies conducted by the Centers for Disease Control and Prevention and other researchers, MRSA infections in patients in U.S. hospitals, including those with MRSA bloodstream infections, are declining.
- In the community, MRSA most often presents as skin infections. According to public health data, the incidence of community-acquired MRSA does not seem to be decreasing.
- MRSA colonization (no sign of active infection) seems to be increasing. The extent to which the increase is attributable to much wider adoption of active surveillance testing (screening in the absence of symptoms of infection) is unknown. The impact of public reporting on increased rates of colonization has not yet been fully explored.
- Decolonization of the nares using mupirocin ointment, povidone-iodine, and ethanol-based nasal sanitizers often yields only transient improvement.
- MRSA colonization increases the probability that the patient will eventually develop an active MRSA infection.
- Contact Precautions are implemented for patients colonized with MRSA and those with active MRSA infections. Institutional polices regarding the discontinuation of Contact Precautions vary widely and are often based on obtaining negative cultures from multiple body sites during a specified period of time. See Appendix E for additional information on Contact Precautions.

- MRSA prevention within a healthcare setting is achieved with good hand hygiene practices in combination with following Standard and Contact Precautions.
- The most commonly obtained MRSA cultures are from skin/wounds, blood, urine and sputum.
- When obtaining a MRSA culture from a wound, clean the infected site of drainage using a sterile irrigant (sterile saline is often used). An accurate culture can only be obtained if old organic matter and accumulated wound drainage have first been removed.
- When obtaining MRSA cultures from indwelling devices (e.g., vascular access or urinary catheters) follow the institution's instructions to reduce the potential contamination of the specimen by exposure to bacterial biofilm.
- Patient bathing (actively by self or passively by a caregiver) with a chlorhexidine gluconate product reduces the MRSA bioburden on skin and may be a useful adjunct to prevention efforts in situations as appropriate, such as for preoperative and intensive care unit patients.

REFERENCES

Centers for Disease Control and Prevention. Methicillin-resistant *Staphylococcus aureus* (MRSA) infections. May 16, 2016. http://www.cdc.gov/mrsa.

US Department of Health and Human Services Office of Disease Prevention and Health Promotion. Health Care–Associated Infections: Overview. December 27, 2017. https://health.gov/hcq/prevent-hai.asp.

ADDITIONAL RESOURCE

Agency for Healthcare Research and Quality. MRSA Toolkit for Outpatient Clinics/Offices. October 17, 2012. https://innovations.ahrq.gov/qualitytools/mrsa-toolkit-outpatient-clinicsoffices.

Quick Facts: *Clostridium difficile*

- *Clostridium difficile* is a spore-forming, Gram-positive anaerobic bacillus that produces two exotoxins: toxin A and toxin B.
- Symptoms of *C. difficile* infection (CDI) include diarrhea, fever, nausea and poor appetite, and abdominal pain or tenderness.
- CDI was once primarily associated with healthcare settings but is increasingly common in the community.
- CDI is addressed in the U.S. Department of Health and Human Services *National Action Plan to Prevent Health Care-Associated Infections: Road Map to Elimination* (HAI Action Plan). The plan identifies the targets and metrics for national prevention efforts in the United States.
- According to studies conducted by the Centers for Disease Control and Prevention and other researchers, CDI rates are at an historic high in the United States.
- Exposure to antibiotics is a leading cause of CDI. The infection self-resolves within 2 to 3 days after antibiotics are withdrawn.
- CDI can lead to serious complications and result in high mortality rates among patients who are elderly, have serious underlying health conditions, are immunocompromised, or are hospitalized for lengthy periods.
- Patients with CDI are placed on Contact Precautions because patients continue to shed spores after the cessation of diarrhea. Contact Precautions are usually continued for several additional days or weeks following clinical improvement.
- Hand hygiene is performed with soap and water. Alcohol-based hand rubs are far less effective and are not recommended.
- Rigorous environmental cleaning and surface disinfection are required to control the spread of CDI. Standard Environmental Protection Agency (EPA)–registered disinfectants should not be used; EPA-registered sporicidal disinfectants are necessary. Alternatively, solutions of hypochlorite (household bleach) are highly effective, but they may be too harsh for some institutional surfaces. Monitor the correct use of approved disinfectants per manufacturer's directions and institutional policies and procedures.

