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The content presented in this section is based on a variety of sources. In order to apply appropriate safe food handling practices, a foodservice manager needs to understand the basics about foodborne microorganisms.

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Pathogens
Pathogenic bacteria can cause foodborne illness. These bacteria can cause illness by invading human tissue or producing toxins that can alter normal body functions. The twelve most common foodborne pathogens are:
Campylobacter jejuni
Clostridium botulinum
Clostridium perfringens
Escherichia coli 0157:H7
Listeria monocytogenes
Salmonella Enteritidis
Salmonella Typhimurium
Shigella
Staphylococcus aureus
Vibrio cholerae
Vibrio vulnificus
Yersinia enterocolitica

Spoilers
Spoilage bacteria are microorganisms that are too small to be seen without a microscope and that can cause food to deteriorate and develop unpleasant odors, tastes, and textures. These one-celled microorganisms can cause fruits and vegetables to get mushy or slimy, or meat to develop a bad odor. There are different spoilage bacteria and each grows at specific temperatures. Some can grow at the low temperatures -- in the refrigerator or freezer. Others grow well at room temperature and in the "Temperature Danger Zone." Bacteria will grow anywhere they have access to nutrients and water. Under the correct conditions, spoilage bacteria reproduce rapidly and the populations can grow very large. In some cases, they can double their numbers in as little as 30 minutes. The large number of microorganisms and their waste products cause the objectionable changes in odor, taste, and texture.

Beneficial
Most bacteria are beneficial to us in our every day lives, both inside our bodies and in other applications. Some examples of beneficial bacteria include:

E. coli (not 0157:H7) plays an important role in our digestive system. It is present in the human small intestine. *E. coli* helps create vitamin in the body and aids in digestion.
Streptomyces is soil bacteria used to make Streptomycin, an antibiotic used to treat infections.
Lactobacillus acidophilus turns milk into yogurt

Bacteria also assist with the production of certain foods, such as cheese, buttermilk, sauerkraut, vinegar, and pickles. In some plants like legumes, bacteria can take nitrogen from the air to the roots and change it into ammonia, which is one of several important compounds required for health plant growth.

Bacteria also play a role in recycling. They have the ability to decompose waste in the environment by breaking it down into nutrients that are useful to soil (also known as composting).

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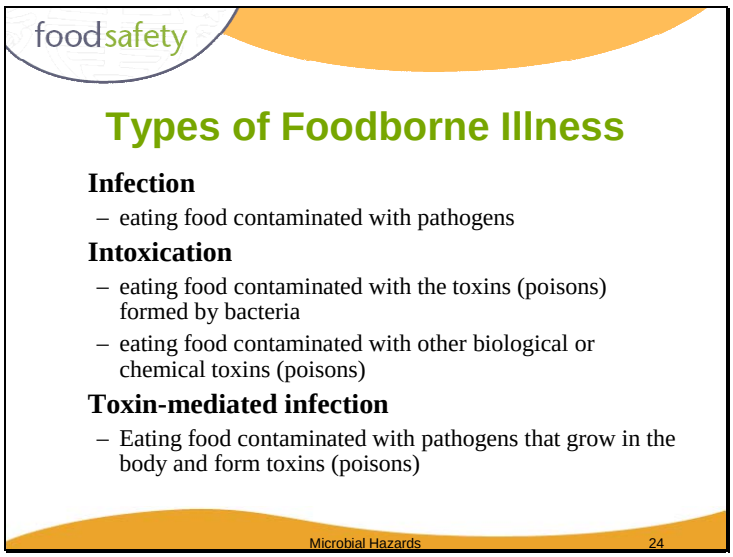

Microbiological hazards cause most foodborne illnesses in the United States. The three microbiological hazards of concern are bacteria, viruses, and parasites. These microorganisms can cause one of three types of illness -- infection, intoxication, or toxin-mediated infection.

Infection. A foodborne illness is when a person eats food containing harmful microorganisms, which then grow in the intestinal tract and cause illness. Some bacteria, all viruses, and all parasites cause foodborne illness via infection. The foodborne bacteria that cause infection are: *Salmonella* spp., *Listeria monocytogenes*, *Campylobacter jejuni*, *Vibrio parahaemolyticus*, *Vibrio vulnificus*, and *Yersinia enterocolitica*. The most common viral agents that cause foodborne illness are: Hepatitis A, Norovirus, and rotavirus. The most common foodborne parasites are: *Trichinella spiralis*, *Anisakis simplex*, *Giardia duodenalis*, *Toxoplasma gondii*, *Cryptosporidium parvum*, and *Cyclospora cayetanensis*.

Intoxication. An intoxication results when a person eats food containing toxins that cause illness. Toxins are produced by harmful microorganisms, the result of a chemical contamination, or are naturally part of a plant or seafood. Some bacteria cause an intoxication. Viruses and parasites do not cause foodborne intoxication. The foodborne bacteria that cause intoxication are: *Clostridium botulinum*, *Staphylococcus aureus*, *Clostridium perfringens*, and *Bacillus cereus*. Chemicals that can cause an intoxication include cleaning products, sanitizers, pesticides and metals (lead, copper, brass, zinc, antimony, and cadmium). Seafood toxins include ciguatera toxin, scromboid toxin, shellfish toxins, and systemic fish toxins. Plants and mushrooms can also cause an intoxication.

Toxin-mediated infection. A toxin-mediated infection is when a person eats food containing harmful bacteria. While in the intestinal tract, the bacteria produce toxins that cause illness. Some bacteria cause toxin-mediated infection. Viruses and parasites do not cause a toxin-mediated infection. The foodborne bacteria that cause toxin-mediated infection are: *Shigella* spp. And Shiga toxin-producing *Escherichia coli*.

SOURCE: American Public Health Association. 2000. *Control of Communicable Diseases Manual*. J. Chin, Editor. Washington, DC. 624 pp.

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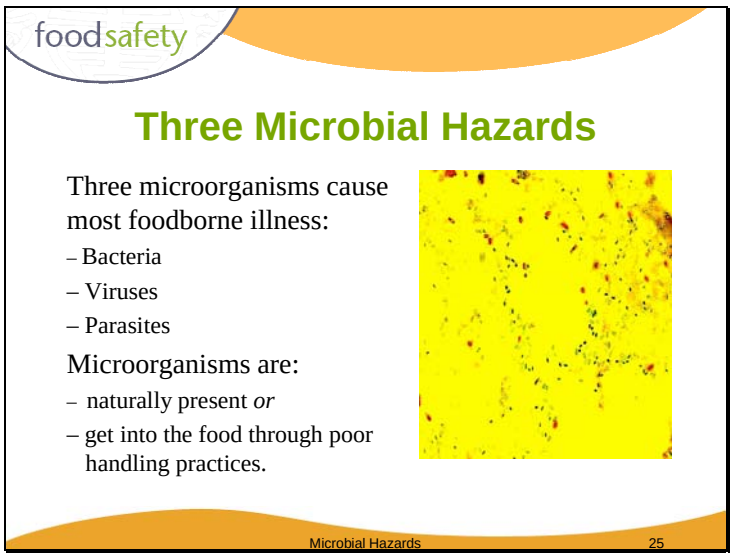

PHOTOGRAPH CREDITS:
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This strain of *Bacillus cereus* was isolated from a sample of gasoline-contaminated soil and cultured on blood agar during the Summer Microbiology Practicum at the Des Moines University, Iowa. Spores were present after 3 days, however, this picture was taken 1 week after culture. Endospores are extremely hardy bacterial structures that contain the organism genome. Endospores remain viable through many extreme conditions, such as common cooking techniques. Endospores can be destroyed by proper pressure canning or pressure cooking. *B. cereus* can cause severe food poisoning with a short incubation period. A common source can be fried rice made from unrefrigerated cooked rice. Short incubation *B. cereus* food poisoning can be mistaken for staphylococcal food poisoning. This picture allows students to see spores utilizing a simple, reliable method of staining.

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Common symptoms of foodborne illness include diarrhea, abdominal cramping, fever, headache, vomiting, severe exhaustion, and sometimes blood or pus in the stools. However, symptoms will vary according to the type of microorganism and the amount eaten.

In rare instances, symptoms may come on as early as 30 minutes after eating contaminated food but they typically do not develop for several days or weeks. Symptoms of viral or parasitic illnesses may not appear for several weeks after exposure. Symptoms usually last only one to two days, but in some cases can persist for between seven and ten days. For most healthy people, foodborne illnesses are neither long-lasting nor life-threatening. However, they can cause severe consequences in the very young, the very old, and people with certain diseases and conditions. Conditions that can make one at high-risk for foodborne illness include:
liver disease, either from excessive alcohol use, viral hepatitis, or other causes
hemochromatosis, an iron disorder
diabetes
stomach problems, including previous stomach surgery and low stomach acid (for example, from antacid use)
cancer
immune disorders, including HIV infection
long-term steroid use, as for asthma and arthritis.

When foodborne illness symptoms are severe, the victim should see a doctor or get emergency help. This is especially important for those who are at high risk. For mild cases of foodborne illness, the individual should drink plenty of liquids to replace fluids lost through vomiting and diarrhea.

Foodborne illness often shows itself as flu-like symptoms such as nausea, vomiting, diarrhea, or fever, so many may not recognize that the illness is caused by eating contaminated food. Experts from the Centers for Disease Control and Prevention (CDC) report that many of the intestinal illnesses commonly referred to as stomach flu are actually caused by foodborne pathogens. People do not associate these illnesses with food because the onset of symptoms often occurs two or more days after the contaminated food was eaten.

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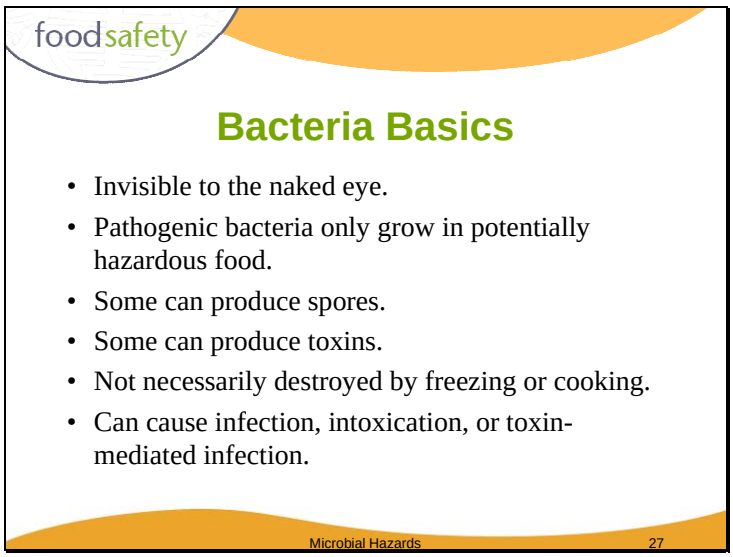

Bacteria are single-celled microorganisms that serve many functions.

Beneficial bacteria. Most bacteria are very useful. They live in a variety of places and grow whenever conditions are suitable. A few beneficial functions of bacteria are the production of food products including dairy products, such as yogurt; sauerkraut; fermented meats, such as summer sausage, and vinegar. Bacteria also help fix nitrogen in the soil and are responsible for decomposing organic materials, which returns important nutrients back to the soil. The beneficial aspects of microorganisms far outweigh their harmful effects.

Pathogenic bacteria. These bacteria produce illness in humans, animals and plants and are called pathogenic bacteria. They are a relatively few in number and produce illness by growing on or in certain tissues and producing harmful poisons or toxins, which people and animals eat.

Spoilage bacteria. As bacteria live and grow they produce changes in food products that damage flavor, texture and composition. Specific bacteria can cause milk to sour or develop off flavors; meat to spoil; and wine to turn to vinegar

Spore-forming bacteria. When certain bacteria grow, they can develop resistance to extreme heat, dryness, and chemicals. These bacteria are called spore-formers because they develop a "shell" which is capable of protecting the cell under adverse conditions. The spore is the "resting stage" of the live bacteria and it can begin to grow into an active cell when proper growth conditions are provided. Because spores are resistant to heat, higher temperatures and pressure are used in food canning to destroy them. Spores cannot be destroyed by cooking on a stovetop or in a oven.

Toxin-forming bacteria. Some bacteria form toxins (or poisons) that can damage host cells and tissues causing foodborne illness. There are three types of toxins -- exotoxins (common to most toxin-forming bacteria that cause foodborne illness), endotoxins, and enterotoxins (common to *E. coli*).

