Microbial Diseases of the Digestive System

Microbiology
CCV
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Structures of the Digestive System

- **Digestive System Structures Are Divided into Two Groups**
  - Gastrointestinal tract (GI tract)
    - The pathway from the mouth to the anus
    - Most organs of the GI tract are protected by the peritoneum
  - Accessory digestive organs
    - Organs involved in grinding food or providing digestive secretions

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Structures of the Digestive System

- **The Gastrointestinal Tract**
  - Digests food, absorbs nutrients and water into the blood, and eliminates waste
  - Components of the gastrointestinal tract
    - Mouth
    - Esophagus
    - Stomach
    - Small intestine
    - Large intestine (colon)
    - Rectum and anus

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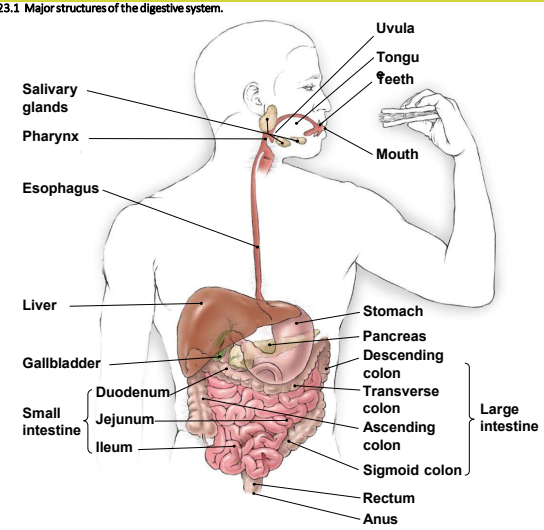
Figure 23.1 Major structures of the digestive system.



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Structures of the Digestive System

- **The Accessory Digestive Organs**
  - Tongue and teeth
  - Salivary glands
  - Liver
  - Gallbladder
  - Pancreas

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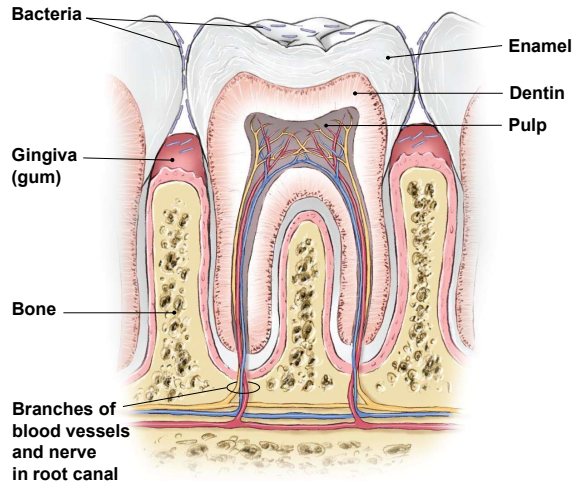
Figure 23.2 Detailed structure of teeth and socket.



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Normal Microbiota of the Digestive System

- Esophagus, stomach, duodenum
  - These regions are almost free of microbes
  - Peristalsis and rapid transport of food helps prevent microbial colonization
- Tongue, teeth, jejunum, ileum, colon, rectum
  - Viridans streptococci are most prevalent in this region
- Lower small intestine and colon
  - Microbiota here are microbial antagonists
  - Mucous membrane prevents entry of microbes into the bloodstream

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Bacterial Diseases of the Digestive System

- **Dental Caries, Gingivitis, and Periodontal Disease**
  - Signs and symptoms
    - Caries
      - Appears as holes or pits in the teeth
    - Periodontal disease
      - Gums that are swollen, tender, bright red, or bleeding
  - Pathogen, virulence factors, and pathogenesis
    - *Streptococcus mutans* is a frequent cause of caries
      - Dextran and pili allow biofilm formation on the tooth
    - *Porphyromonas gingivalis* causes periodontal disease
      - Proteases break down gingival tissue

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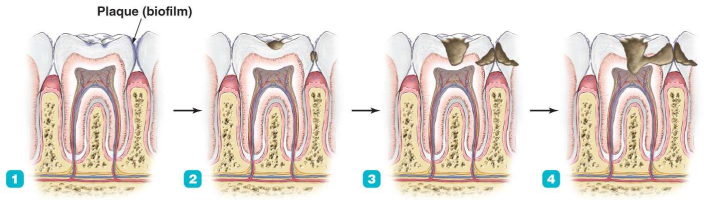
Figure 23.3 The process of tooth decay.