- Since 2000, a new, highly virulent epidemic strain of CDI has emerged and is seen in younger patients traditionally thought to be at much lower risk. The epidemic strain may be referred to as *type BI, North American Pulsed Field type 1* (NAP1), or *PCR ribotype 027*. In addition to its toxin production, this new strain is often resistant to fluoroquinolones.
- CDI diagnostic testing may include molecular, antigen, and/or toxin testing. Stool cultures, although highly sensitive, are performed less frequently than in the past, because of the frequency of false-positive results and the delayed turnaround time. Verify with the laboratory which testing methods are used and the expected turnaround time for results.

REFERENCES

Centers for Disease Control and Prevention. *Clostridium difficile* Infection. March 1, 2016. http://www.cdc.gov/HAI/organisms/cdiff/Cdiff_infect.html.

Gould CV, McDonald LC. Bench-to-beside review: *Clostridium difficile* colitis. *Crit Care.* 2008;12(1):203. Epub 2008(Jan 18).

ADDITIONAL RESOURCES

Agency for Healthcare Research and Quality. Toolkit for Reduction of *Clostridium difficile* Infections Through Antimicrobial Stewardship. November 2014. https://www.ahrq.gov/professionals/quality-patient-safety/patient-safety-resources/resources/cdifftoolkit/index.html.

American Hospital Association, Hospital Improvement Innovation Network. *Clostridium Difficile* Infection (CDI). http://www.hret-hiin.org/topics/clostridium-difficile-infection.shtml.

Quick Facts: Seasonal Influenza (Flu)

- To access the most up-to-date information about seasonal influenza, visit the Centers for Disease Control and Prevention (CDC) Influenza page at http://www.cdc.gov/flu/index.htm.
- Seasonal flu is a respiratory illness caused by influenza viruses. Types A and B are the most common causes of seasonal flu epidemics. Specific types of flu (e.g., avian/bird, swine, bat) are reported separately and not included in seasonal influenza programs.
- "Flu season" is generally associated with fall and winter months but can peak in late spring. The CDC conducts year-round influenza surveillance to carefully monitor strains, prevalence, regional variations and severity, especially in high-risk groups.
- Influenza is spread primarily from person to person through large-particle respiratory droplet transmission from up to 6 feet away. Transmission from contact with contaminated surfaces and airborne transmission are also possible but are thought to be less common than droplet transmission and are not as well documented in scientific studies.
- Symptoms of the flu may be difficult to differentiate from other respiratory illnesses. Flu symptoms include fever, chills, cough, sore throat, headache, rhinitis, myalgia, and fatigue. Vomiting and diarrhea have also been reported.
- Influenza prevention is based on annual vaccination. Everyone ages 6 months and older should be vaccinated unless they have specific medical contraindications. For example, individuals with a febrile or other serious illness should delay vaccination until directed by their physician.
- If vaccines are in short supply, the CDC provides risk criteria to direct limited quantities to those most susceptible and/or at risk for serious complications. See the CDC website for the Summary of Influenza Recommendations.
- Available flu vaccines include the trivalent influenza vaccine (TIV), which is administered as an intramuscular injection (the traditional "flu shot"), and a quadrivalent vaccine used for individuals age 4 years and older. The quadrivalent vaccine includes immunization against influenza A (H1N1), influenza A (H3N2), and two additional influenza viruses determined through research based on antigenic drift to be common during the upcoming season.

- Following immunization programs, hand hygiene, respiratory etiquette, use of masks and tissues to contain secretions, and reducing exposure to infected individuals are the mainstays of infection prevention programs.
- Treatment includes symptom support and possible use of one of three available antiviral agents for seasonal influenza: oseltamivir, zanamivir, and peramivir. Use of adamantanes (amantadine and rimantadine) to treat type A flu is no longer recommended because of increasing levels of resistance.
- A variety of diagnostic tests are available for influenza, but their availability differs among laboratories. It is important to know which tests are readily available and their specific specimen-collection requirements.
- Rapid influenza diagnostic tests (RIDTs) provide results in less than 30 minutes. Commercially available RIDTs differ in their diagnostic uses; some only detect type A flu. RIDT is less sensitive than viral culture or reverse transcription polymerase chain reaction in detecting type A seasonal influenza.

REFERENCES

Centers for Disease Control and Prevention. Influenza (Flu). December 22, 2017. https://www.cdc.gov/flu/index.htm.

