Diseases of the Digestive System

Microbial diseases of the digestive system are second only to respiratory diseases as causes of illness in the United States. Most result from the ingestion of food or water contaminated with pathogens or their toxins (endotoxins and exotoxins). Pathogens usually enter the food or water supply after being shed in the feces of people or animals infected with them. The diseases are transmitted by a fecal-oral route. Infection can be prevented by good sanitation practices in food handling, modern methods of sewage treatment, and disinfection of drinking water.

Digestive System

The digestive system can be divided into two parts:

1. gastrointestinal (GI) tract or alimentary canal - It is a tubelike structure that includes the oral cavity (mouth), pharynx (throat), esophagus, stomach, small intestines, and large intestine.

2. accessory structures - They include the teeth, tongue, salivary glands, liver, gall bladder, and pancreas.

Bacteria heavily populate many parts of the digestive system. In the mouth, each milliliter of saliva contains millions of bacteria, such as streptococcal and staphylococcal species, Lactobacillus, Moraxella catarrhalis, and Haemophilus influenzae.

The large intestine contains microbial populations exceeding 100 billion bacteria per gram of feces. Up to 40% of fecal mass is microbial cell material. The population of the large intestine is composed of mostly anaerobes such as the genera Lactobacillus and Bacterioides, and facultative anaerobes (survive in the presence or absence of oxygen), such as E. coli, Enterobacter, Klebsiella, and Proteus. Most of these bacteria assist in the enzymatic breakdown of foods, and some synthesize useful vitamins.

The stomach and small intestines have relatively few microorganisms because of the hydrochloric acid produced by the stomach and the rapid movement of food through the small intestines.

The liver, gall bladder, and pancreas are normally free of microorganisms.

The lining of the intestinal tract is protected by structural, mechanical, and biochemical defenses. Chewing, swallowing, churning of the stomach, and peristalsis dislodge microorganisms that are not adapted to adhere to the linings. Saliva contains lysozymes which are antibacterial enzymes. Hydrochloric acid in the stomach and bile salts in the upper part of the small intestines destroy microorganisms. The intestinal epithelium secretes IgA antibodies.
Several symptoms may occur with digestive system diseases:

1. **gastitis** - infection or inflammation of the stomach causing pain in the upper abdomen and occasionally is accompanied by bleeding.

2. **gastroenteritis** - infection or inflammation of the stomach and intestines, causing diarrhea, and sometimes nausea, vomiting, and crampy abdominal pain.

3. **colitis** - infection or inflammation of the large intestine or colon, causing diarrhea often containing blood and/or mucus. Colitis may sometimes involve some of the lower small intestine and it is specifically referred to as enterocolitis.

Diseases of the Digestive System

Bacterial Diseases

An infection occurs when a pathogen enters the gastrointestinal tract and multiplies. Microorganisms can penetrate into the intestinal mucosa and grow, or they can pass through to other organs. Infections are characterized by a delay in the appearance of gastrointestinal disturbance while the pathogen increases in numbers or affects invaded tissue. There is also usually a fever, one of the body's general responses to an infective organism.

Some pathogens cause disease by producing toxins that affect the GI tract. **Intoxication** is caused by the ingestion of a preformed toxin. They are characterized by a very sudden appearance (usually in only a few hours) of symptoms of a GI disturbance. Fever is less often one of the symptoms.

Bacteria cause most lethal infections of the intestinal tract.

Food Poisoning

1. **Staphylococcal Enterotoxicosis** *(staphylococcal food poisoning)*
   
   a. **causative agent**: *Staphylococcus aureus*
b. method of transmission: Ingestion of exotoxin in food, usually improperly refrigerated. The microorganism is a normal flora of the nasal passages and found in skin lesions. Contamination of food can occur from both sources. Enterotoxins of serological types A and D are produced and released into the food. Foods such as custards, whipped cream, eggs, cream pies, potato salad, mayonnaise, dairy products, ham, and poultry can be contaminated.

c. symptoms: Nausea, vomiting, abdominal cramps, and inflammation of the intestinal mucosa and inhibition of water absorption resulting in diarrhea, but usually not fever. Symptoms usually appear in 1 to 6 hours depending on the concentration of toxin. Symptoms usually last about 8 hours.

d. prevention: Adequate refrigeration during storage to prevent toxin formation. Contamination is difficult to detect because it produces no changes in the food’s appearance, taste, or odor. Cooking foods can kill the microorganisms, but does not destroy the toxin. The toxin is heat stable and can survive boiling for 30 minutes.

e. treatment: For healthy adults, no treatment is required because the disease is self-limiting. It can be severe and cause death in infants, the elderly, and debilitated patients.