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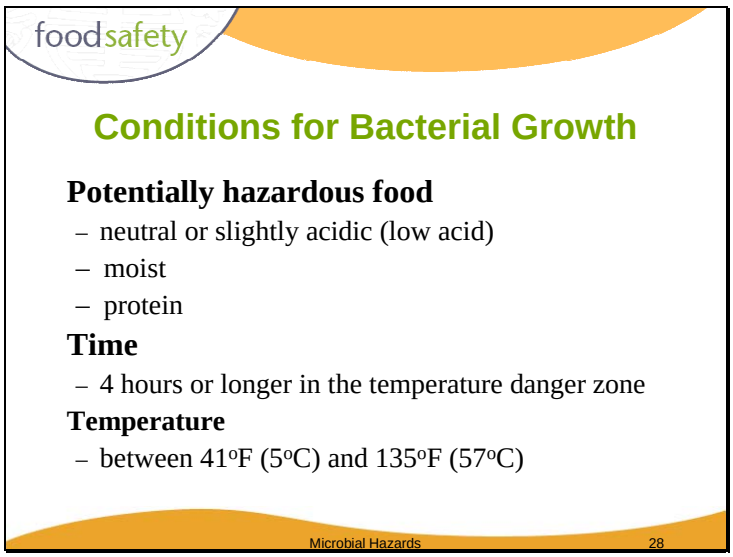

Bacteria are everywhere. Some are beneficial, such as those used to make fermented dairy and meat products. Others cause spoilage. And, a small percentage are harmful or pathogenic.

Unlike animals and plants that are composed of many cells, bacteria are single-celled organisms. Each bacterium cell is self-sufficient and so is able to live independently. Bacteria come in a variety of shapes and are impossible to see without a microscope. Because they are about 1/25,000th of an inch long, they must be magnified about 1,000 times to be seen. For example, about 400 million bacteria clumped together would be about the size of a grain of sugar.

When bacteria grow, they increase in numbers not in size. This process is called cell division (or doubling). Under ideal conditions, the number of bacteria can double every 30 minutes. Therefore, one becomes two, two become four, four become eight, and so on. If you start with one bacterial cell, after 12 hours there would be as many as 33,000,000. The rate at which bacteria grow is different for each type or organism and is affected by many factors.

Factors Affecting Microbial Growth. Many factors affect bacterial growth but the most important ones are:
Water -- Bacteria need water to dissolve the food they use for energy and growth. Water allows the food to get into the cells, is used for the many chemical reactions necessary for life and growth, and allows waste products to escape.
Food/Nutrients -- All bacteria require energy to live and grow. Energy sources, such as sugars, starch, protein, fats and other compounds provide the nutrients.
Oxygen -- Some bacteria require oxygen to grow (aerobes) while others can grow only in the absence of oxygen (anaerobes). However, many bacteria grow under either condition and they are facultative anaerobes.
Temperature -- Bacteria in general are capable of growing over a wide range of temperatures and are usually classified according to the temperature at which they grow. Psychrotrophic bacteria are those that are capable of growing at 32°F to 45°F but their optimum is from 68°F to 86°F. They cause spoilage in foods stored under refrigeration. Several pathogenic bacteria are psychrotrophic -- *Yersinia* and *Listeria*. Mesophilic bacteria. Most bacteria are capable of growing at 60°F to 110°F and belong in this group. Most pathogenic bacteria grow at these temperatures. Thermophilic bacteria. These microorganisms grow at higher temperatures such as 110°F to 150°F. Temperature is the most widely used method of controlling bacterial growth. Bacteria grow slowly at temperatures below 45°F and thermal destruction occurs at

temperatures above 140°F. But in the temperature danger zone -- between 40°F and 135°F -- many bacteria are not controlled.
pH -- pH is a measure of acid or alkali in a product. It is indicated on a scale from 0 to 14, with seven being neutral. If the pH value is below 7, the food is classified as acid; if it is above 7, the food is classified as alkaline. Most bacteria grow well at neutral pH, but many can reproduce in a pH range from 4.5 to 10.0.

Although each of the major factors listed above plays an important role, the interplay between the factors ultimately determines whether a microorganism will grow in a given food. Often, the results of such interplay are unpredictable, as poorly understood synergism or antagonism may occur. An advantage is taken of this interplay with regard to preventing the outgrowth of *C. botulinum*. Food with a pH of 5.0 (within the range for *C. botulinum*) and an a w of 0.935 (above the minimum for *C. botulinum*) may not support the growth of this bacterium. Certain processed cheese spreads take advantage of this fact and are therefore shelf stable at room temperature even though each individual factor would permit the outgrowth of *C. botulinum*. Therefore, predictions about whether or not a particular microorganism will grow in a food can, in general, only be made through experimentation. Also, many microorganisms do not need to multiply in food to cause disease.

SOURCE: U.S. Food and Drug Administration. *Bad Bug Book.* Available online at http://www.cfsan.fda.gov/~mow/intro.html

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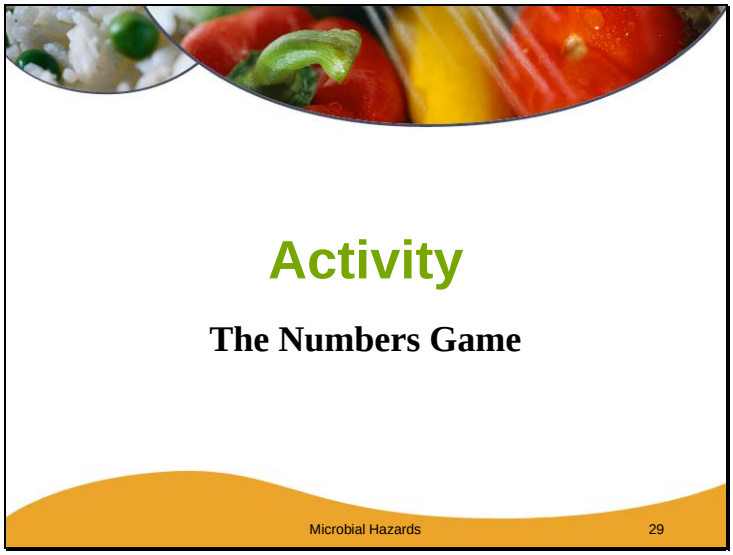

ACTIVITY INSTRUCTIONS: There is a direct relationship between temperature and bacterial growth. Pathogenic bacteria only grow in potentially hazardous foods and so require time-temperature control for safety (TCS). The colder the temperature at which food is held or stored the longer time it takes for bacteria to grow. As a general rule, if food is at 90 degrees F, it will take bacteria about 30 minutes to double; at 70 degrees F, it will take bacteria about 60 minutes to double; and 60 degrees F it will take bacteria about two hours to double.

The purpose of this activity is to demonstrate the relationship between temperature and bacterial growth. Write the following information on a board.
Hamburger at 90 degrees F -- 10 bacteria at 12:00 noon
Hamburger at 70 degrees F – 10 bacteria at 12:00 noon
Hamburger at 60 degrees F – 10 bacteria at 12:00 noon
Have the participants determine how many bacteria will be in each hamburger at 5:00 (five hours in the temperature danger zone).

Answer key:
Hamburger at 90 degrees F -- 10 bacteria at 12:00 noon (doubles every 30 minutes) so at 5:00 there will be 10,240 bacterial cells. For some types of bacteria, this is enough bacteria to cause illness.
Hamburger at 70 degrees F – 10 bacteria at 12:00 noon (doubles every 60 minutes) so at 5:00 there will be 360 bacterial cells.
Hamburger at 60 degrees F – 10 bacteria at 12:00 noon (doubles every two hours) so at 5:00 there will be 60 bacterial cells.

Additional activities can be found at: http://www.foodsafetysite.com/foodservice/conducting/microworld/

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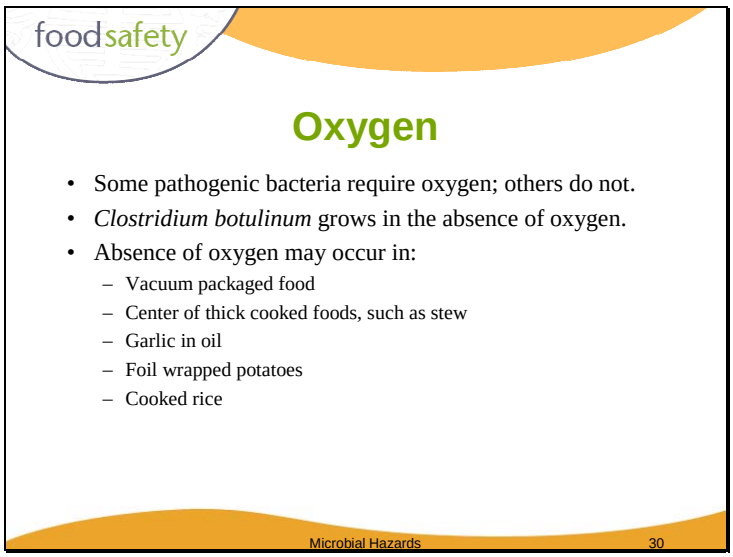

In order for some bacteria to grow, they need oxygen. These bacteria are called "aerobic." Aerobic bacteria need oxygen to get energy for growth. Most spoilage bacteria, molds, and yeast require oxygen to grow. Some bacteria grow in oxygen-free environments and are called "anaerobic." An example of a common anaerobic foodborne bacteria is the *Clostridium* species, such as *Clostridium botulinum* and *Clostridium perfringens*. Some bacteria are facultative, which means that they can grow in either the presence or absence of oxygen. Most foodborne pathogens are facultative with the exception of the above-mentioned *Clostridium*. Some are microaerophilic, meaning they grow in low concentrations of oxygen.

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foodsafety

Controlling Bacteria

Good personal hygiene

- Only allow healthy workers to prepare food.
- Have all workers wash their hands properly and frequently.

Prevent cross-contamination

- Store foods properly.
- Only use cleaned and sanitized utensils and surfaces for food preparation.

Time-temperature control

- Cook foods to proper temperatures.
- Hold foods at proper temperatures.

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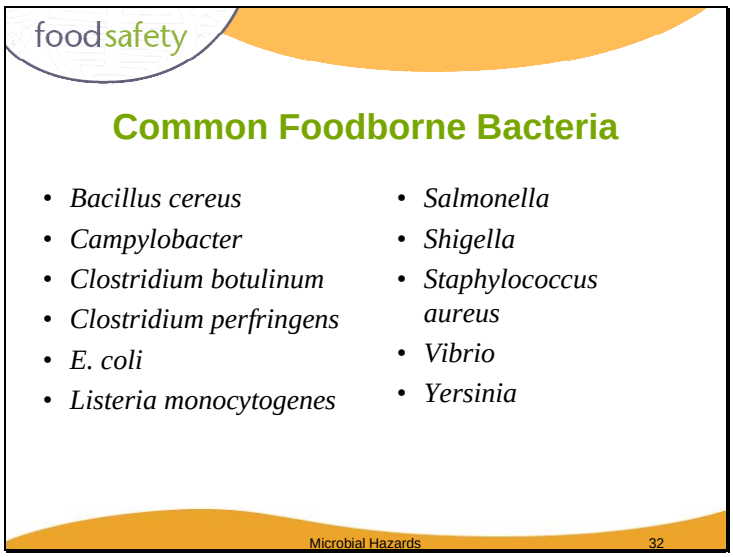

BACILLUS CEREUS

B. cereus can cause two types of foodborne illness -- diarrheal type illness and vomiting (emetic) type of illness.

Nature of Disease: The symptoms of *B. cereus* diarrheal type food poisoning mimic those of *Clostridium perfringens* food poisoning. The onset of watery diarrhea, abdominal cramps, and pain occurs 6 to 15 hours after eating contaminated food. Nausea may accompany diarrhea, but vomiting (emesis) rarely occurs. Symptoms persist for 24 hours in most instances. The emetic type of food poisoning is characterized by nausea and vomiting within 0.5 to 6 h after consumption of contaminated foods. Occasionally, abdominal cramps and/or diarrhea may also occur. Duration of symptoms is generally less than 24 hours. The symptoms of this type of food poisoning parallel those caused by *Staphylococcus aureus* foodborne intoxication. Some strains of *B. subtilis* and *B. licheniformis* have been isolated from lamb and chicken incriminated in food poisoning episodes. These microorganisms demonstrate the production of a highly heat-stable toxin, which might be similar to the vomiting type toxin produced by *B. cereus*.

The presence of large numbers of *B. cereus* (greater than 10^6 organisms/g) in a food is indicative of active growth and proliferation of the organism and is consistent with a potential hazard to health.

Diagnosis of Human Illness: Confirmation of *B. cereus* as the cause of a foodborne outbreak requires either (1) isolation of strains of the same serotype from the suspect food and feces or vomitus of the patient, (2) isolation of large numbers of a *B. cereus* serotype known to cause foodborne illness from the suspect food or from the feces or vomitus of the patient, or (3) isolation of *B. cereus* from suspect foods and determining their enterotoxigenicity by serological (diarrheal toxin) or biological (diarrheal and emetic) tests. The rapid onset time to symptoms in the emetic form of disease, coupled with some food evidence, is often sufficient to diagnose this type of food poisoning.