Tille PM, ed. *Bailey & Scott's Diagnostic Microbiology*. 14th ed. St. Louis, MO: Mosby; 2017.

World Health Organization. Influenza. http://www.who.int/influenza/en.

Quick Facts: Isolation Precautions

- Standard Precautions are the front-line barrier to protect patients and healthcare workers from unexpected exposures to infectious agents. They
  - reduce the risk of transmission of known or unknown infectious agents;
  - include hand hygiene and treating all blood, body fluids, secretions, excretions except sweat, nonintact skin and mucous membranes as containing transmissible infectious agents;
  - apply to all patients; and
  - require use of personal protective equipment (PPE), such as gloves, gown, mask, eye protection, or face shield, as appropriate to the recognized hazard.
- Transmission-Based Precautions are extensions of Standard Precautions. They include Contact, Droplet, and Airborne Precautions.
- Contact Precautions are used to reduce the risk of contamination and transmission of pathogenic microorganisms spread by direct or indirect contact with the patient and/or the patient's environment.
- Contact Precautions are most used in healthcare settings to prevent the transmission of methicillin-resistant *Staphylococcus aureus* (MRSA) and *Clostridium difficile*. However, Contact Precautions may be used for other microorganisms as well.
- In acute care, patients who require Contact Precautions should be placed in a private room. If a private room is not available, patient cohorting should be implemented after with consultation with an infection preventionist.
- Gowns and gloves must be removed when exiting the patient's room (or other area of placement; anteroom). When the gown and gloves have been removed and discarded, hand hygiene is performed.
- Lab coats, scrub attire and personal garments (e.g., sweaters, jackets) are not used in lieu of institutionally provided gowns for Contact Precautions.
- Gowns may not be worn outside the area designated for their use (e.g., patient room, cubicle, treatment room) and are not reused.

- To the extent possible, dedicated equipment should be used for patients requiring Contact Precautions. Disposable, noncritical equipment should also be considered. If these options are not feasible, equipment must be thoroughly cleaned and disinfected according to policy and manufacturers' recommendation before it is used again. Equipment taken to a reprocessing/soiled utility area should be placed in a plastic biohazard bag or appropriate container for sharp equipment for transport.
- Spaces occupied by patients on Transmission-Based Precautions should be cleaned at least daily with emphasis on high-touch surfaces, such as bed rails, tabletops, door handles, and bathroom fixtures.
- Contact Precautions are required even if the healthcare worker or visitor has no direct contact with the patient. The high levels of environmental microbial contamination and the persistence of microbes on high-touch surfaces support the rigorous use of Contact Precautions by all who enter the room.
- In nonacute settings, including ambulatory care, patient placement should be expedited and carefully managed to reduce the risk of transmission to other patients.
- Always refer to your facility's Infection Control policies to follow Standard and Transmission-Based Precautions.

	APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT (PPE)	TRANSPORT OR MOVEMENT WITHIN FACILITY	EQUIPMENT	CLEANING AND DISINFECTION OF PATIENT ROOM
Contact Precautions	Gloves, gown	Cover or contain infected or colonized area. Remove all PPE and perform hand hygiene. No PPE use during transport. Don clean PPE at the new location to work with patient.	Use disposable or dedicated equipment. If shared equipment is unavoidable, clean and disinfect according to policy and manufacturers' recommendations between each use.	Clean high-touch surfaces daily. Follow your institution's policy for appropriate cleaning upon patient discharge; typically, a terminal clean.
Droplet Precautions	Mask, gloves	Patient should don mask and follow the respiratory hygiene and cough etiquette requirements specific to your facility.	Use disposable or dedicated equipment. If shared equipment is unavoidable, clean and disinfect according to policy and manufacturers' recommendations between each use.	Clean high-touch surfaces daily. Follow your institution's policy for appropriate cleaning upon patient discharge; typically, a terminal clean.
Airborne Precautions: airborne infection isolation room	N95 mask respirator*	Patient should don a mask and follow the respiratory hygiene and cough etiquette requirements specific to your facility.	Use disposable or dedicated equipment. If shared equipment is unavoidable, clean and disinfect according to policy and manufacturers' recommendations between each use.	Clean high-touch surfaces daily. Follow your institution's policy for appropriate cleaning upon patient discharge; typically, a terminal clean.

*Powered air-purifying respirator (PAPR) is an alternative to N95 respirators for high-risk aerosol-generation.