2. Salmonellosis (salmonella gastroenteritis)

a. causative agent: Salmonella enteritidis; S. typhimurium

b. method of transmission: Ingestion of contaminated food or drink. The sources of the bacteria are the intestinal tracts of many animals and meats which can be contaminated readily in packing plants. Poultry, eggs, and egg products are often contaminated.

c. symptoms: Incubation time is about 12 to 36 hours. The bacteria invade the intestinal mucosa and multiply. Sometimes they pass through the intestinal mucosa and enter the lymphatic and cardiovascular systems, and from there they may spread to many organs. There is usually a moderate fever accompanied by nausea, abdominal pain and cramps, and diarrhea with blood and mucus.

d. prevention: Good sanitation practices to deter contamination and proper refrigeration to prevent increases in bacteria. The bacteria are normally destroyed by normal cooking that heats the food to an internal temperature of at least 140°F. Contaminated food can contaminate a surface, such as a cutting board, contaminating another food cut on the board. Death rate is about 1%, but it is higher in infants, the elderly, and immunosuppressed individuals. Death is usually caused by septicemia (multiplication of the bacteria in the blood)
e. treatment: Oral rehydration and recovery is complete in a few days, but many individuals will continue to shed the bacteria in their feces for up to 6 months.

3. Shigellosis (bacillary dysentery)

a. causative agent: Shigella dysenteriae, S. sonnei, S. flexneri, S. boydii

b. method of transmission: Ingestion of contaminated food and drink. Humans, monkeys, gorillas, and chimpanzees are reservoirs of infection, but the bacteria can persist in food for up to a month. The pathogens are spread by contaminated food, fingers, flies, feces, and fomites and transmitted by the fecal-oral route.

c. symptoms: After incubation of 1 to 4 days, abdominal cramps, fever, profuse diarrhea with blood and mucus from ulceration of the intestinal lining suddenly appear. S. dysenteriae produces Shiga toxin which acts as a neurotoxin.

d. prevention: Prevention is difficult because many people have inapparent infections and it is highly communicable. Good sanitation and hand washing reduce the possibility of infection.

e. treatment: Restoration of fluids and electrolytes, and a combination of ampicillin, tetracycline, and nalidixic acid.

4. Vibriosis

a. causative agent: Vibrio parahaemolyticus

b. method of transmission: Ingestion of contaminated fish and shellfish such as shrimp and crabs.

c. symptoms: The incubation time is less than 24 hours. Once inside the intestines they colonize the mucosa and release an enterotoxin resulting in gastroenteritis. Symptoms of nausea, vomiting, diarrhea, burning sensation in the stomach, and abdominal pain appear about 12 hours after ingestion, and they last 2 to 5 days.

d. prevention: Prevention is difficult because the bacteria multiply extremely rapidly. Refrigeration and thorough cooking of fish and shellfish.

e. treatment: Restoration of fluids and electrolytes. It is self-limiting and recovery occurs within a few days.
5. Traveler’s Diarrhea

a. causative agent: Escherichia coli

b. method of transmission: Ingestion of contaminated food or drink, especially hamburger and raw milk.

c. symptoms: Symptoms range from mild to severe and include nausea, vomiting, diarrhea, bloating, malaise, and abdominal pain. A typical case causes 4 to 5 loose stools per day for 3 to 4 days. Enterotoxigenic strains produce an enterotoxin that causes a watery diarrhea. Enteroinvasive strains produce an enterotoxin similar to Shiga toxin and they penetrate the lining of the intestinal tract, resulting in inflammation, diarrhea, and gastroenteritis. Enteropathogenic strains cause diarrhea in newborn infants, sometimes causing epidemics in hospital nurseries.

d. prevention: Good sanitation practices and cooking hamburger thoroughly.

e. treatment: Restoration of fluids and electrolytes and trimethoprim-sulfamethoxazole or ciprofloxacin.