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Bacterial Diseases of the Digestive System

- **Dental Caries, Gingivitis, and Periodontal Disease**
  - Epidemiology
    - Most adults have experienced dental caries
    - Diets high in sucrose increase the risk of decay
  - Diagnosis, treatment, and prevention
    - Caries
      - Diagnosed by visual inspection
      - Treated by filling cavities if caught early
    - Gingivitis
      - Diagnosed by inspection of gums
      - Treated by scaling and use of antibacterial rinses
    - Prevention involves good oral hygiene

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Bacterial Diseases of the Digestive System

- **Peptic Ulcers**
  - Signs and symptoms
    - Abdominal pain is main symptom
  - Pathogen and virulence factors
    - Caused by *Helicobacter pylori*
    - Numerous virulence factors
      - Flagella enable burrowing through stomach lining
      - Adhesins facilitate attachment to gastric cells
      - Urease neutralizes stomach acid

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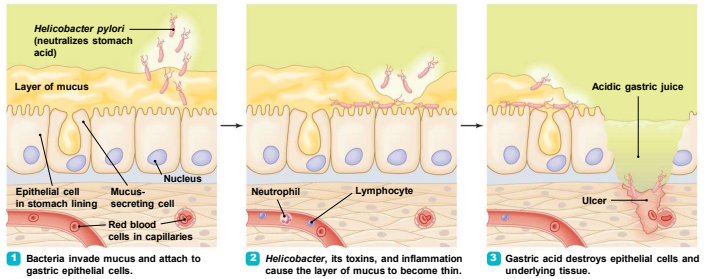
Figure 23.4 The role of *Helicobacter pylori* in the formation of ulcers.



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Bacterial Diseases of the Digestive System

- **Peptic Ulcers**
  - Epidemiology
    - Fecal-oral transmission is likely
    - Stress may worsen ulcer symptoms
  - Diagnosis, treatment, and prevention
    - Diagnosis based on X-ray exam to identify ulcers and presence of *H. pylori* in clinical specimens
    - Treated with antimicrobials and drugs that inhibit stomach acid
    - Prevented by avoiding fecal-oral transmission

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Bacterial Diseases of the Digestive System

- **Bacterial Gastroenteritis**
  - Inflammation of stomach or intestines caused by bacteria
  - Associated with contaminated food or water and poor living conditions
  - General features
    - Similar manifestations despite different causative agents
      - Nausea, vomiting, diarrhea, abdominal pain, and cramps
    - Dysentery produces loose, frequent stool containing mucus and blood

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Bacterial Diseases of the Digestive System

- **Bacterial Gastroenteritis: Shigellosis**
  - Pathogen and virulence factors
    - Caused by four species of *Shigella*
    - Virulence factors include type III secretion systems and enterotoxins
  - Pathogenesis and epidemiology
    - Pathogen colonizes cells of the small, then large intestine
  - Diagnosis, treatment, and prevention
    - Diagnosed by symptoms and presence of *Shigella* in stool
    - Supportive treatment and administration of antimicrobials

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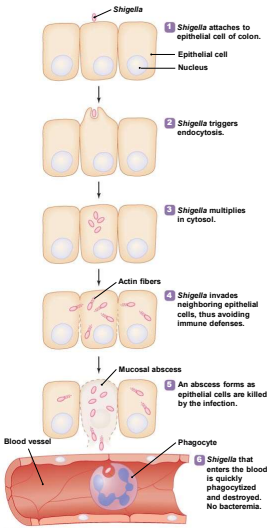
Figure 23.5 The events in shigellosis.



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Bacterial Diseases of the Digestive System

- **Bacterial Gastroenteritis: Traveler's Diarrhea**
  - Pathogen and virulence factors
    - Caused by *Escherichia coli*
    - Virulence factors: adhesins, fimbriae, and toxins
  - Pathogenesis and epidemiology
    - Diarrhea mediated by enterotoxins
    - Common in developing countries
  - Diagnosis, treatment, and prevention
    - Diagnosis is based on signs and symptoms
    - Treatment is based on fluid and electrolyte replacement
      - Antidiarrheal drugs prolong the symptoms

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Bacterial Diseases of the Digestive System

- **Bacterial Gastroenteritis: *Campylobacter* Diarrhea**
  - Pathogen and virulence factors
    - Caused by *Campylobacter jejuni*
    - Virulence factors: adhesins, cytotoxins, endotoxin
  - Pathogenesis and epidemiology
    - Virulence factors cause bleeding lesions and inflammation
    - Chickens are the main source of human infections
  - Diagnosis, treatment, and prevention
    - Diagnosis is based on signs and symptoms
    - Most cases resolve without treatment
    - Prevented with proper hygiene after handling raw poultry

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Figure 23.6 *Campylobacter jejuni*, the most common cause of bacterial gastroenteritis in the United States.