REFERENCES

Centers for Disease Control and Prevention. Infection Control: Transmission-based Precautions. February 28, 2017. https://www.cdc.gov/infectioncontrol/basics/transmission-based-precautions.html.

Siegel J, Rhinehart E, Jackson M, Chiarello L. The Healthcare Infection Control Practices Advisory Committee. 2007 guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. *Am J Infect Control*. 2007;35(10 Suppl 2):S65–S164.

APPENDIX F

Quick Facts: Antibiograms

An antibiogram is a table that allows healthcare personnel to see information about the pathogens most commonly found in the hospital and the antimicrobials to which those pathogens are susceptible. Figure 1 is an example of a hospital-specific antibiogram. Each box in the grid indicates the percentage of the organisms that are sensitive to an antimicrobial. In the antibiogram's Gram-negative nonurine isolates example, *Escherichia coli* isolates are 100% susceptible to amikacin, and 52.6% of all *E.coli* isolates are susceptible to ampicillin. However, when reviewing the Gram-negative urine isolates for *E.coli,* 99.7% are susceptible to amikacin and 53.3% of all isolates are susceptible to ampicillin.

- Antibiograms are generally prepared by the laboratory according to the Clinical and Laboratory Standards Institute guidelines (document M39-A4).
- Data are analyzed for the most common isolates (usually 30) for a given pathogen.
- Antibiograms report susceptibility only to antimicrobials that are routinely used.
- Antibiograms help to answer two questions:
  - For this pathogen in this hospital, what is the best antimicrobial to use? (Highest susceptibility)
  - Has the susceptibility of this pathogen changed or increased?
- Only the first isolate is included for patients with multiple positive cultures. If there are multiple positive cultures or multiple organisms are suspected, consult the microbiology laboratory or the institution's infectious disease pharmacist (PharmD) for additional information.
- Antibiograms report the percentage of susceptible isolates. This percentage does not include the isolates with intermediate susceptibility. (The exception is intermediate susceptibility of *S. pneumoniae* to penicillin.)
- Changing resistance may indicate a need for increased infection prevention interventions.

REFERENCE

Arnold FW. Antimicrobials and resistance. In: *APIC Text Online*. November 1, 2017. http://text.apic.org/toc/microbiology-and-risk-factors-for-transmission/antimicrobials-and-resistance.

Figure 1. Antibiogram for Gram-negative non-urine isolates and Gram-negative urine isolates

Antibiogram

Gram-Negative Non-Urine

	Amikacin	Gentamicin	Tobramycin	Ampicillin	Ampicillin-Sulbactam	Piperacillin-Tazobactam	Aztreonam	Cefazolin	Ceftriaxone	Cefepime	Ertapenem	Meropenem	Ciprofloxacin	Trimethoprim-Sulfamethoxazole
Escherichia coli (135)	100.0%	89.6%	89.6%	52.6%	55.6%	94.8%	96.3%	85.2%	94.1%	94.8%	100.0%	100.0%	80.0%	83.0%
Klebsiella pneumoniae (70)	100.0%	98.6%	98.6%	R	81.4%	95.7%	97.1%	91.4%	97.1%	95.7%	98.6%	98.6%	94.3%	95.7%
Pseudomonas aeruginosa (84) (B)	98.8%	96.5%	100.0%	R	R	87.2%	82.6%	R	R	90.6%	R	92.7%	89.4%	0.0%

Gram-Negative Urine

	Amikacin	Gentamicin	Tobramycin	Ampicillin	Ampicillin-Sulbactam	Piperacillin-Tazobactam	Aztreonam	Cefazolin	Ceftriaxone	Cefepime	Ertapenem	Meropenem	Ciprofloxacin	Nitrofurantoin (A)	Trimethoprim-Sulfamethoxazole
Escherichia coli (623)	99.7%	89.4%	88.4%	53.3%	56.0%	97.4%	93.3%	86.3%	92.5%	92.8%	99.8%	99.7%	75.0%	97.9%	77.4%
Klebsiella oxytoca (30)	100.0%	100.0%	100.0%	R	36.7%	93.3%	93.3%	70.0%	93.3%	93.3%	100.0%	100.0%	96.7%	90.0%	100.0%
Klebsiella (182)	100.0%	98.4%	96.2%	R	86.3%	95.6%	95.6%	92.8%	95.1%	95.1%	98.9%	99.4%	97.3%	45.9%	94.5%
Proteus mirabilis (72)	100.0%	95.8%	94.4%	75.0%	84.7%	100.0%	97.2%	76.4%	95.8%	98.6%	100.0%	Not Tested	75.0%	R	83.3%
Pseudomonas aeruginosa (84) (B)	100.0%	96.9%	96.9%	R	R	84.6%	75.0%	R	R	90.8%	R	96.8%	86.2%	R	R

Presbyterian Hospital, Albuquerque, NM. Reprinted with permission from Justin Schmetterer.