6. Clostridium perfringens Gastroenteritis

It is probably one of the more common forms of food poisoning in the U.S.

a. causative agent: Clostridium perfringens

It lives in the gastrointestinal tract of animals and humans and is common in feces-rich soil.

b. method of transmission: Ingestion of contaminated food (usually meats) and drink. Meats or meat stews may be contaminated with intestinal contents of animals during slaughter. The bacteria’s nutritional requirements for amino acids is met, when meats are cooked, the oxygen level is lowered enough for growth. The endospores survive most routine heatings, and the generation time is less than 20 minutes under ideal conditions.

c. symptoms: Symptoms usually appear from 8 to 12 hours after ingestion. Growth in the intestinal tract and the production of exotoxin cause the symptoms of gastroenteritis, abdominal pain and diarrhea.

d. prevention: Proper refrigeration of food.

e. treatment: Most cases are mild and self-limiting, last less than a day, and seldom cause significant damage. Replacement of fluids and electrolytes.
7. Clostridium difficile Diarrhea

a. causative agent: Clostridium difficile

b. method of transmission: It is iatrogenic (medically induced). Small populations normally inhabit the intestines and during antibiotic therapy many other bacteria are eliminated from the intestinal tract. The relatively drug-resistant Clostridium survives and flourishes, producing both an enterotoxin and a cytotoxin.

c. symptoms: Colitis with relatively mild diarrhea. Sometimes it can cause a life-threatening enterocolitis or severe persistent diarrhea.

d. prevention: Limit antibiotic therapy.

e. treatment: It resolves itself when antibiotic therapy is discontinued. Vancomycin in severe cases.

8. Bacillus cereus Gastroenteritis

a. causative agent: Bacillus cereus

b. method of transmission: Ingestion of contaminated food, such as rice in oriental dishes and meat and vegetables. It is very common in soil, water, vegetation, and the intestinal tracts of animals and humans. Heating does not kill the endospores, and they germinate as food cools. Because the competing microorganisms have been eliminated in the cooked food, it grows rapidly and produces enterotoxins.

c. symptoms: Symptoms resemble Clostridium perfringens and are almost entirely diarrheal in nature (heat-stable enterotoxin from rice). Other episodes may include nausea and vomiting due to different toxins (heat-labile enterotoxin from meat and vegetables). Symptoms are usually mild and brief.

d. prevention: Properly refrigerate food.

e. treatment: It is self-limiting and in severe cases rehydrate with fluids and electrolytes.

9. Typhoid Fever

a. causative agent: Salmonella typhi
b. method of transmission: It is found in contaminated food or drink and is spread to humans by the fecal-oral route.

c. symptoms: Symptoms begin a week or two after infection, when bacterial cells enter the bloodstream. The first symptoms are a high fever (104°F), a continual headache, and other aches and pains that last for days or weeks. The bacteria multiply in phagocytic cells and become disseminated in the body and can be isolated in blood, urine, and feces. Diarrhea appears during the second or third week, and the fever tends to decline. In severe cases, they can cause perforation of the intestinal wall. Confusion, tiredness, and loss of appetite occur. Some develop rose spots, a faint rash on the skin. Late in the illness, bacteria that have infiltrated the liver are excreted in bile, reenter the GI tract, and are shed with the feces.

d. prevention: Proper sewage disposal, water treatment, food sanitation and good hygiene. A substantial number of recovered individuals become chronic carriers, harbor the organism in their gall bladder, and continue to shed bacteria for several months. A number of carriers continue to shed bacteria indefinitely. Carriers must register with the local public health department and report at intervals and have their stool tested. As long as they remain carriers they must inform the health department of their whereabouts and may not work in occupations requiring food handling or with children.

e. treatment: It is resistant to many antimicrobial drugs. Third-generation cephalosporins such as ceftriaxone, is effective. Immunization is not done in most developed countries except for high-risk laboratory and military personnel. Carriers are treated with antibiotics and may have their gall bladder removed.

10. Campylobacter Gastroenteritis

a. causative agent: *Campylobacter jejuni*
   It has replaced *Shigella* as the second most common cause of diarrhea in the U.S. It is part of the normal flora of the intestinal tract of a number of animals, especially poultry, cattle, sheep, dogs, and cats.

b. method of transmission: Ingestion of contaminated food (meat) or drink (milk). Person-to-person transmission can also occur. Cows with no evidence of illness may excrete the bacteria in their milk.

c. symptoms: Fever, crampy abdominal pain, and diarrhea with blood and mucus. The epithelial lining of the intestinal tract is usually significantly damaged.
d. prevention: Good hygiene, pasteurization of milk, and properly cooking poultry

e. treatment: It is usually self-limiting and normal recovery is in less than a week. Replace fluids and electrolytes, and in debilitated persons, treat with erythromycin or tetracycline.