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Bacterial Diseases of the Digestive System

- **Bacterial Gastroenteritis: *C. diff.* (Antimicrobial-Associated) Diarrhea**
  - Signs and symptoms
    - Pseudomembranous colitis occurs in severe cases
  - Pathogen and virulence factors
    - Caused by *Clostridium difficile*
    - Antimicrobial use facilitates overgrowth of *C. difficile*
    - *C. difficile* produces two toxins
  - Pathogenesis
    - Toxins mediate inflammation and pseudomembrane formation

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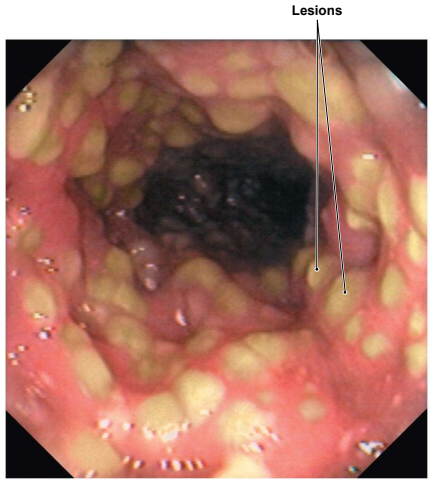
Figure 23.7 Pseudomembranous colitis.



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Bacterial Diseases of the Digestive System

- **Bacterial Gastroenteritis: *C. diff.* (Antimicrobial-Associated) Diarrhea**
  - Epidemiology
    - By-product of modern medicine
    - Any antimicrobial can trigger the disease
  - Diagnosis, treatment, and prevention
    - Diagnosis is based on presence of bacterial toxin in stool
    - Treated with antimicrobials
    - Avoid unnecessary use of antimicrobials

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Bacterial Diseases of the Digestive System

- **Bacterial Gastroenteritis: Salmonellosis and Typhoid Fever**
  - Pathogen and virulence factors
    - Caused by *Salmonella enterica* serotypes
      - Serotypes Typhi and Paratyphi cause typhoid fever
      - Serotypes Enteritidis and Typhimurium cause salmonellosis
    - Bacteria tolerate acidity of stomach and pass to the intestine
      - Toxins disrupt numerous cellular activities
  - Pathogenesis and epidemiology
    - Typhoid fever is acquired by contaminated food or water
    - Salmonellosis is often acquired by consuming contaminated eggs

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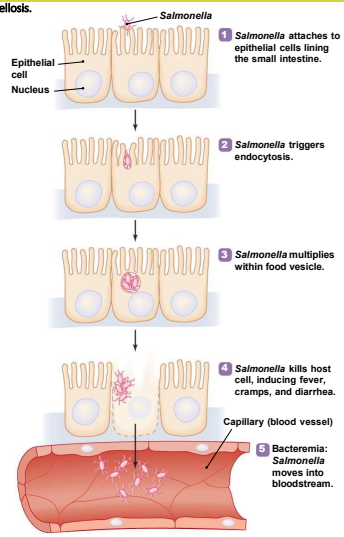
Figure 23.8 The events in salmonellosis.



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Bacterial Diseases of the Digestive System

- **Bacterial Gastroenteritis: Salmonellosis and Typhoid Fever**
  - Diagnosis, treatment, and prevention
    - Diagnosis is made by finding *Salmonella* in stool
    - Salmonellosis is usually self-limiting
    - Typhoid fever can be treated with antimicrobial drugs
    - Prevented with proper hygiene

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Bacterial Diseases of the Digestive System

- **Bacterial Gastroenteritis: Cholera**
  - Pathogen and virulence factors
    - Caused by *Vibrio cholerae*
      - Occurs in salt- and freshwater
    - Environment within the human body activates some *Vibrio* genes
    - Most important virulence factor is production of cholera toxin
  - Pathogenesis and epidemiology
    - Pandemics have occurred throughout history

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Figure 23.9 The action of cholera toxin in intestinal epithelial cells.

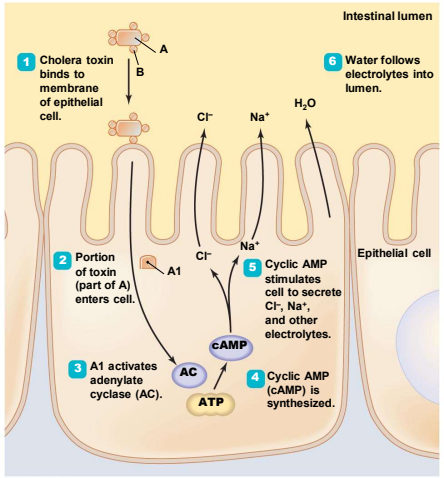

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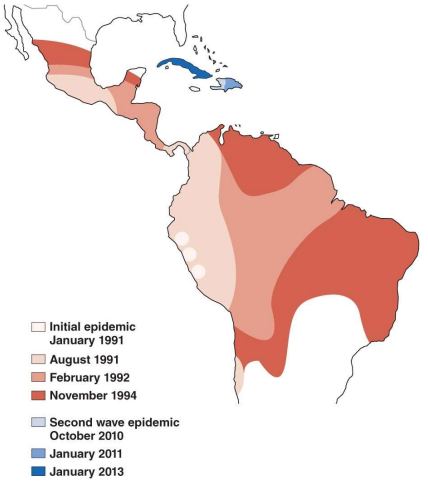
Figure 23.10 Cholera pandemic.