Grey-shaded antibiotics are <50% susceptible or not appropriate. Isolates included in this antibiogram are from hospital inpatients and do not include the Emergency Department.

A. Nitrofurantoin is approved for use only in uncomplicated urinary tract infections; recommended 1st line for uncomplicated female cystitis due to minimal resistance. Avoid if creatinine clearance <30 mL/min.

B. Treatment of *P. aeruginosa* infections in compromised hosts may be optimized with an anti-Pseudomonal beta-lactam, to which the isolate is susceptible, in combination with an aminoglycoside to which the isolate is susceptible.

Abbreviation: R, intrinsically resistant.

APPENDIX G

Quick Facts: Antimicrobial Stewardship

- The misuse and overuse of antimicrobials is considered one of the world's most pressing public health problems. According to the Centers for Disease Control and Prevention (CDC), 47 million unnecessary antibiotic prescriptions are written in doctor's offices, emergency rooms, and hospital-based clinics each year.
- Inappropriate antibiotic use increases the risk for medication side effects, adverse events, antibiotic resistance, medication interactions, anaphylaxis, prolonged hospitalization, additional financial costs, patient duress, and mortality.
- Bacteria are constantly changing and evolving, which has led to the need for increased management of antimicrobial use.
- Interventions and programs designed to improve antibiotic use are referred to as *antimicrobial stewardship* and *antimicrobial stewardship programs*.
- Antimicrobial stewardship programs incorporate a multidisciplinary approach that includes bacterial culture surveillance as well as auditing appropriate use and dosing of antimicrobial agents.
- The infection prevention component of the team focuses on reducing organism resistance.
- The CDC published an awareness and education about antibiotic use (https://www.cdc.gov/antibiotic-use/index.html).
- Antimicrobial stewardship (AS) teams are led by a physician and a pharmacist. Healthcare epidemiologists and infection preventionists are also key members of the AS team. The team also contains an administrative component.
- To reduce antibiotic overutilization and inappropriate use, clinicians should review antibiotic orders for appropriate dose, duration, and indication. This practice helps clinicians change or stop therapy when appropriate.
- Clinicians should take measures to ensure that antibiotic use is tailored to the susceptibility results performed with culturing and identified infectious agent/pathogen.
- An "antibiotic timeout" can be taken when culture results are available, usually within 48 hours, to assess whether the antibiotic is still warranted or if the antibiotic is effective against the identified organism(s).
- Standard and transmission-based precautions are used to help manage the transmission of pathogens, including multidrug-resistant organisms.

REFERENCES

Arnold FW. Antimicrobials and resistance. In: *APIC Text Online*. November 1, 2017. http://text.apic.org/toc/microbiology-and-risk-factors-for-transmission/antimicrobials-and-resistance.

Centers for Disease Control and Prevention. Antibiotic Prescribing and Use in Hospitals and Long-Term Care. November 16, 2017. https://www.cdc.gov/antibiotic-use/healthcare/index.html.

Moody J, Cosgrove S, Olmsted R, et al. Antimicrobial stewardship: a collaborative partnership between infection preventionists and health care epidemiologists. *Am J Infect Control*. 2012;40(2):94–95.

ADDITIONAL RESOURCES

Centers for Disease Control and Prevention. Antibiotic Prescribing and Use in Hospitals and Long-Term Care: Implementation Resources. https://www.cdc.gov/antibiotic-use/healthcare/index.html.

Centers for Disease Control and Prevention. Antibiotic Prescribing and Use in Hospitals and Long-Term Care: Overview and Evidence to Support Appropriate Antibiotic Use. November 22, 2017. https://www.cdc.gov/antibiotic-use/healthcare/evidence.html.