11. Helicobacter Peptic Disease Syndrome
a. causative agent: Helicobacter pylori
b. method of transmission: Presumably ingested.
c. symptoms: Gastric and peptic ulcers. The bacteria binds to the type 0 blood group antigen on the gastric epithelial cells and people of this blood group are twice as likely to develop gastric ulcers. It penetrates the mucosal layer that protects the gastric epithelium from stomach acid and then binds to the epithelial cells. The immune system mounts an attack that damages the epithelium, allowing it to become established and proliferate. Over a period of years, the damaged region may grow causing an ulcer, or it may remain small, and cause gastroenteritis. It can eventually lead to gastric carcinoma, one of the most common cancers in humans.
d. prevention: Unknown.
e. treatment: Metronidazole or bismuth subsalicylate (Pepto-Bismol).

12. Yersinia Gastroenteritis or Enterocolitis
a. causative agent: Yersinia enterocolitica
b. method of transmission: Ingestion of contaminated food or drink. It is an intestinal inhabitant of many wild and domestic animals and is transmitted in meat and milk, raw oysters, and water. It grows best at room temperature and can grow at refrigerator temperatures. It has recently been found in chitlins (pork intestines).
c. symptoms: It can adhere to the intestinal epithelium, invade cells, and produce an enterotoxin. It causes gastroenteritis known as yersiniosis. Symptoms include diarrhea, fever, headache, and abdominal pain. Pain is often severe enough to be misdiagnosed as appendicitis.
d. prevention: Good hygiene and proper cooking of food.
e. **treatment:** Replacement of fluids and electrolytes.

Viral Diseases

Although viruses do not reproduce within the contents of the digestive system like bacteria, they invade many organs associated with the digestive system.

1. Mumps

   a. **causative agent:** paramyxovirus

   b. **method of transmission:** The virus is transmitted in saliva and respiratory secretions, and the portal of entry is the respiratory tract. An infected person is most infectious to others during the first 48 hours before symptoms appear.

   c. **symptoms:** 25% of individuals infected show no symptoms. Once the virus begins to multiply in the respiratory tract and local lymph nodes in the neck, they reach the salivary glands, especially the parotid glands, by way of the blood. **Viremia** (presence of the virus in the blood) occurs several days before the rest of the symptoms and before the virus appears in the saliva. Symptoms begin with a painful swelling of one or both of the parotid glands (parotitis) 16 to 18 days after exposure to the virus, fever, and pain during swallowing. Viruses may be found in the blood 3 to 5 days after onset and in urine after ten days or more. Salivary glands under the tongue and on the jaw may be inflamed without the parotid glands being affected. About 4 to 7 days after the symptoms appear the male testes can become inflamed (orchitis) and sterility is a possible, but rare consequence. Other complications, such as meningitis, inflammation of the ovaries in females, and pancreatitis may occur.

   d. **prevention:** MMR (measles, mumps, rubella) vaccine made from live attenuated viruses. Second attacks are rare and cases involving only one parotid gland and subclinical cases are as effective as bilateral mumps in conferring immunity.

   e. **treatment:** None

2. Cytomegalovirus (CMV) or Inclusion Disease

   a. **causative agent:** herpesvirus
b. **method of transmission:** Bodily secretions, blood transfusions or placental transfer. Viruses are shed at intervals in body secretions such as, saliva, urine, semen, cervical secretions, and breast milk. It can be spread by kissing and other personal contacts, especially to day-care workers. There is a high incidence in the male homosexual population.

c. **symptoms:** It induces a cellular swelling or **cytomegaly** and the cells resemble "owl’s eyes". Once a person is infected it persists for life. It is estimated that 80% of the population in the U.S. may carry the virus. Blood macrophages and T lymphocytes are the probable sites of latency. Symptoms include malaise, fever, abnormal liver function, and lymph node swelling without inflammation. In adults and older children, most infections are subclinical, or at most, much like a mild case of infectious mononucleosis.

d. **prevention:** A primary CMV infection acquired by a nonimmune mother can seriously harm the fetus. The immune status of a woman of childbearing age should be determined. Avoidance of prolonged contact with children shedding the virus.

e. **treatment:** ganciclovir

3. **Infectious Hepatitis or Hepatitis A (HAV)**

   a. **causative agent:** picornavirus - it consists of a single-stranded RNA and lacks an envelope.

   b. **method of transmission:** Fecal-oral route from food, especially shellfish (oysters), or drink contaminated with feces. The virus can survive for several days on such surfaces as cutting boards.