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Bacterial Diseases of the Digestive System

- **Bacterial Gastroenteritis: Cholera**
  - Diagnosis, treatment, and prevention
    - Diagnosis is based on presence of "rice-water" stool
    - Treated with supportive care and administration of doxycycline
    - Available vaccine provides only short-lived immunity
    - Proper hygiene is an important preventive measure

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TABLE **23.1** Common Forms of Bacterial Gastroenteritis

Disease	Pathogen (Minimum Infectious Dose)	Source of Infection	Incubation Period	Distinguishing Manifestations	U.S. Annual Incidence	Complications
Shigellosis	*Shigella dysenteriae*, *S. flexneri*, *S. boydii*, *S. sonnei* (200 cells)	Self-inoculation from fecally contaminated hands, secondarily through consumption of fecally contaminated foods; direct person-to-person spread	1–7 days	Purulent (containing mucus and pus) bloody stools, crampy rectal pain, fever, vomiting, and nausea lasting 2–3 days	14,000 cases	Severe dehydration; febrile seizures, confusion, and other neurological complications may appear in children
Traveler's diarrhea	*Escherichia coli* (unknown)	Fecally contaminated food or water	24–72 hours	Nausea, vomiting, and diarrheal symptoms lasting 1–3 days	Unknown, as reporting is not required; estimated >80,000 cases	Dehydration
***E. coli* O157: H7 infection**	*E. coli* strain O157:H7 (10 cells)	Fecally contaminated milk, fruit juice, or ground beef	24–72 hours	Bloody diarrhea, fatal hemorrhagic colitis, hemolytic uremic syndrome—destruction of erythrocytes and kidney failure	2000–3000 cases	Death
***Campylobacter* diarrhea**	*Campylobacter jejuni* (500 cells)	Zoonotic from domestic poultry, dogs, cats, rabbits, pigs, cattle, and minks through consumption of food, milk, or water contaminated with animal feces; close contact with infected humans	2–5 days	10 or more bowel movements per day lasting 2–5 days; blood may be present in diarrhea	More than 1 million cases estimated	Sepsis, arthritis, Guillain-Barré syndrome (temporary nerve paralysis), death

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TABLE **23.1** Common Forms of Bacterial Gastroenteritis *(Continued)*

Disease	Pathogen (Minimum Infectious Dose)	Source of Infection	Incubation Period	Distinguishing Manifestations	U.S. Annual Incidence	Complications
***C. diff* (antimicrobial associated) diarrhea**	*Clostridium difficile* (unknown)	5% of Americans carry *C. diff.* normally; 20% of hospital patients are infected	48 hours to six weeks	Numerous, watery, foul-smelling stools; pseudomembranes	Estimated 500,000 cases	Pseudomembranous colitis, death
Salmonellosis	*Salmonella enterica* serotypes Enteritidis and Typhimurium ($>10^6$ cells)	Zoonotic from domestic poultry through consumption of fecally contaminated meat or eggs, or consumption of inadequately pasteurized contaminated milk; close contact with infected reptiles; contact with human carriers	8–48 hours	Nonbloody diarrhea, nausea, vomiting, fever, headache, and pain lasting 1–2 weeks; rash of tiny rose spots may appear on the skin	50,000 cases	Dehydration
Typhoid fever	*Salmonella enterica* serotypes Typhi and Paratyphi ($>10^6$ cells)	Primarily contaminated water	8–48 hours	High fever (40°C), headache, muscle and stomach pain, malaise, loss of appetite, rose-colored spots	300–400 cases	Intestinal perforation, hemorrhaging, kidney failure, peritonitis, and death
Cholera	*Vibrio cholerae* ($>10^8$ cells)	Fecally contaminated food or water	48–72 hours	Rice-water stool (watery, colorless, odorless stools flecked with mucus) lasting 2–3 days; patients may lose up to 1 L of fluid per hour	0–8 cases	Death can occur within 48 hours of symptom onset if untreated (25–50% mortality rate)

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Bacterial Diseases of the Digestive System

- **Bacterial Food Poisoning (Intoxication)**
  - Signs and symptoms
    - Nausea, vomiting, diarrhea, cramping
  - Pathogen and virulence factors
    - Caused by *Staphylococcus aureus*
    - Virulence factors include five enterotoxins
  - Pathogenesis and epidemiology
    - Outbreaks are associated with social functions
  - Diagnosis, treatment, and prevention
    - Diagnosis is based on signs and symptoms
    - Treated with fluid and electrolyte replacement
    - Proper hygiene can reduce incidence

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Viral Diseases of the Digestive System

- **Oral Herpes**
  - Signs and symptoms
    - Presence of cold sores
    - Infections may extend beyond the oral cavity
      - Herpetic gingivostomatitis
      - Herpetic pharyngitis
      - Herpes esophagitis
  - Pathogen and pathogenesis
    - Caused by *human herpesvirus 1* (HHV-1)
    - Virions form syncytia to avoid host's immune system
    - Latency established in the trigeminal nerve ganglion

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Figure 23.11 Oral herpes lesion.