Associated Foods: A wide variety of foods including meats, milk, vegetables, and fish have been associated with the diarrheal type food poisoning. The vomiting-type outbreaks have generally been associated with rice products; however, other starchy foods such as potato, pasta and cheese products have also been implicated. Food mixtures, such as sauces, puddings, soups, casseroles, pastries, and salads, have frequently been incriminated in food poisoning outbreaks.

Relative Frequency of Disease: In 1980, 9 outbreaks were reported to the Centers for Disease Control and Prevention (CDC) and included such foods as beef, turkey, and Mexican foods. In 1981, 8 outbreaks were reported which primarily involved rice and shellfish. Other outbreaks go unreported or are misdiagnosed

because of symptomatic similarities to *Staphylococcus sureus* intoxication (*B. cereus* vomiting-type) or *C. perfringens* food poisoning (*B. cereus* diarrheal type).

Course of Disease and Complications: Although no specific complications have been associated with the diarrheal and vomiting toxins produced by *B. cereus*, other clinical manifestations of *B. cereus* invasion or contamination have been observed. They include bovine mastitis, severe systemic and pyogenic infections, gangrene, septic meningitis, cellulitis, panophthalmitis, lung abscesses, infant death, and endocarditis.

Target Populations: All people are believed to be susceptible to *B. cereus* food poisoning.

CAMPYLOBACTER

Name of Disease: Campylobacteriosis is the name of the illness caused by *C. jejuni*. It is also often known as *Campylobacter* enteritis or gastroenteritis.

Major Symptoms: *C. jejuni* infection causes diarrhea, which may be watery or sticky and can contain blood (usually occult) and fecal leukocytes (white cells). Other symptoms often present are fever, abdominal pain, nausea, headache and muscle pain. The illness usually occurs 2-5 days after ingestion of the contaminated food or water. Illness generally lasts 7-10 days, but relapses are not uncommon (about 25% of cases). Most infections are self-limiting and are not treated with antibiotics. However, treatment with erythromycin does reduce the length of time that infected individuals shed the bacteria in their feces. The infective dose of *C. jejuni* is considered to be small. Human feeding studies suggest that about 400-500 bacteria may cause illness in some individuals, while in others, greater numbers are required. A conducted volunteer human feeding study suggests that host susceptibility also dictates infectious dose to some degree. The pathogenic mechanisms of *C. jejuni* are still not completely understood, but it does produce a heat-labile toxin that may cause diarrhea. *C. jejuni* may also be an invasive organism.

Associated Foods: *C. jejuni* frequently contaminates raw chicken. Surveys show that 20 to 100% of retail chickens are contaminated. This is not overly surprising since many healthy chickens carry these bacteria in their intestinal tracts. Raw milk is also a source of infections. The bacteria are often carried by healthy cattle and by flies on farms. Non-chlorinated water may also be a source of infections. However, properly cooking chicken, pasteurizing milk, and chlorinating drinking water will kill the bacteria.

Frequency of the Disease: *C. jejuni* is the leading cause of bacterial diarrhea in the U.S. There are probably numbers of cases in excess of the estimated cases of salmonellosis (2- to 4,000,000/year).

Complications: Complications are relatively rare, but infections have been associated with reactive arthritis,hemolytic uremic syndrome, and following septicemia, infections of nearly any organ. The estimated case/fatality ratio for all *C. jejuni* infections is 0.1, meaning one death per 1,000 cases. Fatalities are rare in healthy individuals and usually occur in cancer patients or in the otherwise debilitated. Only 20 reported cases of septic abortion induced by *C. jejuni* have been recorded in the literature. Meningitis, recurrent colitis, acute cholecystitis and Guillain-Barre syndrome are very rare complications.

Target Populations: Although anyone can have a *C. jejuni* infection, children under 5 years and young adults (15-29) are more frequently afflicted than other age groups. Reactive arthritis, a rare complication of these infections, is strongly associated with people who have the human lymphocyte antigen B27 (HLA-B27).

CLOSTRIDIUM BOTULINUM

Four types of botulism are recognized: foodborne, infant, wound, and a form of botulism whose classification is as yet undetermined. Certain foods have been reported as sources of spores in cases of infant botulism and the undetermined category; wound botulism is not related to foods. Foodborne botulism is the name of the disease (actually a foodborne intoxication) caused by the consumption of foods containing the neurotoxin produced by *C. botulinum*.

Infant botulism, first recognized in 1976, affects infants under 12 months of age. This type of botulism is caused by the ingestion of *C. botulinum* spores which colonize and produce toxin in the intestinal tract of infants (intestinal toxemia botulism). Of the various potential environmental sources such as soil, cistern water, dust and foods, honey is the one dietary reservoir of *C. botulinum* spores thus far definitively linked to infant botulism by both laboratory and epidemiologic studies. The number of confirmed infant botulism cases has increased significantly as a result of greater awareness by health officials since its recognition in 197 6. It is now internationally recognized, with cases being reported in more countries.

Wound botulism is the rarest form of botulism. The illness results when *C. botulinum* by itself or with other microorganisms infects a wound and produces toxins which reach other parts of the body via the blood stream. Foods are not involved in this type of botulism.

Undetermined category of botulism involves adult cases in which a specific food or wound source cannot be identified. It has been suggested that some cases of botulism assigned to this category might result from intestinal colonization in adults, with in vivo production of toxin. Reports in the medical literature suggest the existence of a form of botulism similar to infant botulism, but occurring in adults. In these cases, the patients had surgical alterations of the gastrointestinal tract and/or antibiotic therapy. It is proposed that these procedures may have altered the normal gut flora and allowed *C. botulinum* to colonize the intestinal tract.

Nature of the Disease: Infective dose -- a very small amount (a few nanograms) of toxin can cause illness. Onset of symptoms in foodborne botulism is usually 18 to 36 hours after ingestion of the food containing the toxin, although cases have varied from 4 hours to 8 days. Early signs of intoxication consist of marked lassitude, weakness and vertigo, usually followed by double vision and progressive difficulty in speaking and swallowing. Difficulty in breathing, weakness of other muscles, abdominal distention, and constipation may also be common symptoms.

Clinical symptoms of infant botulism consist of constipation that occurs after a period of normal development. This is followed by poor feeding, lethargy, weakness, pooled oral secretions, and wail or altered cry. Loss of head control is striking. Recommended treatment is primarily supportive care. Antimicrobial therapy is not recommended. Infant botulism is diagnosed by demonstrating botulinal toxins and the organism in the infants' stools.

Diagnosis of Human Illness: Although botulism can be diagnosed by clinical symptoms alone, differentiation from other diseases may be difficult. The most direct and effective way to confirm the clinical diagnosis of botulism in the laboratory is to demonstrate the presence of toxin in the serum or feces of the patient or in the food which the patient consumed. Currently, the most sensitive and widely used method for detecting toxin is the mouse neutralization test. This test takes 48 hours. Culturing of specimens takes 5-7 days.

Associated Foods: The types of foods involved in botulism vary according to food preservation and eating habits in different regions. Any food that is conducive to outgrowth and toxin production, that when processed allows spore survival, and is not subsequently heated before consumption can be associated with botulism. Almost any type of food that is not very acidic (pH above 4.6) can support growth and toxin production by *C. botulinum*. Botulinal toxin has been demonstrated in a considerable variety of foods, such as canned corn, peppers, green beans, soups, beets, asparagus, mushrooms, ripe olives, spinach, tuna fish, chicken and chicken livers and liver pate, and luncheon meats, ham, sausage, stuffed eggplant, lobster, and smoked and salted fish.

Frequency: The incidence of the disease is low, but the mortality rate is high if not treated immediately and properly. There are generally between 10 to 30 outbreaks a year in the United States. Some cases of botulism may go undiagnosed because symptoms are transient or mild, or misdiagnosed as Guillain-Barre syndrome.

The Usual Course of Disease and Complications: Botulinum toxin causes flaccid paralysis by blocking motor nerve terminals at the myoneural junction. The flaccid paralysis progresses symmetrically

downward, usually starting with the eyes and face, to the throat, chest and extremities. When the diaphragm and chest muscles become fully involved, respiration is inhibited and death from asphyxia results. Recommended treatment for foodborne botulism includes early administration of botulinal antitoxin (available from CDC) and intensive supportive care (including mechanical breathing assistance).

Target Populations: All people are believed to be susceptible to the foodborne intoxication.

CLOSTRIDIUM PERFRINGENS

Perfringens food poisoning is the term used to describe the common foodborne illness caused by *C. perfringens*. A more serious but rare illness is also caused by ingesting food contaminated with Type C strains. The latter illness is known as enteritis necroticans or pig-bel disease.

Nature of Disease: The common form of perfringens poisoning is characterized by intense abdominal cramps and diarrhea which begin 8-22 hours after consumption of foods containing large numbers of those *C. perfringens* bacteria capable of producing the food poisoning toxin. The illness is usually over within 24 hours but less severe symptoms may persist in some individuals for 1 or 2 weeks. A few deaths have been reported as a result of dehydration and other complications. Necrotic enteritis (pig-bel) caused by *C. perfringens* is often fatal. This disease also begins as a result of ingesting large numbers of the causative bacteria in contaminated foods. Deaths from necrotic enteritis (pig-bel syndrome) are caused by infection and necrosis of the intestines and from resulting septicemia. This disease is very rare in the U.S.

Infective dose: The symptoms are caused by ingestion of large numbers (greater than 10 to the 8th) vegetative cells. Toxin production in the digestive tract (or in test tubes) is associated with sporulation. This disease is a food infection; only one episode has ever implied the possibility of intoxication (i.e., disease from preformed toxin).

Diagnosis of Human Illness: Perfringens poisoning is diagnosed by its symptoms and the typical delayed onset of illness. Diagnosis is confirmed by detecting the toxin in the feces of patients. Bacteriological confirmation can also be done by finding exceptionally large numbers of the causative bacteria in implicated foods or in the feces of patients.

Associated Foods: In most instances, the actual cause of poisoning by *C. perfringens* is temperature abuse of prepared foods. Small numbers of the organisms are often present after cooking and multiply to food poisoning levels during cool down and storage of prepared foods. Meats, meat products, and gravy are the foods most frequently implicated.

Relative Frequency of Disease: Perfringens poisoning is one of the most commonly reported foodborne illnesses in the U.S. There were 1,162 cases in 1981, in 28 separate outbreaks. At least 10-20 outbreaks have been reported annually in the U.S. for the past 2 decades. Typically, dozens or even hundreds of person are affected. It is probable that many outbreaks go unreported because the implicated foods or patient feces are not tested routinely for *C. perfringens* or its toxin. CDC estimates that about 10,000 actual cases occur annually in the U.S.

Course of Disease and Complications: The disease generally lasts 24 hours. In the elderly or infirm, symptoms may last 1-2 weeks. Complications and/or death only very rarely occur.

Target Populations: Institutional feeding (such as school cafeterias, hospitals, nursing homes, prisons, etc.) where large quantities of food are prepared several hours before serving is the most common circumstance in which perfringens poisoning occurs. The young and elderly are the most frequent victims of perfringens poisoning. Except in the case of pig-bel syndrome, complications are few in persons under 30 years of age. Elderly persons are more likely to experience prolonged or severe symptoms.

***ESCHERICHIA COLI* 0157:H7**

Name of Disease: Hemorrhagic colitis is the name of the acute disease caused by *E. coli* O157:H7.

Major Symptoms: The illness is characterized by severe cramping (abdominal pain) and diarrhea which is initially watery but becomes grossly bloody. Occasionally vomiting occurs. Fever is either low-grade or absent. The illness is usually self-limited and lasts for an average of 8 days. Some individuals exhibit watery diarrhea only. Infective dose -- Unknown, but from a compilation of outbreak data, including the organism's ability to be passed person-to-person in the day-care setting and nursing homes, the dose may be similar to that of *Shigella* spp. (as few as 10 organisms).

Associated Foods: Undercooked or raw hamburger (ground beef) has been implicated in many of the documented outbreaks, however *E. coli* O157:H7 outbreaks have implicated alfalfa sprouts, unpasteurized fruit juices, dry-cured salami, lettuce, game meat, and cheese curds. Raw milk was the vehicle in a school outbreak in Canada.

Frequency of Illness: Hemorrhagic colitis infections are not too common, but this is probably not reflective of the true frequency. In the Pacific Northwest, *E. coli* O157:H7 is thought to be second only to Salmonella as a cause of bacterial diarrhea. Because of the unmistakable symptoms of profuse, visible blood in severe cases, those victims probably seek medical attention, but less severe cases are probably more numerous.