   c. **symptoms:** Incubation period is 2 to 6 weeks and at least 50% of infections are subclinical, especially in children. The virus multiplies in the epithelial lining of the intestinal tract, **viremia** eventually occurs, and the virus spreads to the liver, kidneys and spleen. The virus is shed in the feces, and can be detected in the blood and urine. The amount of virus excreted is greatest before symptoms appear, and then declines rapidly. The initial symptoms are anorexia (loss of appetite), malaise, nausea, diarrhea, abdominal discomfort, fever, and chills. These symptoms are more likely to appear in an adult and last for 2 to 21 days, and the mortality rate is low. In some cases, there is jaundice, with yellowing of the skin and the whites of the eyes, and dark urine typical of liver infections. The liver becomes tender and enlarged.
d. prevention: Hepatitis A immune globulin vaccine, good hygiene and sanitation during food handling. The virus is resistant to the chlorination levels used in water treatment. Passive immunity also occurs.

e. treatment: Alleviation of symptoms.

4. Serum Hepatitis or Hepatitis B Virus (HBV)

a. causative agent: hepadnavirus - a large virus which has double-stranded DNA and it is enveloped.

b. method of transmission: Blood and blood contaminated needles, transfusions, and sexual contact, especially between male homosexuals. It can be transmitted to patients by contaminated instruments of surgeons and dentists. A female carrier can transmit it to her infant at birth, and it can be transmitted by chronic carriers.

c. symptoms: The incubation period is long, about 75 days, and it occurs in high concentrations in the blood, body fluids, tears, saliva, and breast milk. The long incubation period makes it difficult to determine the origin of infection. The symptoms are similar to HAV, but fever and headache are usually absent, and joint pain and destruction of liver cells occurs. Symptoms vary widely and about 50% of the cases are entirely asymptomatic. The mortality rate is higher than HAV. As many as 90% of infants and 3 to 5% of adults become carriers. Chronic carriers have a higher rate of liver disease, and are 200 times more likely to get liver cancer than the general population. The serum of infected individuals contains three types of particles: The Dane particle is the largest and consists of a complete virion, and it is infectious and capable of reproducing. The spherical particle is about half the size of the Dane particle. The filamentous particle is tubular, similar in diameter to the spherical particle, but ten times longer. The spherical and filamentous particles are unassembled capsids of the Dane particle without nucleic acids. These particles contain hepatitis B surface antigens (HB,Ag) which can be detected by antibodies.

d. prevention: Physicians, nurses, dentists, medical technologists, and other high-risk groups who come into daily contact with blood should be vaccinated with the HBV vaccine. The vaccine contains HB,Ag produced by genetically engineered yeast. Babies that are infected during birth can be given immune globulins (HBIG) after birth and they should also be vaccinated.

e. treatment: Alpha interferon has been shown to be effective in chronic carriers.
5. Hepatitis C Virus (HCV) (formerly non-A non-B)

a. causative agent: togavirus or flavavirus - it has single-stranded RNA and is enveloped.

b. method of transmission: Blood and blood transfusions contaminated needles, and occasionally it crosses the placenta.

c. symptoms: The incubation period is 2 to 4 weeks or 8 to 12 weeks depending on the virus and causes symptoms that are subclinical or relatively mild. Almost 50% of the cases progress to chronic hepatitis. The blood contains high concentrations of the liver enzyme alanine transferase released from damaged liver cells.

d. prevention: No vaccines are available.

e. treatment: Many chronic cases respond to alpha interferon, but relapses are frequent.

6. Hepatitis D Virus (Delta virus)

a. causative agent: HDV - it has a single-stranded RNA and a hepatitis B capsid.

b. method of transmission: Blood and must coinfect (acute infection) or superinfect (chronic infection) with the hepatitis B virus. It can cross the placenta.

c. symptoms: The incubation period is 2 to 12 weeks. It is only infectious when it has an external envelope of HBsAg from the HBV. Symptoms are the same as HBV, but a chronic infection causes more severe liver damage and has a higher mortality rate than HBV alone.

d. prevention: Hepatitis B vaccine is effective because coinfection is required.

e. treatment: Alpha interferon.

7. Viral Enteritis

a. causative agent: rotavirus (rota means wheel) - it is the major cause of viral enteritis in infants and young children. It consists of a wheel-shaped double capsid surrounding the virion.

b. method of transmission: Fecal-oral route and it is highly infectious.
c. **symptoms:** The virus damages the intestinal epithelium, and causes a watery diarrhea within 48 hours. 90% of children tested have antibodies to the virus even though the infection may not have been identified when it occurred.

d. **prevention:** Good hygiene and breast feeding because breast milk and colostrum contain IgA antibodies that recognize rotaviruses.

e. **treatment:** Rehydration with fluids and electrolytes.