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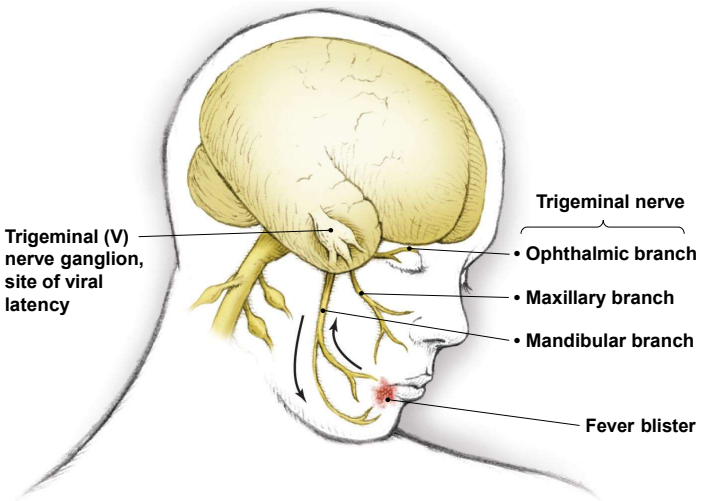
Figure 23.12 Latency and reactivation of oral herpesviruses.



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Viral Diseases of the Digestive System

- **Oral Herpes**
  - Epidemiology
    - Infections occur by casual contact in childhood
    - Primary infections are usually asymptomatic
  - Diagnosis, treatment, and prevention
    - Diagnosis is based on characteristic lesions
    - Topical penciclovir or acyclovir limits duration of lesions
    - Avoid direct contact with infected individuals

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Viral Diseases of the Digestive System

- **Mumps**
  - Caused by the mumps virus
    - Humans are the only natural host
  - Once a very common childhood disease
  - Nearly nonexistent in developed countries because of immunization
  - No specific treatment for mumps
  - Infected individuals develop lifelong immunity

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Viral Diseases of the Digestive System

- **Viral Gastroenteritis**
  - Signs and symptoms
    - Similar to those of bacterial gastroenteritis
    - Dehydration is common complication
  - Pathogens and pathogenesis
    - Caused by caliciviruses, astroviruses, and rotaviruses
    - These viruses infect cells lining the intestinal tract
  - Epidemiology
    - More cases occur in winter
    - Rotaviruses are important cause of childhood deaths in developing countries

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Figure 23.13 Some viruses causing gastroenteritis.

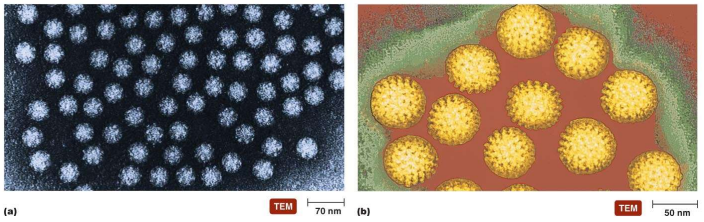

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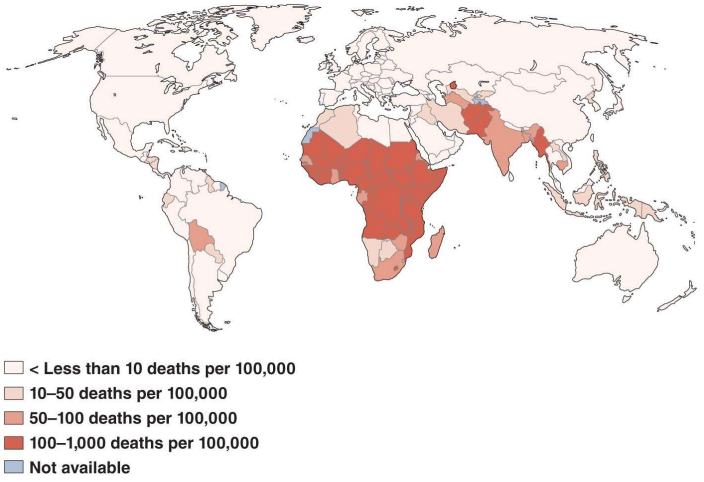
Figure 23.14 Deaths from rotaviral diarrhea are most common in developing countries.