Complications: Some victims, particularly the very young, have developed the hemolytic uremic syndrome (HUS), characterized by renal failure and hemolytic anemia. From 0 to 15% of hemorrhagic colitis victims may develop HUS. The disease can lead to permanent loss of kidney function. In the elderly, HUS, plus two other symptoms, fever and neurologic symptoms, constitutes thrombotic thrombocytopenic purpura (TTP). This illness can have a mortality rate in the elderly as high as 50%.

Target Population: All people are believed to be susceptible to hemorrhagic colitis, but young children and the elderly appear to progress to more serious symptoms more frequently.

LISTERIA MONOCYTOGENES

Listeriosis is the name of the general group of disorders caused by *L. monocytogenes.*

Nature of Disease: Listeriosis is clinically defined when the organism is isolated from blood, cerebrospinal fluid, or an otherwise normally sterile site (e.g. placenta, fetus). The manifestations of listeriosis include septicemia, meningitis (or meningoencephalitis), encephalitis, and intrauterine or cervical infections in pregnant women, which may result in spontaneous abortion (2nd/3rd trimester) or stillbirth. The onset of the aforementioned disorders is usually preceded by influenza-like symptoms including persistent fever. It was reported that gastrointestinal symptoms such as nausea, vomiting, and diarrhea may precede more serious forms of listeriosis or may be the only symptoms expressed. Gastrointestinal symptoms were epidemiologically associated with use of antacids or cimetidine. The onset time to serious forms of listeriosis is unknown but may range from a few days to three weeks. The onset time to gastrointestinal symptoms is unknown but is probably greater than 12 hours.

The infective dose of *L. monocytogenes* is unknown but is believed to vary with the strain and susceptibility of the victim. From cases contracted through raw or supposedly pasteurized milk, it is safe to assume that in susceptible persons, fewer than 1,000 total organisms may cause disease. *L. monocytogenes* may invade the gastrointestinal epithelium. Once the bacterium enters the host's monocytes, macrophages, or polymorphonuclear leukocytes, it is bloodborne (septicemic) and can grow. Its presence intracellularly in phagocytic cells also permits access to the brain and probably transplacental migration to the fetus in pregnant women. The pathogenesis of *L. monocytogenes* centers on its ability to survive and multiply in phagocytic host cells.

Associated Foods: *L. monocytogenes* has been associated with such foods as raw milk, supposedly pasteurized fluid milk, cheeses (particularly soft-ripened varieties), ice cream, raw vegetables, fermented raw-meat sausages, raw and cooked poultry, raw meats (all types), and raw and smoked fish. Its ability to grow at temperatures as low as 3°C permits multiplication in refrigerated foods.

Frequency of the Disease: The 1987 incidence data prospectively collected by CDC suggests that there are at least 1600 cases of listeriosis with 415 deaths per year in the U.S. The vast majority of cases are sporadic, making epidemiological links to food very difficult.

Complications: Most healthy persons probably show no symptoms. The "complications" are the usual clinical expressions of the disease. When listeric meningitis occurs, the overall mortality may be as high as 70%; from septicemia 50%, from perinatal/neonatal infections greater than 80%. In infections during pregnancy, the mother usually survives. Successful treatment with parenteral penicillen or ampicillin has been reported. Trimethoprim-sulfamethoxazole has been shown effective in patients allergic to penicillin.

Target Populations: The main target populations for listeriosis are:
pregnant women/fetus - perinatal and neonatal infections;
persons immunocompromised by corticosteroids, anticancer drugs, graft suppression therapy, AIDS;
cancer patients - leukemic patients particularly;
less frequently reported - diabetic, cirrhotic, asthmatic, and ulcerative colitis patients;
the elderly;
normal people--some reports suggest that normal, healthy people are at risk, although antacids or cimetidine may predispose. A listerosis outbreak in Switzerland involving cheese suggested that healthy uncompromised individuals could develop the disease, particularly if the foodstuff was heavily contaminated with the organism.

SALMONELLA
S. typhi and the paratyphoid bacteria are normally caused septicemic and produce typhoid or typhoid-like fever in humans. Other forms of salmonellosis generally produce milder symptoms.

Nature of Disease: Acute symptoms -- Nausea, vomiting, abdominal cramps, minal diarrhea, fever, and headache. Chronic consequences -- arthritic symptoms may follow 3-4 weeks after onset of acute symptoms. Onset time – 6 to 48 hours.

Infective dose: As few as 15-20 cells; depends upon age and health of host, and strain differences among the members of the genus.

Duration of symptoms: Acute symptoms may last for 1 to 2 days or may be prolonged, again depending on host factors, ingested dose, and strain characteristics.

Cause of disease: Penetration and passage of *Salmonella* organisms from gut lumen into epithelium of small intestine where inflammation occurs; there is evidence that an enterotoxin may be produced, perhaps within the enterocyte.

Diagnosis of Human Illness: Serological identification of culture isolated from stool.

Associated Foods: Raw meats, poultry, eggs, milk and dairy products, fish, shrimp, frog legs, yeast, coconut, sauces and salad dressings, cake mixes, cream-filled desserts and toppings, dried gelatin, peanut butter, cocoa, and chocolate. Various *Salmonella* species have long been isolated from the outside of egg shells. The present situation with *S. enteritidis* is complicated by the presence of the organism inside the egg, in the yolk. This and other information strongly suggest vertical transmission, i.e., deposition of the organism in the yolk by an infected layer hen prior to shell deposition. Foods other than eggs have also caused outbreaks of *S. enteritidis* disease.

Relative Frequency of Disease: It is estimated that from 2 to 4 million cases of salmonellosis occur in the U.S. annually. The incidence of salmonellosis appears to be rising both in the U.S. and in other industrialized nations. *S. enteritidis* isolations from humans have shown a dramatic rise in the past decade, particularly in the northeast United States (6-fold or more), and the increase in human infections is spreading south and west, with sporadic outbreaks in other regions. Reported cases of Salmonellosis in the U.S. excluding typhoid fever for the years 1988 to 1995. The number of cases for each year varies between

40,000 and 50,000. From Summary of Notifiable Diseases, United States MMWR 44(53): 1996 (October 25).

Complications: *S. typhi* and *S. paratyphi* A, B, and C produce typhoid and typhoid-like fever in humans. Various organs may be infected, leading to lesions. The fatality rate of typhoid fever is 10% compared to less than 1% for most forms of salmonellosis. *S. dublin* has a 15% mortality rate when septicemic in the elderly, and *S. enteritidis* is demonstrating approximately a 3.6% mortality rate in hospital/nursing home outbreaks, with the elderly being particularly affected.

Salmonella septicemia has been associated with subsequent infection of virtually every organ system. Postenteritis reactive arthritis and Reiter's syndrome have also been reported to occur generally after 3 weeks. Reactive arthritis may occur with a frequency of about 2% of culture-proven cases. Septic arthritis, subsequent or coincident with septicemia, also occurs and can be difficult to treat.

Target Populations: All age groups are susceptible, but symptoms are most severe in the elderly, infants, and the infirm. AIDS patients suffer from salmonellosis frequently (estimated 20-fold more than general population) and suffer from recurrent episodes.

SHIGELLA

Shigellosis (bacillary dysentery).

Symptoms: Abdominal pain; cramps; diarrhea; fever; vomiting; blood, pus, or mucus in stools; tenesmus.

Onset time: 12 to 50 hours.

Infective dose: As few as 10 cells depending on age and condition of host. The *Shigella spp.* are highly infectious agents that are transmitted by the fecal-oral route. The disease is caused when virulent *Shigella* organisms attach to, and penetrate, epithelial cells of the intestinal mucosa. After invasion, they multiply intracellularly, and spread to contiguous epitheleal cells resulting in tissue destruction. Some strains produce enterotoxin and Shiga toxin (very much like the verotoxin of *E. coli* O157:H7).

Diagnosis of Human Illness: Serological identification of culture isolated from stool.

Associated Foods: Salads (potato, tuna, shrimp, macaroni, and chicken), raw vegetables, milk and dairy products, and poultry. Contamination of these foods is usually through the fecal-oral route. Fecally contaminated water and unsanitary handling by food handlers are the most common causes of contamination.

Relative Frequency of Disease: An estimated 300,000 cases of shigellosis occur annually in the U.S. The number attributable to food is unknown, but given the low infectious dose, it is probably substantial.

Course of Disease and Complications: Infections are associated with mucosal ulceration, rectal bleeding, drastic dehydration; fatality may be as high as 10-15% with some strains. Reiter's disease, reactive arthritis, and hemolytic uremic syndrome are possible sequelae that have been reported in the aftermath of shigellosis.

Target Populations: Infants, the elderly, and the infirm are susceptible to the severest symptoms of disease, but all humans are susceptible to some degree. Shigellosis is a very common malady suffered by individuals with acquired immune deficiency syndrome (AIDS) and AIDS-related complex, as well as non-AIDS homosexual men.

STAPHYLOCOCCUS AUREUS

Name of Acute Disease: Staphylococcus food poisoning (staphyloenterotoxicosis; staphyloenterotoxemia) is the name of the condition caused by the enterotoxins, which some strains of *S. aureus* produce.

Nature of the Disease: The onset of symptoms in staphylococcal food poisoning is usually rapid and in many cases acute, depending on individual susceptibility to the toxin, the amount of contaminated food eaten, the amount of toxin in the food ingested, and the general health of the victim. The most common symptoms are nausea, vomiting, retching, abdominal cramping, and prostration. Some individuals may not always demonstrate all the symptoms associated with the illness. In more severe cases, headache, muscle cramping, and transient changes in blood pressure and pulse rate may occur. Recovery generally takes two days, However, it us not unusual for complete recovery to take three days and sometimes longer in severe cases. Infective dose -- a toxin dose of less than 1.0 microgram in contaminated food will produce symptoms of staphylococcal intoxication. This toxin level is reached when *S. aureus* populations exceed 100,000 per gram.

Diagnosis of Human Illness: In the diagnosis of staphylococcal foodborne illness, proper interviews with the victims and gathering and analyzing epidemiologic data are essential. Incriminated foods should be collected and examined for staphylococci. The presence of relatively large numbers of enterotoxigenic staphylococci is good circumstantial evidence that the food contains toxin. The most conclusive test is the linking of an illness with a specific food or in cases where multiple vehicles exist, the detection of the toxin in the food sample(s). In cases where the food may have been treated to kill the staphylococci, as in pasteurization or heating, direct microscopic observation of the food may be an aid in the diagnosis. A number of serological methods for determining the enterotoxigenicity of *S. aureus* isolated from foods as well as methods for the separation and detection of toxins in foods have been developed and used successfully to aid in the diagnosis of the illness. Phage typing may also be useful when viable staphylococci can be isolated from the incriminated food, from victims, and from suspected carrier such as food handlers.

Foods Incriminated: Foods that are frequently incriminated in staphylococcal food poisoning include meat and meat products; poultry and egg products; salads such as egg, tuna, chicken, potato, and macaroni; bakery products such as cream-filled pastries, cream pies, and chocolate eclairs; sandwich fillings; and milk and dairy products. Foods that require considerable handling during preparation and that are kept at slightly elevated temperatures after preparation are frequently involved in staphylococcal food poisoning. Staphylococci exist in air, dust, sewage, water, milk, and food or on food equipment, environmental surfaces, humans, and animals. Humans and animals are the primary reservoirs. Staphylococci are present in the nasal passages and throats and on the hair and skin of 50 percent or more of healthy individuals. This incidence is even higher for those who associate with or who come in contact with sick individuals and hospital environments. Although food handlers are usually the main source of food contamination in food poisoning outbreaks, equipment and environmental surfaces can also be sources of contamination with *S. aureus*. Human intoxication is caused by ingesting enterotoxins produced in food by some strains of *S. aureus*, usually because the food has not been kept hot enough (140°F or above) or cold enough (45°F or below).

Frequency of Illness: The true incidence of staphylococcal food poisoning is unknown for a number of reasons, including poor responses from victims during interviews with health officials; misdiagnosis of the illness, which may be symptomatically similar to other types of food poisoning (such as vomiting caused by *Bacillus cereus* toxin); inadequate collection of samples for laboratory analyses; and improper laboratory examination. Of the bacterial pathogens causing foodborne illnesses in the U.S. (127 outbreaks, 7,082 cases recorded in 1983), 14 outbreaks involving 1,257 cases were caused by *S. aureus*. These outbreaks were followed by 11 outbreaks (1,153 cases) in 1984, 14 outbreaks (421 cases) in 1985, 7 outbreaks (250 cases) in 1986 and one reported outbreak (100 cases) in 1987.