8. **Norwalk Agent**

a. **causative agent:** Norwalk virus - it resembles the calcivirus found in animals. It is responsible for nearly half of the outbreaks of acute infectious nonbacterial enteritis in the U.S. It affects older children and adults more often than preschoolers and infants. It is the second most common cause of illness in U.S. families.

b. **method of transmission:** Fecal-oral route.

c. **symptoms:** Following an incubation period of 48 hours there is nausea, vomiting, abdominal pain, and diarrhea.

d. **prevention:** Good hygiene and careful hand washing.

e. **treatment:** Replacement of fluids and electrolytes.

**Fungal Disease**

Fungi produce toxins called **myotoxins** which cause loss of muscle coordination, tremors, weight loss, and some are carcinogenic.

**Ergot Poisoning (ergolism)**

a. **causative agent:** *Claviceps purpurea*

It is a fungus causing smut infections on grain crops.

b. **method of transmission:** Ingestion of rye or other cereal grains contaminated with the fungus.
c. symptoms: The toxin can restrict blood flow in the extremities, and gangrene results. It may also cause hallucinogenic symptoms, producing bizarre behavior similar to that caused by LSD, high fever, convulsions, and ultimately death.

d. prevention: Fungicides sprayed on grain crops and production of resistant strains of grain.

e. treatment: antispasmodic drugs

Protozoan Diseases

A number of pathogenic protozoans complete their life cycle in the human digestive system. Ultimately they are ingested as resistant, infectious cysts and are shed in greatly increasing numbers as newly produced cysts.

1. Giardiasis

It is the most common cause of epidemic waterborne diarrhea in the U.S.

a. causative agent: Giardia lamblia

b. method of transmission: Ingestion of food or water contaminated with feces. The protozoan is shed by a number of wild mammals, especially beavers. Campers and backpackers are infected by drinking water from streams. About 7% of the population are healthy carriers and shed the cysts in their feces.

c. symptoms: The flagellated protozoan attaches firmly to the wall of the small intestine. It feeds on mucus, forming cysts that are deposited in mucus and passed intermittently in mucus stools. Symptoms may persist for weeks and include inflammation of the intestine, diarrhea, malaise, flatulence (gas), abdominal cramps, weakness, dehydration, and weight loss. Nutritional deficiencies are common in infected children because the parasites can occupy so much of the intestine that they interfere with food absorption. Many individuals remain symptom-free while continuing to pass infectious cysts in their stools.

d. prevention: The cysts are relatively resistant to chlorine and filtration of water supplies is usually necessary to eliminate the cysts. Good hygiene and boiling or chemically treating of water when camping.

e. treatment: Metronidazole (Flagyl), furazolidine, or quinacrine hydrochloride (Atabrine) is usually effective within a week.
2. Amoebic Dysentery (Amoebiasis)

   a. causative agent: Entamoeba histolytica

       b. method of transmission: Ingestion of cysts in food or water contaminated with fecal matter. Stomach acid can destroy the vegetative cells, but it does not affect the cysts. They are not killed by normal chlorine concentrations in water. Cockroaches and flies can also be mechanical vectors.

       c. symptoms: In the intestinal tract the cyst wall is digested away and the vegetative forms are released. They reproduce in the intestinal epithelium of the large intestine and cause colitis and significant ulceration. A severe dysentery results and the feces contains blood and mucus. Vegetative forms feed on red blood cells and destroy tissue in the GI tract. Severe bacterial infection results and the intestinal wall is perforated. The protozoan may enter blood vessels and travel to other tissues and organs such as the liver and lungs, or they allow bacteria in fecal material to enter the body cavity and cause peritonitis. Abscesses might have to be treated surgically. 5% of the population in the U.S. are asymptomatic carriers.

       d. prevention: Good hygiene and sanitary handling of food and water.

       e. treatment: metronidazole plus iodoquinol.