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Viral Diseases of the Digestive System

- **Viral Gastroenteritis**
  - Diagnosis, treatment, and prevention
    - Serological test distinguishes among viruses
    - Treatment is based on fluid and electrolyte replacement
    - Prevention involves proper treatment of water and sewage and good hygiene practices
    - Vaccine for rotavirus exists

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Viral Diseases of the Digestive System

- **Viral Hepatitis**
  - Signs and symptoms
    - Jaundice, abdominal pain, fatigue, vomiting, weight loss
    - Symptoms may occur years after initial infection
  - Pathogen and pathogenesis
    - Liver damage due mostly to host immune response
    - Pathogens
      - Hepatitis A virus (HAV)
      - Hepatitis B virus (HBV)
      - Hepatitis C virus (HCV)
      - Hepatitis delta virus (HDV)
      - Hepatitis E virus (HEV)

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TABLE **23.2** Comparison of Hepatitis Viruses

Feature	*Hepatovirus* Hepatitis A virus (HAV)	*Orthohepadnavirus* Hepatitis B virus (HBV)	*Hepacivirus* Hepatitis C virus (HCV)	*Deltavirus* Hepatitis delta virus (HDV)	*Hepevirus* Hepatitis E virus (HEV)
Virus family	*Picornaviridae*	*Hepadnaviridae*	*Flaviviridae*	*Arenaviridae*	*Hepeviridae*
Genome	+ssRNA	Partly ssDNA, partly dsDNA	+ssRNA	−ssRNA	+ssRNA
Envelope present?	No	Yes	Yes	Yes	No
Transmission	Fecal-oral	Needles; sex; blood and fluids	Needles; sex	Needles; sex	Fecal-oral
Incubation period	15–45 days	70–100 days	42–49 days	7–24 days	15–60 days
Severity (mortality rate)	Mild (<0.5%)	Occasionally severe (15–25%)	Usually subclinical (0.5–4%)	Requires simultaneous hepatitis B infection to replicate; together severity may be very high (10–20%)	Mild (1–3%; pregnant women 15–25%)
Chronic carrier state?	No	Yes	Yes	No	No
Common name of disease	Infectious hepatitis	Serum hepatitis	Non-A, non-B hepatitis; chronic hepatitis	Hepatitis delta	Enteric hepatitis
Other disease associations	—	Hepatic cancer	Hepatic cancer	Cirrhosis	—

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Viral Diseases of the Digestive System

- **Viral Hepatitis**
  - Diagnosis, treatment, and prevention
    - Initial diagnosis made by observation of jaundice, enlarged liver, or fluid in the abdomen
    - Serological testing can identify viral antigens
    - HBV diagnosed by viral proteins in body fluids
    - Supportive care for symptoms
    - Alpha interferon and nucleotide analogs help reduce levels of virus
    - Prevented with good hygiene and protected sex or abstinence
    - Vaccines are available against HAV and HBV

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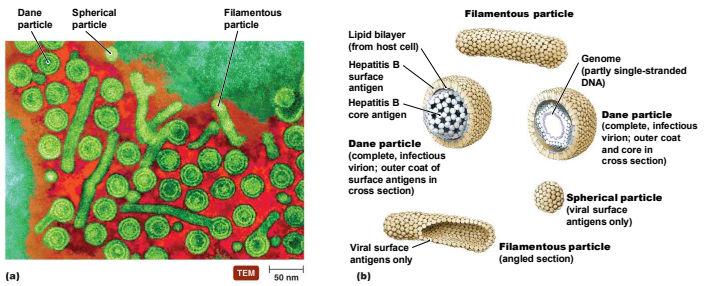
Figure 23.15 Three types of viral protein particles produced by hepatitis B viruses.



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Protozoan Diseases of the Intestinal Tract

- **Giardiasis**
  - Signs and symptoms
    - Often asymptomatic
    - Diarrhea and associated symptoms can last up to four weeks
  - Pathogen
    - Caused by *Giardia intestinalis*
    - *G. intestinalis* cysts are resistant to chlorine, heat, drying, and stomach acid

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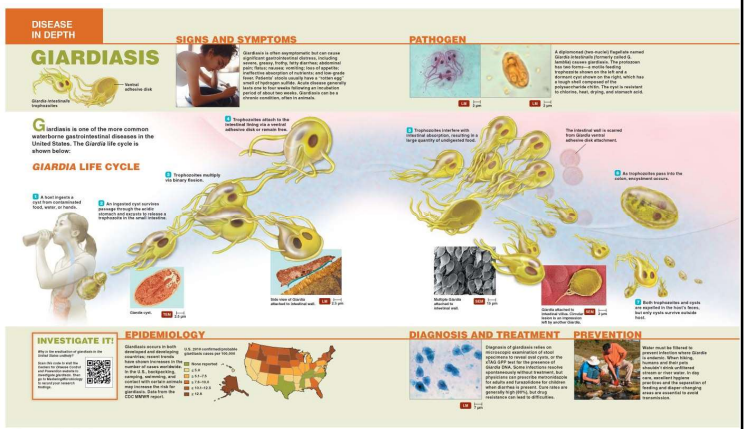
Disease in Depth: Giardiasis: Multiple *Giardia* attached to the intestinal wall