Complications: Death from staphylococcal food poisoning is very rare, although such cases have occurred among the elderly, infants, and severely debilitated persons.

Target Population: All people are believed to be susceptible to this type of bacterial intoxication; however, intensity of symptoms may vary.

VIBRIO VULNIFICUS

Name of Disease: This organism causes wound infections, gastroenteritis, or a syndrome known as "primary septicemia."

Major Symptoms: Wound infections result either from contaminating an open wound with sea water harboring the organism, or by lacerating part of the body on coral, fish, etc., followed by contamination with the organism. The ingestion of *V. vulnificus* by healthy individuals can result in gastroenteritis. The "primary septicemia" form of the disease follows consumption of raw seafood containing the organism by individuals with underlying chronic disease, particularly liver disease (see below). In these individuals, the microorganism enters the blood stream, resulting in septic shock, rapidly followed by death in many cases (about 50%). Over 70% of infected individuals have distinctive bulbous skin lesions. Infective dose -- the infective dose for gastrointestinal symptoms in healthy individuals is unknown but for predisposed persons, septicemia can presumably occur with doses of less than 100 total organisms.

Associated Foods: This organism has been isolated from oysters, clams, and crabs. Consumption of these products raw or recontaminated may result in illness.

Frequency of Illness: No major outbreaks of illness have been attributed to this organism. Sporadic cases occur frequently, becoming more prevalent during the warmer months.

Complications: In healthy individuals, gastroenteritis usually occurs within 16 hours of ingesting the organism. Ingestion of the organism by individuals with some type of chronic underlying disease [such as diabetes, cirrhosis leukemia , lung carcinoma, acquired immune deficiency syndrome (AIDS), AIDS-related complex (ARC), or asthma requiring the use of steroids] may cause the "primary septicemia" form of illness. The mortality rate for individuals with this form of the disease is over 50%.

Target Population: All individuals who consume foods contaminated with this organism are susceptible to gastroenteritis. Individuals with diabetes, cirrhosis, or leukemia, or those who take immunosuppressive drugs or steroids are particularly susceptible to primary septicemia. These individuals should be strongly advised not to consume raw or inadequately cooked seafood, as should AIDS/ARC patients.

VIBRIO PARAHAEMOLYTICUS

Name of Disease: *V. parahaemolyticus*-associated gastroenteritis is the name of the infection caused by this organism.

Major Symptoms: Diarrhea, abdominal cramps, nausea, vomiting, headache, fever, and chills may be associated with infections caused by this organism. The illness is usually mild or moderate, although some cases may require hospitalization. The median duration of the illness is 2.5 days. The incubation period is 4-96 hours after the ingestion of the organism, with a mean of 15 hours. Disease is caused when the organism attaches itself to an individuals' small intestine and excretes an as yet unidentified toxin. Infective dose -- a total dose of greater than one million organisms may cause disease; this dose may be markedly lowered by coincident consumption of antacids (or presumably by food with buffering capability).

Associated Foods: Infections with this organism have been associated with the consumption of raw, improperly cooked, or cooked, recontaminated fish and shellfish. A correlation exists between the probability of infection and warmer months of the year. Improper refrigeration of seafoods contaminated with this organism will allow its proliferation, which increases the possibility of infection.

Frequency of Illness: Major outbreaks have occurred in the U.S. during the warmer months of the year. Sporadic cases occur along all coasts of the U.S.

Complications: Diarrhea caused by this organism is usually self-limiting, with few cases requiring hospitalization and/or antibiotic treatment.

Target Population: All individuals who consume raw or improperly cooked fish and shellfish are susceptible to infection by this organism.

YERSINIA

Yersiniosis There are 3 pathogenic species in the genus *Yersinia*, but only *Y. enterocolitica* and *Y. pseudotuberculosis* cause gastroenteritis. To date, no foodborne outbreaks caused by *Y. pseudotuberculosis* have been reported in the United States, but human infections transmitted via contaminated water and foods have been reported in Japan. *Y. pestis*, the causative agent of "the plague" is genetically very similar to *Y. pseudotuberculosis* but infects humans by routes other than food.

Nature of Disease: Yersiniosis is frequently characterized by such symptoms as gastroenteritis with diarrhea and/or vomiting; however, fever and abdominal pain are the hallmark symptoms. *Yersinia* infections mimic appendicitis and mesenteric lymphadenitis, but the bacteria may also cause infections of other sites such as wounds, joints and the urinary tract.

Infective dose: Unknown. Illness onset is usually between 24 and 48 hours after ingestion, which (with food or drink as vehicle) is the usual route of infection.

Diagnosis of Human Illness: Diagnosis of yersiniosis begins with isolation of the organism from the human host's feces, blood, or vomit, and sometimes at the time of appendectomy. Confirmation occurs with the isolation, as well as biochemical and serological identification, of *Y. enterocolitica* from both the human host and the ingested foodstuff. Diarrhea is reported to occur in about 80% of cases; abdominal pain and fever are the most reliable symptoms. Because of the difficulties in isolating *yersiniae* from feces, several countries rely on serology. Acute and convalescent patient sera are titered against the suspect serotype of *Yersinia spp*. Yersiniosis has been misdiagnosed as Crohn's disease (regional enteritis) as well as appendicitis.

Associated Foods: Strains of *Y. enterocolitica* can be found in meats (pork, beef, lamb, etc.), oysters, fish, and raw milk. The exact cause of the food contamination is unknown. However, the prevalence of this organism in the soil and water and in animals such as beavers, pigs, and squirrels, offers ample opportunities for it to enter our food supply. Poor sanitation and improper sterilization techniques by food handlers, including improper storage, cannot be overlooked as contributing to contamination.

Frequency of the Disease: Yersiniosis does not occur frequently. It is rare unless a breakdown occurs in food processing techniques. CDC estimates that about 17,000 cases occur annually in the USA. Yersiniosis is a far more common disease in Northern Europe, Scandinavia, and Japan.

Complications: The major "complication" is the performance of unnecessary appendectomies, since one of the main symptoms of infections is abdominal pain of the lower right quadrant. Both *Y. enterocolitica* and *Y. pseudotuberculosis* have been associated with reactive arthritis, which may occur even in the absence of obvious symptoms. The frequency of such postenteritis arthritic conditions is about 2-3%.

Another complication is bacteremia (entrance of organisms into the blood stream), in which case the possibility of a disseminating disease may occur. This is rare, however, and fatalities are also extremely rare.

Target Populations: The most susceptible populations for the main disease and possible complications are the very young, the debilitated, the very old and persons undergoing immunosuppressive therapy. Those most susceptible to postenteritis arthritis are individuals with the antigen HLA-B27 (or related antigens such as B7).

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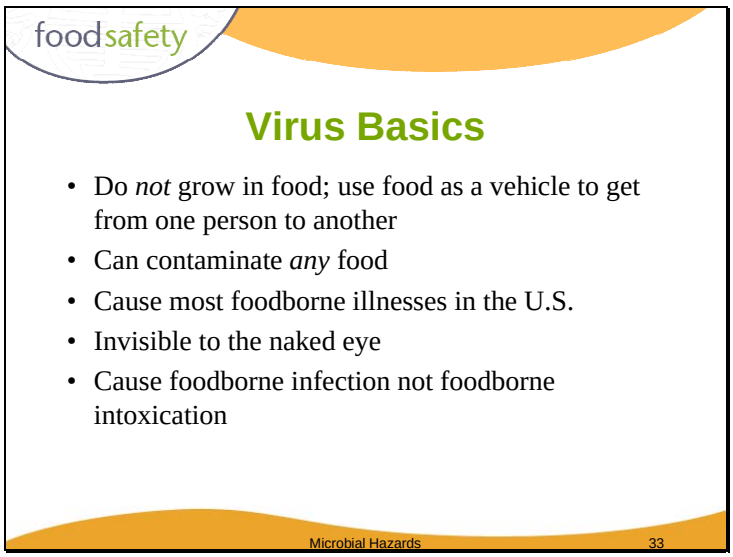

Viruses are the smallest of the foodborne microbial contaminants. They are packets of infectious genetic material wrapped with an outer layer of protein. Most experts believe that viruses are the most common cause of foodborne illness in the U.S.

Viral gastroenteritis affects people all over the world. In the U.S. the most common foodborne viral agents are hepatitis A, norovirus, and rotavirus. Viral gastroenteritis outbreaks can occur in institutional settings, such as schools, child care facilities, and nursing homes, and can also occur in other group settings, such as banquet halls, cruise ships, dormitories, and campgrounds.

Water, salads, shellfish, iced drinks, and other ready-to-eat foods are the most common sources of viral foodborne illnesses. The points of potential contamination determine the appropriate intervention strategy for preventing a viral foodborne disease. Food may be contaminated at the source (i.e. polluted shellfish beds, vegetable growing fields, or during processing). Shellfish may be contaminated by sewage, and persons who eat raw or undercooked shellfish harvested from contaminated waters may get diarrhea. Drinking water can also be contaminated by sewage and be a source to spread viruses. Preventing this type of contamination requires monitoring of water overlying shellfish beds and providing sanitary facilities for food workers and enforcement of sanitary practices.

Food may also be contaminated while being prepared for consumption; uncooked foods will remain infectious. For example, a food handler who has viral gastroenteritis could transmit viral agents to food if they do not wash their hands regularly after using the bathroom.

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Most outbreaks of viral gastroenteritis are self-limited so they tend to end or be resolved without treatment. However, certain factors create risks of intense or prolonged transmission that may require aggressive intervention. Whatever the initial source of the outbreak, subsequent viral transmission is often person-to-person, with both direct fecal-oral and airborne transport probably involved. Although interruption of this transmission may be difficult, the following measures may be helpful in controlling or preventing the spread of infection.

Shellfish. Obtain shellfish from sources that are included in the most current "Interstate Certified Shellfish Shippers List." This list is available online at: http://vm.cfsan.fda.gov/~acrobat/icss0402.pdf.
To eliminate hepatitis A from oysters, clams, and other shellfish that are harvested from contaminated areas, heat them to 185°F-194°F for 4 minutes or steam them for 90 seconds before eating.

Identify and Eliminate a Common Source. For viral outbreaks, a sick food handler is a likely source, although water, ice, and shellfish are other common sources. In many settings, employees (e.g., health-care providers, staff of day-care centers) are at highest risk for transmitting disease because of their many contacts with ill persons. Any staff member with symptoms that suggest infection should be excluded from contact with potentially susceptible persons for at least two days after resolution of illness. This exclusion is particularly important for food handlers, who also should not be involved in preparing food for the same period.

Prevent Employees from Getting Sick. Employees coming into direct contact with ill persons should wear disposable plastic gloves. When contamination of clothing with fecal material is possible, personnel should also wear gowns. Hands, which are the most likely means by which viral spread occurs, should be washed after each contact. The recommended procedure is to rub all surfaces of lathered hands together vigorously for at least 20 seconds, with plain soap or an antimicrobial-containing product, and then thoroughly rinse the hands under a stream of water. Since spattering or aerosols of infectious material may be involved in disease transmission, wearing of masks should be considered, particularly by persons who clean areas grossly contaminated by feces or vomitus.

Use Safeguards with Laundry. Soiled linens and clothes should be handled as little as possible and with minimum agitation to prevent microbial contamination of the air and of persons handling the linen. Laundry should be transported in an enclosed and sanitary manner (e.g., in a plastic bag if the laundry is wet or moist), promptly machine washed with a detergent in water at the maximum cycle length, and then machine dried (109).

Clean Soiled Surfaces. Because environmental surfaces in certain settings have been implicated in the transmission of enteric viruses, bathrooms and rooms occupied by ill persons should be kept visibly clean on a routine basis. Surfaces that have been soiled, especially by feces or vomitus, should first be cleaned of visible material and then disinfected with an appropriate commercial germicidal product according to the manufacturer's instructions. Feces and vomitus collected during the cleaning procedure should be promptly disposed of in a manner that prevents transfer of this material to other surfaces or persons. Persons performing these tasks should wear appropriate protective barriers (e.g., utility gloves--and if splashing is anticipated, a mask or face shield and garments such as a uniform, jumpsuit, or gown to protect street clothing).

Minimize Contact Between Well and Ill Persons. When possible, ill persons should be separated from well persons until at least 2 days after resolution of symptoms. If nosocomial rotavirus is involved, this period should be longer -- at least until the ill person's stool is negative by antigen detection, which may be greater than or equal to 1 week. In certain settings (e.g., camp, cruise ship, or nursing home), the clinic may function as a focus of transmission; persons with complaints of gastroenteritis should be seen by medical care personnel in the patient's living quarters, or at least in a separate area of the clinic.