3. Cryptosporidiosis

   a. causative agent: Cryptosporidium parvum

       b. method of transmission: Fecal-oral route and they are transmitted by way of water systems contaminated by animal wastes, especially cattle. They are inhabitants of the intestinal tract of many kinds of animals, including fish, reptiles, and mammals, such as humans, calves, kittens, and puppies. Occasional cases result by fecal-oral contamination from close contact with infected animals.

       c. symptoms: It invades the intestinal epithelium and multiplies, causing mild enterocolitis, usually followed by abdominal pain and a watery, bloodless diarrhea. In healthy individuals, the microorganism causes intestinal distress of short duration of 10 days or less. In immunosuppressed individuals, such as those with AIDS, a severe life-threatening diarrhea becomes progressively worse and 50 or more stools may be produced per day and may persist for months.

       d. prevention: The cysts are resistant to chlorine and must be removed from water supplies by filtration. Good hygiene and avoiding high-risk sexual behavior is crucial.
Helminth Diseases

Helminth parasites are very common in the human intestinal tract, especially under conditions of poor sanitation. They often produce few symptoms because they have become so well adapted to their human hosts, and vice versa, that when their presence is revealed it is often a surprise. Although most are prevalent only in tropical regions, several are endemic to the U.S. and are acquired while traveling in tropical areas.

1. Tapeworm Infections

a. causative agent: *Taenia saginata* (beef), *Taenia solium* (pork), *Diphyllobothrium latum* (fish)

b. method of transmission and symptoms: Ingestion of uncooked, or poorly cooked beef, pork, or fish (trout, perch, pike, and salmon). The eggs of the pork tapeworm may be ingested as a result of poor sanitary practices or possibly by autoinfection (when eggs produced by the adult tapeworm in the intestinal tract somehow enter the stomach).

c. symptoms: When adult tapeworms develop in the intestines, they absorb large quantities of nutrients and lead to malnutrition even when the person has an adequate diet. A tangled mass of worms may block passage of materials through the intestine.

*Taenia saginata*'s life cycle extends through three stages. The adult worm lives in the intestine of humans, where it produces eggs that are excreted in the feces. The eggs are ingested with contaminated feed by grazing cattle and hatch into a larval form called a cysticercus that lodges in the animal’s muscles. When a human ingests undercooked beef containing cysticerci, the cysticerci develop into adult worms. The adults attach to the intestinal wall by suckers and hooks on the scolex. The adult worm can live in the human intestine for 25 years and reaches a length of 5 to 25 meters. Even a worm 6m (18 feet) long seldom causes significant symptoms beyond a vague abdominal discomfort.

*Taenia solium* has a life cycle similar to the beef tapeworm and can reach a length of 2 to 7m. When pigs ingest tapeworm eggs, the cysticerci migrate to muscles and encyst. When undercooked pork is ingested by humans, the cysticerci are released and develop into adults. An important difference is that it may produce the larval stage in the human host. The infection can arise from the tapeworm egg rather than only from ingestion of undercooked pork containing cysticerci. Cysticerci can develop in many human
organs. When this occurs in muscle tissue, the symptoms are seldom severe. If they develop in the eyes or brain, it is more serious.

Diphyllobothrium latum is ingested in poorly cooked or raw fish in Japanese dishes such as sushi and sashimi. When humans ingest the infected fish, the worms in the fish muscle are released and mature in the intestine. Adult worms attach to the intestine and produce eggs. They absorb large quantities of vitamin B₁₂ and impair the person's ability to absorb the vitamin, leading to a vitamin B₁₂ deficiency.

d. prevention: Avoidance of eating raw or poorly cooked beef, pork, and fish.

e. treatment: Niclosamide or praziquantel. Cysticercosis may require surgery.

2. Hydatid Disease

a. causative agent: Echinococcus granulosus - It is one of the most dangerous tapeworms and it is only a few millimeters in length.

b. method of transmission: Ingestion of eggs through contact with infected dogs, especially when the dogs lick the faces of children.

c. symptoms: The adult form lives in the intestinal tract of carnivorous animals, such as dogs and wolves. Humans become infected from the feces of a dog that has become infected by eating the flesh of a sheep or deer containing the cyst form of the tapeworm. Humans can be an intermediate host, and cysts develop in the body. Once ingested, the eggs may migrate to various tissues of the body, such as the liver, lungs, and the brain. The egg develops into a hydatid cyst that can grow to a diameter of 10mm in a few months. In some locations, cysts may not be apparent for many years. Some may become enormous and contain up to 15 liters (4 gallons) of fluid. If the cyst ruptures it can lead to the development of a large number of daughter cysts. The fluid contains proteinaceous material, to which the host becomes sensitized. If the cyst suddenly ruptures, the result can be life-threatening anaphylactic shock.

d. prevention: Administration of worm medication to dogs and avoidance of facial licking by dogs.