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Protozoan Diseases of the Intestinal Tract

- **Giardiasis**
  - Epidemiology
    - Occurs in developed and developing countries
    - Individuals ingest cysts from contaminated water, food, or hands
    - Hikers, campers, and swimmers are at particular risk
  - Diagnosis, treatment, and prevention
    - Diagnosed by microscopic observation of *Giardia* in stool
    - Treated with metronidazole (adults) or furazolidone (children)
    - Prevention relies on good hygiene and filtering water in endemic areas

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Protozoan Diseases of the Intestinal Tract

- **Cryptosporidiosis**
  - Signs and symptoms
    - Severe watery diarrhea with potentially serious complications
  - Pathogen and pathogenesis
    - Caused by *Cryptosporidium parvum*
    - Pathogenicity of *C. parvum* is unclear
  - Epidemiology
    - Infection results from drinking contaminated water
  - Diagnosis, treatment, and prevention
    - Presence of oocysts in feces is diagnostic
    - Treated with fluid and electrolyte replacement
    - Prevented with proper hygiene

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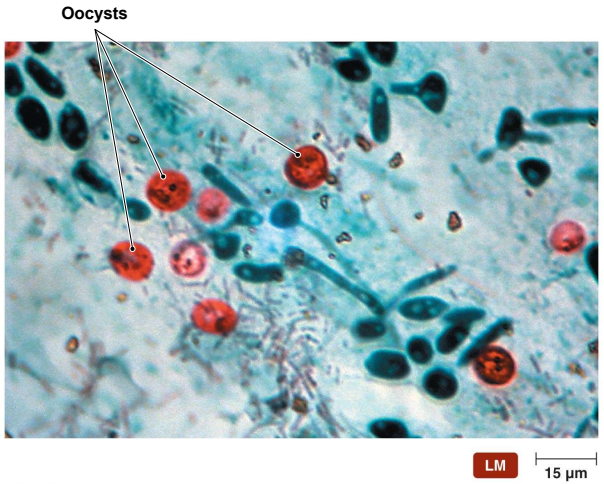
Figure 23.16 Oocysts of *Cryptosporidium parvum* in feces.



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Protozoan Diseases of the Intestinal Tract

- **Amebiasis**
  - Signs and symptoms
    - Luminal amebiasis is asymptomatic
    - Invasive amebic dysentery causes severe diarrhea, colitis, appendicitis
    - Invasive extraintestinal amebiasis causes necrotic lesions in various organs
  - Pathogen, virulence factors, and pathogenesis
    - Caused by *Entamoeba histolytica*
    - Virulent strains produce numerous proteins that are toxic to cells and facilitate invasion
    - Trophozoites in the peritoneal cavity or blood cause symptoms

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Protozoan Diseases of the Intestinal Tract

- **Amebiasis**
  - Epidemiology
    - Transmitted by consumption of contaminated food or water, from contaminated hands, or oral-anal intercourse
    - Majority of individuals develop luminal amebiasis
    - Human carriers help maintain transmission
  - Diagnosis, treatment, and prevention
    - Diagnosed by microscopic observation of *Entamoeba* in stool or intestinal biopsy
    - Treated with oral rehydration therapy and antiamebic drugs
    - Prevent with proper hygiene, safe sex practices
    - Individuals in endemic areas should drink bottled water and avoid uncooked vegetables or unpeeled fruits

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Helminthic Infestations of the Intestinal Tract

- Helminths are macroscopic, multicellular worms
- Helminths can infest the GI tract as non-disease-causing parasites

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Helminthic Infestations of the Intestinal Tract

- **Tapeworm Infestations**
  - Tapeworm is the common name for a cestode
    - Flat, segmented, parasitic helminth
    - Intestinal parasites that lack own digestive system
  - Signs and symptoms
    - Usually asymptomatic
    - Nausea, abdominal pain, weight loss, and diarrhea may occur
  - Pathogens
    - *Taenia saginata*: beef tapeworm
    - *Taenia solium*: pork tapeworm
    - Life cycle split between primary and intermediate host

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Figure 23.17 Features of tapeworm morphology.

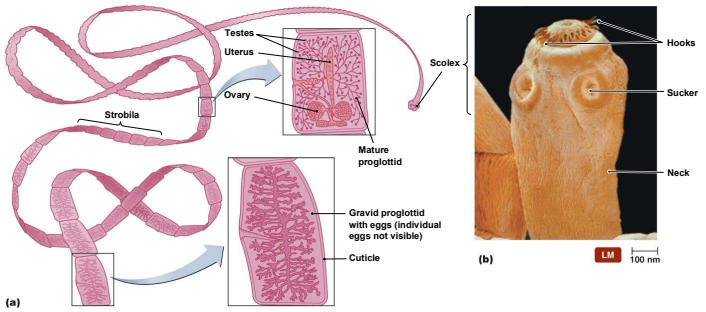

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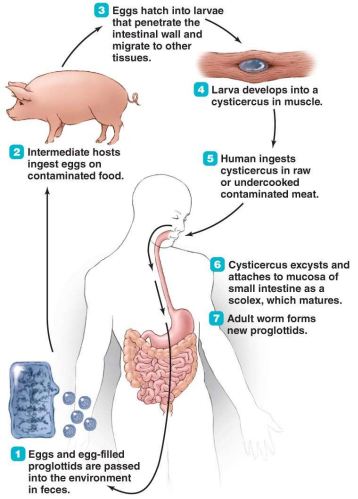
Figure 23.18 Life cycle of *Taenia solium*.