Most viruses can be destroyed in foods by heating but the time-temperature schedule will vary depending on the target viral agent. For example, one study reported that a poliovirus was found to survive stewing, frying, baking, and steaming of oysters. However, heating it is recommended to destroy Hepatitis A virus that oysters, clams, and other shellfish harvested from contaminated areas be heated from 185 to 194F for four minutes or steamed for 90 seconds before eating. The best way to prevent foodborne illness from viral agents is to prevent contamination to begin with.

SOURCES: DiGirolamo, R., J. Liston, and J.R. Matches. 1970. Survival of virus in chilled, frozen, and processed oysters. *Appl. Microbiol.* 20:58-63.

Chin, J (ed.) 2000. *Control of Communicable Diseases Manual.* American Public Health Association, Washington, DC p. 241.

The Centers for Disease Control and Prevention
http://wonder.cdc.gov/wonder/prevguid/p0000277/P0000277.asp#head010000000000000

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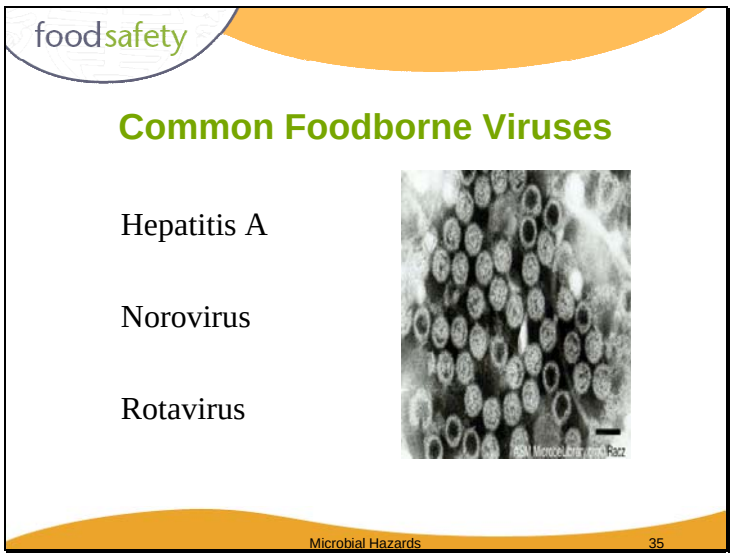

HEPATITIS A
Hepatitis A is usually a mild illness characterized by sudden onset of fever, malaise, nausea, anorexia, and abdominal discomfort, followed in several days by jaundice. The infectious dose is unknown but presumably is 10-100 virus particles.

Associated Foods: Hepatitis A virus (HAV) is excreted in feces of infected people and can produce clinical disease when susceptible individuals consume contaminated water or foods. Cold cuts and sandwiches, fruits and fruit juices, milk and milk products, vegetables, salads, shellfish, and iced drinks are commonly implicated in outbreaks. Water, shellfish, and salads are the most frequent sources. Contamination of foods by infected workers in food processing plants and restaurants is common.

Relative Frequency of Disease: Hepatitis A has a worldwide distribution occurring in both epidemic and sporadic fashions. About 22,700 cases of hepatitis A representing 38% of all hepatitis cases (5-year average from all routes of transmission) are reported annually in the U.S. In 1988 an estimated 7.3% cases were foodborne or waterborne. HAV is primarily transmitted by person-to-person contact through fecal contamination, but common-source epidemics from contaminated food and water also occur. Poor sanitation and crowding facilitate transmission. Outbreaks of HA are common in institutions, crowded house projects, and prisons and in military forces in adverse situations. In developing countries, the incidence of disease in adults is relatively low because of exposure to the virus in childhood. Most individuals 18 and older demonstrate an immunity that provides lifelong protection against reinfection. In the U.S., the percentage of adults with immunity increases with age (10% for those 18-19 years of age to 65% for those over 50). The increased number of susceptible individuals allows common source epidemics to evolve rapidly.

NOROVIRUS
The disease is self-limiting, mild, and characterized by nausea, vomiting, diarrhea, and abdominal pain. Headache and low-grade fever may occur. The infectious dose is unknown but presumed to be low. Diagnosis of Human Illness: Specific diagnosis of the disease can only be made by a few laboratories possessing reagents from human volunteer studies. Identification of the virus can be made on early stool specimens using immune electron microscopy and various immunoassays. Confirmation often requires demonstration of seroconversion, the presence of specific IgM antibody, or a four-fold rise in antibody titer to Norwalk virus on paired acute-convalescent sera.

Associated Foods: Norwalk gastroenteritis is transmitted by the fecal-oral route via contaminated water and foods. Secondary person-to-person transmission has been documented. Water is the most common source of outbreaks and may include water from municipal supplies, well, recreational lakes, swimming pools, and water stored aboard cruise ships. Shellfish and salad ingredients are the foods most often implicated in Norwalk outbreaks. Ingestion of raw or insufficiently steamed clams and oysters poses a high risk for infection with Norwalk virus. Foods other than shellfish are contaminated by ill food handlers.

Relative Frequency of Disease: Only the common cold is reported more frequently than viral gastroenteritis as a cause of illness in the U.S. Although viral gastroenteritis is caused by a number of viruses, it is estimated that Norwalk viruses are responsible for about 1/3 of the cases not involving the 6-to-24-month age group. In developing countries the percentage of individuals who have developed immunity is very high at an early age. In the U.S. the percentage increases gradually with age, reaching 50% in the population over 18 years of age. Immunity, however, is not permanent and reinfection can occur.

Course of Disease and Complications: A mild and brief illness usually develops 24-48 h after contaminated food or water is consumed and lasts for 24-60 hours. Severe illness or hospitalization is very rare.

Target Populations: All individuals who ingest the virus and who have not (within 24 months) had an infection with the same or related strain, are susceptible to infection and can develop the symptoms of gastroenteritis. Disease is more frequent in adults and older children than in the very young.

ROTAVIRUS

Rotaviruses cause acute gastroenteritis. Infantile diarrhea, winter diarrhea, acute nonbacterial infectious gastroenteritis, and acute viral gastroenteritis are names applied to the infection caused by the most common and widespread group A rotavirus.

Nature of Disease: Rotavirus gastroenteritis is a self-limiting, mild to severe disease characterized by vomiting, watery diarrhea, and low-grade fever. The infective dose is presumed to be 10-100 infectious viral particles. Because a person with rotavirus diarrhea often excretes large numbers of virus (108-1010 infectious particles/ml of feces), infection doses can be readily acquired through contaminated hands, objects, or utensils. Asymptomatic rotavirus excretion has been well documented and may play a role in perpetuating endemic disease.

Diagnosis of Human Illness: Specific diagnosis of the disease is made by identification of the virus in the patient's stool. Enzyme immunoassay (EIA) is the test most widely used to screen clinical specimens, and several commercial kits are available for group A rotavirus. Electron microscopy (EM) and polyacrylamide gel electrophoresis (PAGE) are used in some laboratories in addition or as an alternative to EIA. A reverse transcription-polymerase chain reaction (RT-PCR) has been developed to detect and identify all three groups of human rotaviruses.

Associated Foods: Rotaviruses are transmitted by the fecal-oral route. Person-to-person spread through contaminated hands is probably the most important means by which rotaviruses are transmitted in close communities such as pediatric and geriatric wards, day care centers and family homes. Infected food handlers may contaminate foods that require handling and no further cooking, such as salads, fruits, and hors d'oeuvres. Rotaviruses are quite stable in the environment and have been found in estuary samples at levels as high as 1-5 infectious particles/gal. Sanitary measures adequate for bacteria and parasites seem to be ineffective in endemic control of rotavirus, as similar incidence of rotavirus infection is observed in countries with both high and low health standards.

Relative Frequency of Disease: Group A rotavirus is endemic worldwide. It is the leading cause of severe diarrhea among infants and children, and accounts for about half of the cases requiring hospitalization. Over 3 million cases of rotavirus gastroenteritis occur annually in the U.S. In temperate areas, it occurs primarily in the winter, but in the tropics it occurs throughout the year. The number attributable to food

contamination is unknown. Group B rotavirus, also called adult diarrhea rotavirus or ADRV, has caused major epidemics of severe diarrhea affecting thousands of persons of all ages in China.

Group C rotavirus has been associated with rare and sporadic cases of diarrhea in children in many countries. However, the first outbreaks were reported from Japan and England.

Course of Disease and Complications: The incubation period ranges from 1-3 days. Symptoms often start with vomiting followed by 4-8 days of diarrhea. Temporary lactose intolerance may occur. Recovery is usually complete. However, severe diarrhea without fluid and electrolyte replacement may result in severe diarrhea and death. Childhood mortality caused by rotavirus is relatively low in the U.S., with an estimated 100 cases/year, but reaches almost 1 million cases/year worldwide. Association with other enteric pathogens may play a role in the severity of the disease.

Target Populations: Humans of all ages are susceptible to rotavirus infection. Children 6 months to 2 years of age, premature infants, the elderly, and the immunocompromised are particularly prone to more severe symptoms caused by infection with group A rotavirus.

PHOTOGRAPH CREDITS:
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Rotaviruses are a major cause of viral gastroenteritis in infants and young adults. Many rotavirus infections are subclinical or cause mild illness. When disease occurs, symptoms may include diarrhea, fever, vomiting, and abdominal pain. Transmission is from human to human, primarily via the fecal-oral route. Rotaviruses are segmented double-stranded RNA viruses. The viral particles are approximately 70 nm in diameter, have icosahedral symmetry, and possess three concentric protein shells or capsids (core, internal capsid, and external capsid). The term "rota," meaning wheel, is derived from the appearance of the complete triple-capsid particle when viewed by electron microscopy. The electron micrograph illustrates the appearance of negatively stained rotavirus particles in a human stool sample from an individual with gastroenteritis. Specimen was stained with 2% PTK (potassium phosphotungstate). Micrographs were taken with a Philips EM-400T electron microscope operated at 80 kV. Primary magnification x163,600. The bar represents 100 nm.

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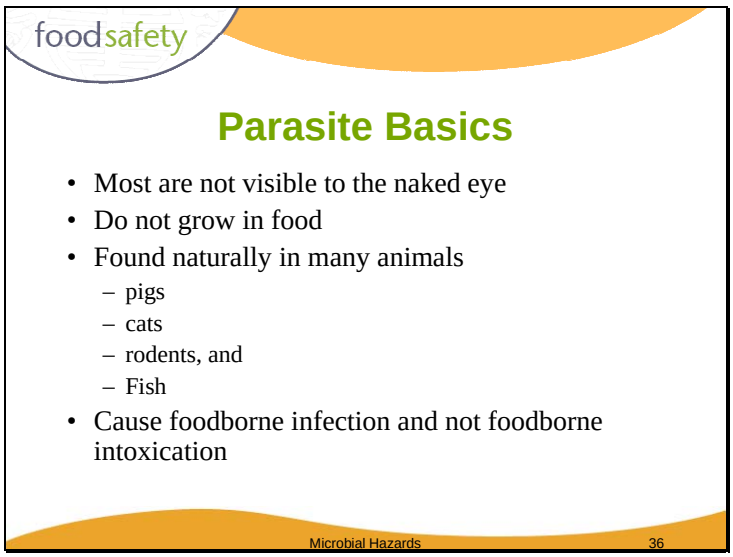

In many food safety education programs, the term "parasite" actually refers to protozoa. Protozoa are unicellular and microscopic. They are notable for their ability to move independently. Most protozoal species are aerobic, but some anaerobic species have been found in the human intestine and animal rumen.

Protozoa are located in most moist habitats. Free-living species inhabit freshwater and marine environments, and terrestrial species inhabit decaying organic matter. Some species are "parasites" of plants and animals.

Protozoa vary substantially in size and shape. Smaller species may be the size of fungal cells; large species may be visible to the unaided eye. Many protozoa alternate between a free-living vegetative form known as a trophozoite and a resting form called a cyst. The protozoal cyst is somewhat similar to the bacterial spore, because it resists harsh conditions in the environment. Many protozoal parasites are taken into the body in the cyst form.

Protozoa that are associated with foodborne illness include: *Trichinella spiralis*, *Cryptosporodium* spp., *Cyclospora* spp, *Giardia lamblia*, and *Anisakis*, etc. For more information about these protozoa go to the *FDA Bad Bug Book* available at: www.cfsan.fda.gov/~mow/intro.html

There are two ways that parasites are commonly transmitted to humans via food. (1) Some parasites are present in human fecal matter and so may contaminate drinking water, foods handled by infected persons, or vegetables and fruits grown on soils fertilized with infectious feces. (2) The infectious form of the parasite may develop in the tissues of a food animal, such as cattle, swine, or fish, and the infect humans who eat the meat.