e. treatment: Surgical removal of cysts, but care must be taken to avoid release of the fluid. If removal is not feasible, albendazole can kill the cysts.
Nematode Infestations (roundworms)

1. Pinworm Infection

   It is the most common roundworm infection in the U.S.

   a. **causative agent:** Enterobius vermicularis

   b. **method of transmission:** Ingestion of the eggs. Eggs remain infectious for more than a week on fomites, such as tabletops, furniture, and countertops. The eggs are transmitted by bedclothes, debris under the fingernails of those who scratch the itchy area around the anus, and inhalation of airborne eggs. Whole households can become infected, and infections can occur in day care centers.

   c. **symptoms:** The ingested eggs hatch in the small intestine and release larva that mature into adults in the large intestine. The adult worm attaches to the epithelium of the large intestine, mates, and the female produces eggs. The females migrate toward the anus during the night, release their eggs on the exterior of the anus, and then crawl back in. Infection may be symptomless and is not debilitating, but may cause considerable discomfort and can interfere with adequate rest and nutrition, especially in children. Infection with large numbers can cause the rectum to protrude from the body.

   d. **prevention:** Thorough cleaning and laundering of towels, bedclothes, and bed linens.

   e. **treatment:** piperazine, mebendazole, or pyrantel pamoate.

2. Hookworm Infections

   a. **causative agent:** Necator americanus

   b. **method of transmission:** Larva in the soil penetrate the skin.

   c. **symptoms:** Eggs in human feces quickly hatch into larva in moist soil. They usually penetrate the skin of the feet and legs, and bacterial infection at the site of penetration causes itching. After entering through the skin larva make their way through the bloodstream to the heart and alveoli, where they are coughed up and swallowed. They pass into the intestinal tract and develop into adults. The adults attach to the intestinal wall and feed on blood and tissue, rather than partially digested food. Tiny hemorrhages occur in the lungs, but the greatest damage occurs in the entire lining of the small intestine. Abdominal pain, loss of appetite, protein and iron deficiencies occur. The production of a large number of worms can lead to anemia and lethargic behavior.
Large infestations can lead to a bizarre symptom, pica, which is a craving for peculiar foods, such as laundry starch or soil containing a certain type of clay.

d. prevention: Sanitary disposal of human wastes and wearing shoes.

e. treatment: tetrachloroethylene, bephenium hydroxynaphthalate (Alcopar), mebendazole, or pyrantel pamoate.

5. Ascariasis

a. causative agent: *Ascaris lumbricoides*

b. method of transmission: Ingestion of food or water contaminated with eggs.

c. symptoms: Eggs are shed in human feces and, under poor sanitary conditions, are ingested by another person. Once in the intestine, the eggs hatch, and the larvae penetrate the intestinal wall and enter the lymph and blood vessels and pass to the lungs. They migrate through the respiratory tract to the pharynx and are swallowed. The larva move to the small intestine, mature, and begin to produce eggs. In the lungs the larva may cause some pulmonary or asthma-like symptoms, and extremely large numbers cause pneumonia. Adult worms cause malnutrition, but they feed on the contents of the intestines and do little damage to the mucosa. Large numbers can cause intestinal blockage and sometimes perforation of the intestine, resulting in peritonitis.

d. prevention: Good sanitation and personal hygiene.

e. treatment: piperazine, mebendazole, or pyrantel pamoate.

6. Trichinosis

a. causative agent: *Trichinella spiralis* (trichina worm)

b. method of transmission: Ingestion of larva in undercooked pork, and sometimes venison, bear meat, and horse meat.
c. **symptoms:** It is ingested as encysted larva (1mm) in poorly cooked meat. In the intestine, the cysts release larva that develop into adults. The adults mate, the male dies, and the females produce living larva before they die. The larva migrate through the blood and lymph vessels to the liver, heart, lungs, and other tissues. When they reach skeletal muscles, especially eye, tongue, chewing muscles, and diaphragm they form cysts. They cause tissue damage as adults and as migrating and encysted larva. The adult females penetrate the intestinal mucosa and release toxic wastes that produce symptoms similar to food poisoning. Wandering larva damage blood vessels and any tissues they enter. Death can result from heart failure, kidney failure, respiratory disorders, or reaction to toxins. Encysted larva cause muscle pain.

d. **prevention:** Thoroughly cooking meat and cleaning machinery used to grind meat.

e. **treatment:** Treatment is directed at relieving symptoms because the disease can not be cured. Mebendazole or thiabendazole to kill intestinal worms, and corticosteroids to reduce inflammation.