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Helminthic Infestations of the Intestinal Tract

- **Tapeworm Infestations**
  - Epidemiology
    - *Taenia* species live worldwide where beef and pork are food
    - High incidence
      - Regions of inadequate sewage treatment
      - Regions where humans live in close contact with livestock
  - Diagnosis, treatment, and prevention
    - Diagnosed by presence of proglottids in fecal sample
    - Treated with niclosamide or praziquantel
    - Prevention relies on thorough cooking of meats

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Helminthic Infestations of the Intestinal Tract

- **Pinworm Infestations**
  - Pinworms are nematodes
    - Long, thin, unsegmented, cylindrical helminth
  - Signs and symptoms
    - Perianal itching, irritability, decreased appetite
    - One-third of cases are asymptomatic
  - Pathogen and infestation
    - Caused by *Enterobius vermicularis*
    - Females deposit eggs in the perianal region at night
      - Eggs can be dislodged and spread the disease

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Helminthic Infestations of the Intestinal Tract

- **Pinworm Infestations**
  - Epidemiology
    - Infections commonly occur in children
    - *Enterobius* is the most common parasitic worm in the U.S.
  - Diagnosis, treatment, and prevention
    - Diagnosis is based on identification of eggs or adult pinworms
    - Treated with pyrantel pamoate or mebendazole
    - Prevention requires strict personal hygiene

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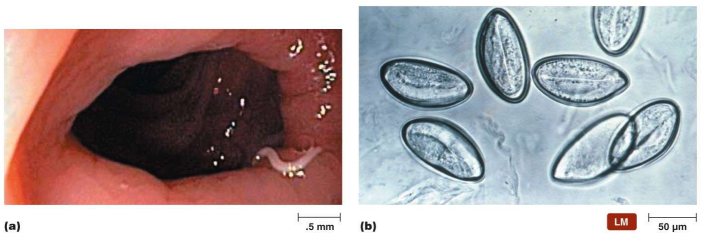
Figure 23.19 Nematodes.



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Helminthic Infestations of the Intestinal Tract

- **Anisakiasis**
  - Anisakiasis results from infestation by several parasitic nematodes
  - Signs and symptoms
    - Typically asymptomatic
    - Abdominal pain, nausea, vomiting, and fever may occur
    - Some individuals develop an allergic rash
  - Pathogen and infestation
    - Most commonly caused by *Anisakis simplex*
    - Complex life cycle with several larval stages

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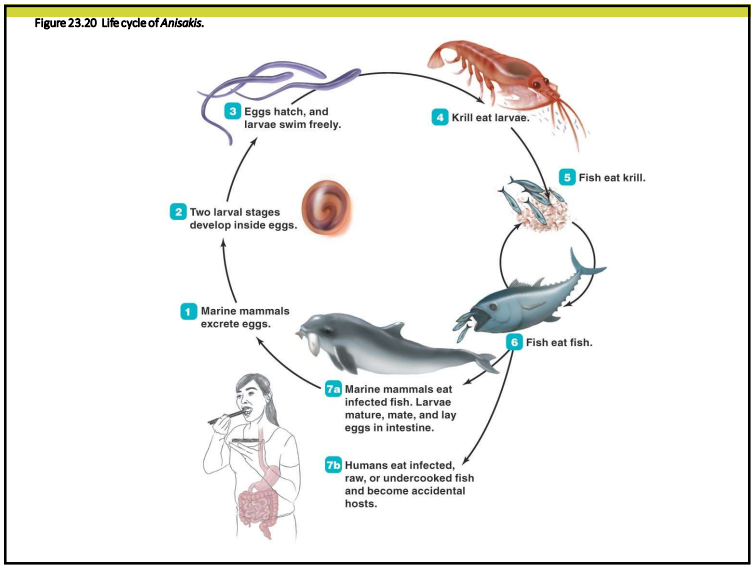

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Helminthic Infestations of the Intestinal Tract

- **Anisakiasis**
  - Epidemiology
    - About 20,000 cases occur worldwide
  - Diagnosis, treatment, and prevention
    - Diagnosis is generally made using endoscopy to visualize worms
    - Treatment involves removing worms from the intestine
    - Prevented by avoiding raw and undercooked marine fish

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