Abbreviations Used in This Reference

AFB	Acid-fast bacilli
AIDS	Acquired immunodeficiency syndrome
aka	Also known as
APIC	Association for Professionals in Infection Control and Epidemiology
AS	Antimicrobial stewardship
ASP	Antimicrobial stewardship program
BCG	Bacillus Calmette-Guerin
BHF	Bolivian hemorrhagic fever
CCHF	Crimean-Congo hemorrhagic fever
CDC	Centers for Disease Control and Prevention
CDI	*Clostridium difficile* infection
CERC	Crisis and Emergency Risk Communication
CJD	Creutzfeldt-Jakob disease
CMV	Cytomegalovirus
CNS	Central nervous system
CTFV	Colorado tick fever virus
DHF	Dengue hemorrhagic fever

DNA	Deoxyribonucleic acid
DSS	Dengue shock syndrome
DTaP	Diphtheria, tetanus, and pertussis
EBV	Epstein-Barr virus
ECHO	Enteric, cytopathic, human, orphan
EEE	Eastern equine encephalitis
EEEV	Eastern equine encephalitis virus
e.g.	For example
EPA	Environmental Protection Agency
FFA	Fatal familial insomnia
fka	Formerly known as
GI	Gastrointestinal
GSS	Gerstmann-Straussler-Scheinker syndrome
GU	Genitourinary
HA	Hemagglutinin
HAART	Highly active antiretroviral therapy
HACEK	***H****aemophilus* species, ***A****ggregatibacter aphrophilus,* ***C****ardiobacterium hominis,* ***E****ikenella corrodens,* ***K****ingella kingae*

HAI	Healthcare-associated infection
HAV	Hepatitis A virus
HBV	Hepatitis B virus
HCV	Hepatitis C virus
HDV	Hepatitis D virus
HEV	Hepatitis E virus
HHV-6	Human herpesvirus 6
HHV-7	Human herpesvirus 7
HHV-8	Human herpesvirus 8
HIB	*Haemophilus influenzae* type B
HIV	Human immunodeficiency virus
HPV	Human papillomavirus
HSV	Herpes simplex virus
HTLV	Human T-cell lymphotropic virus
HUS	Hemolytic uremic syndrome
ICU	Intensive care unit
IV	Intravenous
JCV	John Cunningham (JC) virus
JEV	Japanese encephalitis virus
KFD	Kyasanur Forest disease

LACV	La Crosse virus
MAC	*Mycobacterium avium* complex
MCV	*Molluscum contagiosum* virus
MDR-TB	Multidrug-resistant *Mycobacterium tuberculosis*
MI	Medically important
MMR	Measles-mumps-rubella
MOTT	Mycobacteria other than tuberculosis
MRSA	Methicillin-resistant *Staphylococcus aureus*
MSSA	Methicillin-susceptible *Staphylococcus aureus*
NA	Neuraminidase
NDV	Newcastle disease virus
NiV	Nipah virus
NLV	Norwalk-like virus
OHFV	Omsk hemorrhagic fever virus
PAPR	Powered air-purifying respirator
PCR	Polymerase chain reaction
PID	Pelvic inflammatory disease
PML	Progressive multifocal leukoencephalopathy
PPE	Personal protective equipment
PrEP	Pre-exposure prophylaxis

PVL	Panton-Valentine leukocidin
RIDT	Rapid influenza diagnostic test
RNA	Ribonucleic acid
RSV	Respiratory syncytial virus
RVFV	Rift Valley fever virus
SAPHO	Synovitis, acne, pustulosis, hyperostosis, and osteomyelitis
SARS	Severe acute respiratory syndrome
SARS-CoV	SARS–associated coronavirus
SFTSV	Severe fever with thrombocytopenia syndrome virus
SLEV	St. Louis encephalitis virus
TBE	Tick-borne encephalitis
TBEV	Tick-borne encephalitis virus
Tdap	Tetanus, diphtheria, and pertussis

TIG	Tetanus immune globulin
TIV	Trivalent influenza vaccine
TSS	Toxic shock syndrome
UTI	Urinary tract infection
vCJD	Variant Creutzfeldt-Jakob disease
VEE	Venezuelan equine encephalitis
VRE	Vancomycin-resistant *Enterococcus*
VRSA	Vancomycin-resistant *Staphylococcus aureus*
VZV	Varicella-zoster virus
WEE	Western equine encephalitis
WEEV	Western equine encephalitis virus
WHO	World Health Organization
XDR-TB	Extensively drug-resistant *Mycobacterium tuberculosis*
YF	Yellow fever

Index