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Cooking foods to minimum safe endpoint cooking temperatures destroys all foodborne parasites. Freezing will also kill some parasites in food. For example, to destroy parasites in fish that is to be served raw, the fish can be:
frozen and stored at a temperature of –4 degrees F (-20 degrees C) or colder for 168 (7 days) or
frozen at –31 degrees F (-35 degrees C) or colder until solid and stored at –31 degrees F (-35 degrees C) for 15 hours.
If the fish are tuna of the species *Thunnus alalunga, Thunnus albacares* (Yellowfin tuna), *Thunnus atlanticus, Thunnus maccoyii* (Bluefin tuna, Southern), *Thunnus obesus (Bigeye tuna),* or *Thunnus thynnus* (Bluefin tuna, Northern), the fish may be served in a raw, raw-marinated, or partially cooked form without being frozen first. Certain types of tuna not susceptible to parasites so exempt from the freezing that applies to other fish species to be eaten raw. Species that normally have parasites do not have the same parasite hazard when raised on pelleted food in an aquaculture operation. Only heat treated feed or feed otherwise produced in a manner that would kill parasite intermediate stages should be used.

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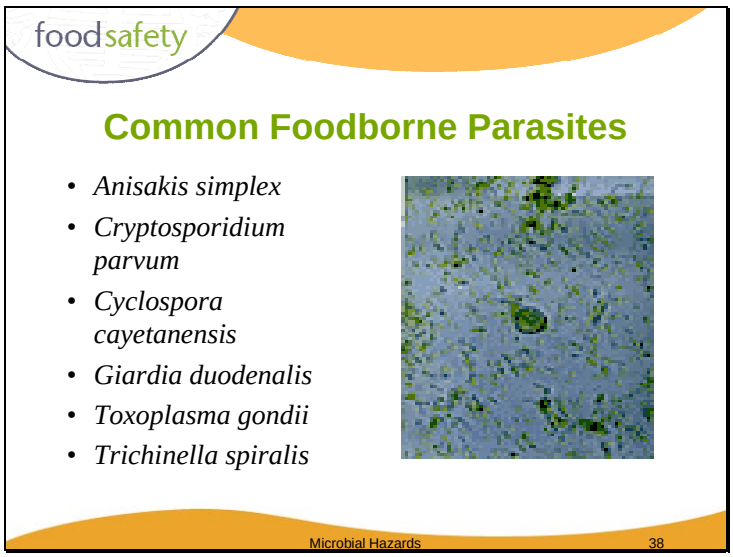

ANISAKIS SIMPLEX
Anisakiasis is a type of illness caused by eating the parasite *Anisakis simplex*.

Nature of Disease: In North America, anisakiasis is most frequently diagnosed when the affected individual feels a tingling or tickling sensation in the throat and coughs up or manually extracts a nematode. In more severe cases there is acute abdominal pain, much like acute appendicitis accompanied by a nauseous feeling. Symptoms occur from as little as an hour to about 2 weeks after consumption of raw or undercooked seafood. One nematode is the usual number recovered from a patient. With their anterior ends, these larval nematodes from fish or shellfish usually burrow into the wall of the digestive tract to the level of the muscularis mucosae (occasionally they penetrate the intestinal wall completely and are found in the body cavity). They produce a substance that attracts eosinophils and other host white blood cells to the area. The infiltrating host cells form a granuloma in the tissues surrounding the penetrated worm. In the digestive tract lumen, the worm can detach and reattach to other sites on the wall. Anisakids rarely reach full maturity in humans and usually are eliminated spontaneously from the digestive tract lumen within 3 weeks of infection. Penetrated worms that die in the tissues are eventually removed by the host's phagocytic cells.

Associated Foods: Seafoods are the principal sources of human infections with these larval worms. The adults of *A. simplex* are found in the stomachs of whales and dolphins. Fertilized eggs from the female parasite pass out of the host with the host's feces. In seawater, the eggs embryonate, developing into larvae that hatch in sea water. These larvae are infective to copepods (minute crustaceans related to shrimp) and other small invertebrates. The larvae grow in the invertebrate and become infective for the next host, a fish or larger invertebrate host such as a squid. The larvae may penetrate through the digestive tract into the muscle of the second host. Some evidence exists that the nematode larvae move from the viscera to the flesh if the fish hosts are not gutted promptly after catching. The life cycles of all the other anisakid genera implicated in human infections are similar. These parasites are known to occur frequently in the flesh of cod, haddock, fluke, pacific salmon, herring, flounder, and monkfish.

Relative Frequency of Disease: Fewer than 10 cases are diagnosed in the U.S. annually. However, it is suspected that many other cases go undetected. The disease is transmitted by raw, undercooked or insufficiently frozen fish and shellfish, and its incidence is expected to increase with the increasing popularity of sushi and sashimi bars.

Course of Disease and Complications: Severe cases of anisakiasis are extremely painful and require surgical intervention. Physical removal of the nematode(s) from the lesion is the only known method of reducing the pain and eliminating the cause (other than waiting for the worms to die). The symptoms apparently persist after the worm dies since some lesions are found upon surgical removal that contain only nematode remnants. Stenosis (a narrowing and stiffening) of the pyloric sphincter was reported in a case in which exploratory laparotomy had revealed a worm that was not removed.

Target Populations: The target population consists of consumers of raw or underprocessed seafood.

CRYPTOSPORIDIUM PARVUM

Intestinal cryptosporidiosis is characterized by severe watery diarrhea but may, alternatively, be asymptomatic. Pulmonary and tracheal cryptosporidiosis in humans is associated with coughing and frequently a low-grade fever; these symptoms are often accompanied by severe intestinal distress. Infectious dose--Less than 10 organisms and, presumably, one organism can initiate an infection. The mechanism of disease is not known; however, the intracellular stages of the parasite can cause severe tissue alteration.

Associated Foods: *Cryptosporidium* sp. could occur, theoretically, on any food touched by a contaminated food handler. Incidence is higher in child day care centers that serve food. Fertilizing salad vegetables with manure is another possible source of human infection. Large outbreaks are associated with contaminated water supplies.

Relative Frequency of Disease: Direct human surveys indicate a prevalence of about 2% of the population in North America. Serological surveys indicate that 80% of the population has had cryptosporidiosis. The extent of illness associated with reactive sera is not known. Summary of Notifiable Diseases, United States, 1997:MMWR 46(54) **Reported cases of Cryptosporidiosis, United States 1997**

Course of Disease and Complications: Intestinal cryptosporidiosis is self-limiting in most healthy individuals, with watery diarrhea lasting 2-4 days. In some outbreaks at day care centers, diarrhea has lasted 1 to 4 weeks. To date, there is no known effective drug for the treatment of cryptosporidiosis. Immunodeficient individuals, especially AIDS patients, may have the disease for life, with the severe watery diarrhea contributing to death. Invasion of the pulmonary system may also be fatal.

Target Populations: In animals, the young show the most severe symptoms. For the most part, pulmonary infections are confined to those who are immunodeficient. However, an infant with a presumably normal immune system had tracheal cryptosporidiosis (although a concurrent viremia may have accounted for lowered resistance). Child day care centers, with a large susceptible population, frequently report outbreaks.

CYCLOSPORA CAYETANENSIS

A single-cell parasite that causes cylclosporiasis, a diarrheal illness.

Associated Foods. Fresh produce or water that was contaminated with human stool.

Nature of the Illness. The incubation period is generally one week. The symptoms include diarrhea, loss of appetite, sybstantial loss of weight, bloating, increased gas, stomach cramps, nausea, vomiting, muscle aches, low-grade fever, and fatigue. The illness lasts from a few days to a month or longer.

GIARDIA DUODENALIS

Organisms that appear identical to those that cause human illness have been isolated from domestic animals (dogs and cats) and wild animals (beavers and bears). A related but morphologically distinct organism infects rodents, although rodents may be infected with human isolates in the laboratory. Human giardiasis may involve diarrhea within 1 week of ingestion of the cyst, which is the environmental survival form and

infective stage of the organism. Normally illness lasts for 1 to 2 weeks, but there are cases of chronic infections lasting months to years. Chronic cases, both those with defined immune deficiencies and those without, are difficult to treat.

The disease mechanism is unknown, with some investigators reporting that the organism produces a toxin while others are unable to confirm its existence. The organism has been demonstrated inside host cells in the duodenum, but most investigators think this is such an infrequent occurrence that it is not responsible for disease symptoms. Mechanical obstruction of the absorptive surface of the intestine has been proposed as a possible pathogenic mechanism, as has a synergistic relationship with some of the intestinal flora. Infectious Dose - Ingestion of one or more cysts may cause disease, as contrasted to most bacterial illnesses where hundreds to thousands of organisms must be consumed to produce illness.

Associated Foods: Giardiasis is most frequently associated with the consumption of contaminated water. Five outbreaks have been traced to food contamination by infected or infested food handlers, and the possibility of infections from contaminated vegetables that are eaten raw cannot be excluded. Cool moist conditions favor the survival of the organism.

Frequency of Disease: Giardiasis is more prevalent in children than in adults, possibly because many individuals seem to have a lasting immunity after infection. This organism is implicated in 25% of the cases of gastrointestinal disease and may be present asymptomatically. The overall incidence of infection in the United States is estimated at 2% of the population. This disease afflicts many homosexual men, both HIV-positive and HIV-negative individuals. This is presumed to be due to sexual transmission. The disease is also common in child day care centers, especially those in which diapering is done.

Course of Disease and Complications: About 40% of those who are diagnosed with giardiasis demonstrate disaccharide intolerance during detectable infection and up to 6 months after the infection can no longer be detected. Lactose (i.e., milk sugar) intolerance is most frequently observed. Some individuals (less than 4%) remain symptomatic more than 2 weeks; chronic infections lead to a malabsorption syndrome and severe weight loss. Chronic cases of giardiasis in immunodeficient and normal individuals are frequently refractile to drug treatment. Flagyl is normally quite effective in terminating infections. In some immune deficient individuals, giardiasis may contribute to a shortening of the life span.

Target Populations: Giardiasis occurs throughout the population, although the prevalence is higher in children than adults. Chronic symptomatic giardiasis is more common in adults than children.

CRYPTOSPORIDIUM PARVUM
Name of Disease: Intestinal, tracheal, or pulmonary cryptosporidiosis

Major Symptoms: Intestinal cryptosporidiosis is characterized by severe watery diarrhea but may, alternatively, be asymptomatic. Pulmonary and tracheal cryptosporidiosis in humans is associated with coughing and frequently a low-grade fever; these symptoms are often accompanied by severe intestinal distress. Infectious dose--Less than 10 organisms and, presumably, one organism can initiate an infection. The mechanism of disease is not known; however, the intracellular stages of the parasite can cause severe tissue alteration.

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Complications: Intestinal cryptosporidiosis is self-limiting in most healthy individuals, with watery diarrhea lasting 2-4 days. In some outbreaks at day care centers, diarrhea has lasted 1 to 4 weeks. To date, there is no known effective drug for the treatment of cryptosporidiosis. Immunodeficient individuals, especially AIDS patients, may have the disease for life, with the severe watery diarrhea contributing to death. Invasion of the pulmonary system may also be fatal.

Target Population: In animals, the young show the most severe symptoms. For the most part, pulmonary infections are confined to those who are immunodeficient. However, an infant with a presumably normal immune system had tracheal cryptosporidiosis (although a concurrent viremia may have accounted for lowered resistance). Child day care centers, with a large susceptible population, frequently report outbreaks.

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The images shown in this series are from a stool specimen from a man with acute watery diarrhea, in whom infection with *Cyclospora cayetanensis* was suspected. This organism's 8-to10-µm cyst is best detected by using a modified acid-fast stain (Fig. 1), while the internal structure can often be seen in a formalin-fixed, iodine-stained concentrate (Fig. 2). Occasionally, the clear wrinkled negative image of the organism (Fig. 3, arrow) is detectable on routine trichrome staining of polyvinyl alcohol-fixed stool sample.

This organism had been seen occasionally in stools of patients with watery diarrhea and was recognized first as a cause of human illness in 1977. For many years, it was thought to be a cyanobacterium-like organism or blue green alga. By 1993, it was reported to be a protozoal parasite.

The oocyst is resistant to chlorine and, in order to be infective, it exits the human host in feces and sporulates in the environment. This may take several days. Transmission occurs only where sewage treatment is poor or "night soil" is used as a fertilizer.

In 1996, over 1,000 cases of *Cyclospora* infection were reported in the United States and Canada between May and July. Epidemiological tracing soon found that these cases were associated with consumption of raspberries imported from Guatemala.

Daniel G. Colley, from the Centers for Disease Control and Prevention in Atlanta, Ga., reported (Emerging Infectious Disease, 1996, vol. 2, no. 4) that the *Cyclospora* outbreaks raised issues concerning the management of the emerging problem of widespread multistate and international food-borne outbreaks of both infectious and toxic nature. Such outbreaks are increasing and can be expected to worsen as the world moves toward a global food economy. What contaminates a particular food item on a farm, in a herd or crop, at a processing shed, or from a handler can now cause widely distributed outbreaks, continents away, in a day.

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Molds are microscopic fungi that live on plant or animal matter. No one knows how many species of fungi exist, but estimates range from tens of thousands to perhaps 300,000 or more. Most are filamentous (threadlike) organisms and produce spores. These spores can be transported by air, water, or insects.

Unlike bacteria that are single-celled, molds are made up of many cells and can sometimes be seen with the naked eye. Under a microscope, they look like thin mushrooms. In many molds, the body consists of root threads that invade the food it lives on; a stalk rising above the food; and spores that form at the ends of the stalks. The spores give mold the color that you see. When airborne the spores spread the mold from place to place. Molds also have branches and roots that are like very thin threads. The roots may be difficult to see when the mold is growing on food and may be very deep in the food.

Some molds cause allergic reactions and respiratory problems. And a few molds, in the right conditions, produce mycotoxins, poisonous substances that can make you sick. Mycotoxins are produced by certain molds found primarily in grain and nut crops, but are also known to be on celery, grape juice, apples, and other produce. Alfa toxin, probably the best-known and most intensively researched mycotoxin in the world, is an example of a mycotoxin. It is produced by certain fungi in or on foods and feeds, especially in field corn and peanuts.

However, not all molds are harmful. Some molds are used to make certain kinds of cheeses and can be on the surface of cheese or be developed internally. Blue veined cheese such as Roquefort, blue, Gorgonzola, and Stilton are created by the introduction of *P. roqueforti* or *Penicillium roqueforti* spores. Cheeses, such as Brie and Camembert, have white surface molds. Other cheeses have both an internal and a surface mold. The molds used to manufacturer these cheeses are safe to eat.

Molds are found in virtually every environment and can be detected, both indoors and outdoors, year round. Mold growth is encouraged by warm and humid conditions. Outdoors, they can be found in shady, damp areas, or places where leaves or other vegetation are decomposing. Indoors, they can be found where humidity levels are high.

Molds forms spores which, when dry, float through the air and find suitable conditions where they can start the growth cycle again. While most molds prefer warmer temperatures, they can grow at refrigerator temperatures. Molds also tolerate salt and sugar better than most other spoilage microorganisms. Therefore, molds can grow in refrigerated jams and jelly and on cured, salty meats, such as ham, bacon, salami, and bologna.

SOURCE: U.S. Department of Agriculture. 2002. Molds on Food: Are They Dangerous. Available at: www.fsis.usda.gov/oa/pubs/molds.pdf

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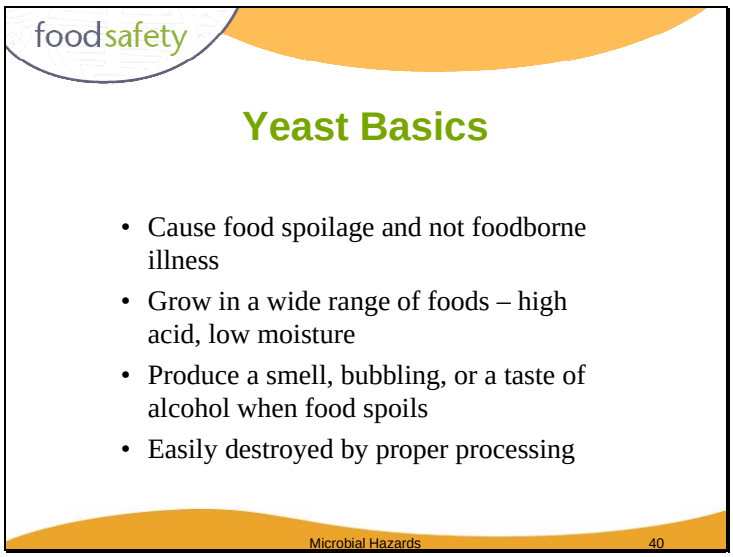

Yeast are a type of fungi. Fungi include several thousand species of yeast, mold, and mushrooms. They are single-celled organisms that are usually larger than bacteria. Individually, yeast are invisible to the naked eye, but large masses can be easily seen. Yeast come in a variety of forms and shapes; they can be spherical, oval, lemon-shaped, pear-shaped, cylindrical or triangular. The size and shape of the 350 known types of yeast are used to classify them into groups for identification. Yeast are commonly found on plants, grains, fruits, and other foods containing sugar. They are present in soil, in the air, on the skin and in the intestines of animals and in some insects. They are transferred from place to place by carriers (people, equipment, food) and air currents. Yeast are the most important and widely used microorganism in the food industry. Although they were first observed by early scientists in the 1600's, they have been used for centuries to ferment fruit juices, leaven bread, and make foods palatable and nutritious.

Types of Yeast
Although some yeast are known to cause disease in plants, animals, and man and others can cause spoilage of foods, yeast are primarily beneficial to the food industry.

Beneficial Yeast
Yeast fermentations are involved in the manufacture of foods such as bread, beer, wine, liquor, surface ripened cheese, soy sauce, vitamins, and enzymes.

Alcohol Fermentation. The best known and one of the most important uses of yeast is the production of ethyl alcohol from carbohydrates (sugar or starch). This fermentation process is used in the manufacture of beer, wine, liquor, (rum, scotch, bourbon, gin) bread, chemicals, and many other products.

Baking. The use of yeast as a leavening (rising) agent in baking dates back to early civilizations. Today, selected yeast are mixed with bread dough and are allowed to grow and ferment. This fermentation produces carbon dioxide, which is responsible for the leavening of the dough. The quality of the product depends on the type of yeast; choice of raw materials; and growth conditions (time and temperature of incubation)

Yeast as Food
Several types of yeast have been grown in mass culture and used as a source of food for humans and animals. Because they are easy to grow and have a high nutritive value, yeast have been used to supplement diets and to improve a variety of food products.

Spoilage Yeast
Yeast are undesirable when they cause spoilage of sauerkraut, molasses, meats, fruit juices, honey, beer, syrups, jellies, and wine. Salt tolerant yeast can spoil salted meats, fish and soy sauces; they can also grow in curing brines containing cucumbers and meats.

Pathogenic Yeast
The great majority of yeast are beneficial to man, but some yeast are capable of causing disease in humans and plants. Yeast infections in humans usually affect the skin, nails and mucous membranes.

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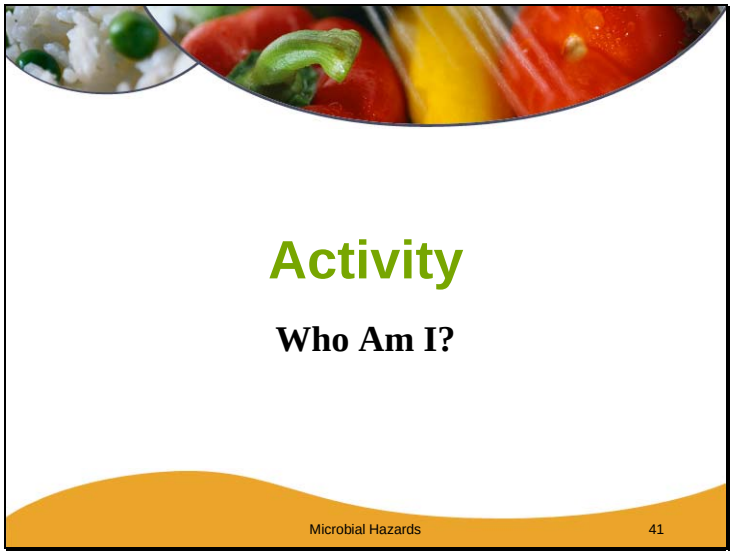

ACTIVITY INSTRUCTIONS: Have the participants identify the group(s) of microorganisms most likely to make the food unsafe or the situation that is shown unsafe to eat.

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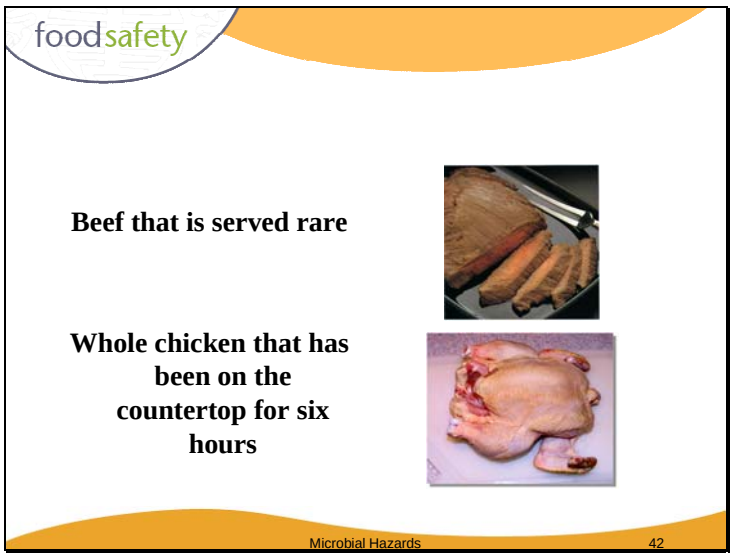

Hamburger that is served rare – bacteria, specifically *E. coli* 0157:H7, will not be adequately destroyed if the hamburger is not cooked to at least 155 degrees F for 15 seconds.
Whole chicken that has been on the countertop for six hours – pathogenic bacteria, such as *Salmonella* and *Campylobacteria*, can grow when a food is in the temperature danger zone for more than four hours.

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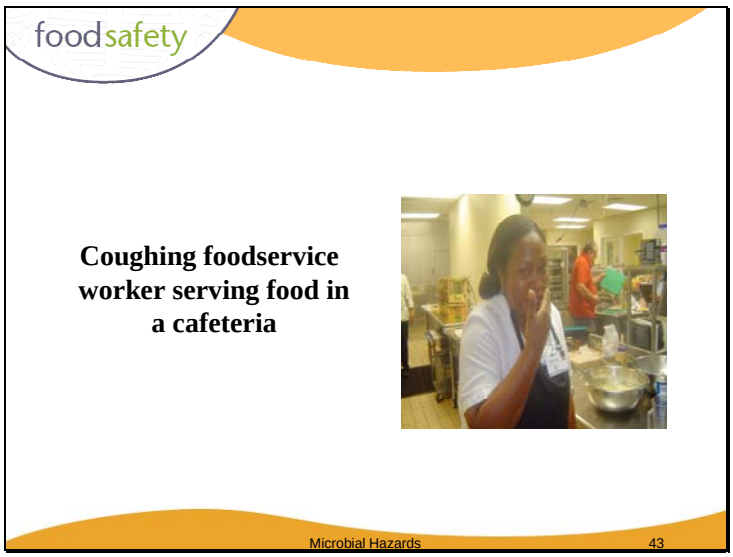

Coughing foodservice worker serving food in a cafeteria -- Viruses. For about 67% of reported foodborne illness outbreaks the cause is unknown. Experts believe that based on the symptoms of these unknown cases, that they are due to viruses.

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Uncooked pork – Parasites, specifically *Trichinella spiralis*
Raw fish – parasites, specifically *Anisakis simplex*

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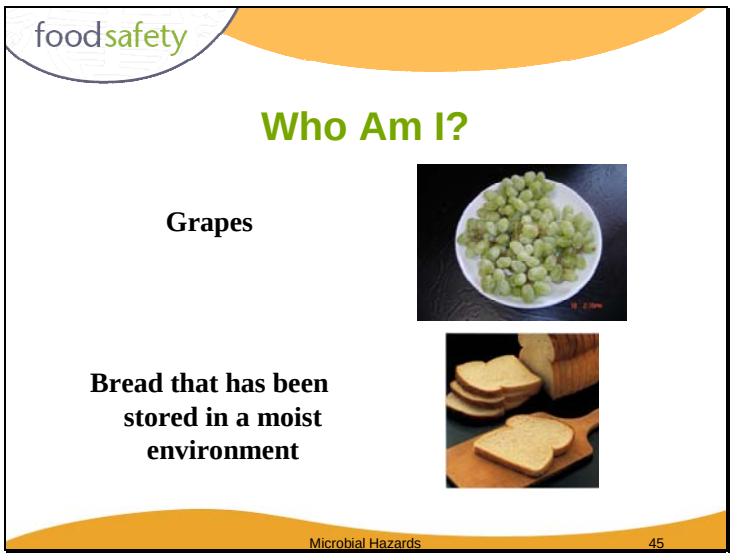

Grapes – Mold
Bread -- Mold

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Apple Juice -- Yeast
Jam -- Mold