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# UNIT 8 IMPORTANT MICROORGANISMS IN FOOD

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## 8.0 OBJECTIVES

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After reading this unit, you will be able to:

- enumerate different types of microorganisms that frequently spoil the food, especially meat and meat products; and
- identify different types and causes of food poisoning, the food products involved, symptoms and ways to avoid it.

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## 8.1 INTRODUCTION

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Let us study to know about the microorganisms. As the name indicates these are small living forms of life, which we cannot see with the naked eye. Microorganisms are the most ubiquitous in nature. Six major groups of microorganisms are generally recognized, namely bacteria, fungi, virus, algae, protozoa and rickettsia. Some people often confuse and almost always misunderstand, their functions, but they are just as real and alive as you are. They eat, grow, reproduce and die.

Have you ever wondered just how small microorganisms really are? Molds can be seen with only slight magnification by the use of an ordinary magnifying glass. Yeasts must be viewed through a microscope that magnifies several hundred times. Bacteria can best be seen when studied with a more powerful microscope that enlarges 1,000 times. Bacteria, yeasts and molds can be found everywhere. Scientists have gathered them from clouds above mountain tops and in the deepest parts of the ocean. They are present on animals, human beings and even in the air we breathe. Microorganisms have a direct impact on our daily lives. Some

are helpful. They aid our bodily processes by helping break down complex foods into simpler substances. Some, called germs, are harmful to us by the role they play in causing diseases.

## 8.2 TYPES OF MICROORGANISMS IN FOOD

The numbers and types of microorganisms present in a food or food products are influenced by the following conditions :

- General environment from where the food was originally obtained
- Microbiological quality of the food in its raw or unprocessed state
- Sanitary conditions under which the product is handled and processed
- Adequacy of subsequent packaging, handling and storage conditions.

### 8.2.1 Bacteria in Food

Bacteria make up the largest group of microorganisms and therefore, we will deal the same in details. People often think of them only as germs and the harm they do. Actually, only a small number of bacterial genera are pathogenic (disease causing). Most are harmless and many are beneficial. The bacteria and fungi are most important in relation to food. The most important genera of bacteria known to occur in foods are listed below in alphabetical order:

Acetobacter, Acinetobacter, Aeromonas, Alcaligenes, Alteromonas, Bacillus, Brochothrix, Campylobacter, Citrobacter, Clostridium, Corynebacterium, Entereobacter, Erwinia, Escherichia, Flavobacterium, Lactobacillus, Leuconostoc, Micrococcus, Moraxella, Pediococcus, Proteus, Pseudomonas, Salmonella, Serratia, Shigella, Staphylococcus, Streptococcus, Vibrio and Yersinia.

Some of these are highly desirable in certain foods, while others bring about spoilage or cause food poisoning or gastroenteritis in humans. One-third of bacteria causing food poisoning belongs to the family *Enterobacteriaceae*.

### Shapes and Arrangement of Bacteria

There are thousands of different kinds of bacteria. Some differ only slightly and it takes a highly trained person and a number of biochemical tests to identify them. There are also groups, which differ greatly in growth habits and appearance (morphology), and are quite easily identified. But regardless of minor differences, most bacteria can be classified into five basic cell shapes namely cocci (round-shaped), rods (elongated) spirochete (spiral), vibrio (comma-shaped) and filamento bacteria (branched) (*Fig. 8.1*). In addition to their different shapes, their cell arrangement also varies. For example, some round-shaped bacteria (cocci) are always grouped in pairs (diplococci), some in chains (streptococci) and some in the form of bunch of grapes (staphylococci), these have been illustrated in *Fig. 8.2*. Diplococci are the kind that causes pneumonia. Streptococci are often associated with 'sore throat'. Staphylococci are familiar to many because of their role in infections causing 'pus formation' and some types of 'food poisoning'. Bacteria also vary somewhat in size, but average about 1/25,000 inch. In other words, 25,000 bacteria laid side by side would occupy only one inch of space. One cubic inch is big enough to hold nine trillion average size bacteria.

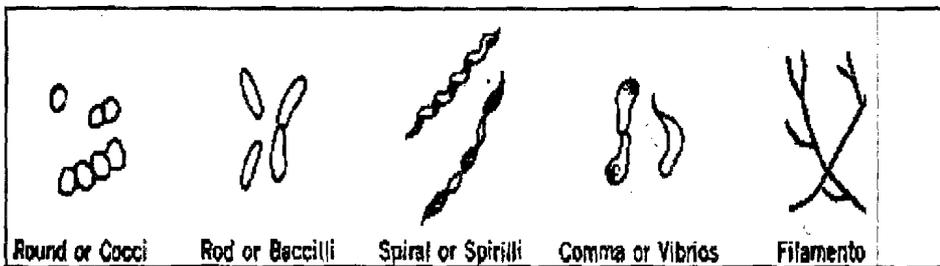


Fig. 8.1: Bacterial Cell Shapes

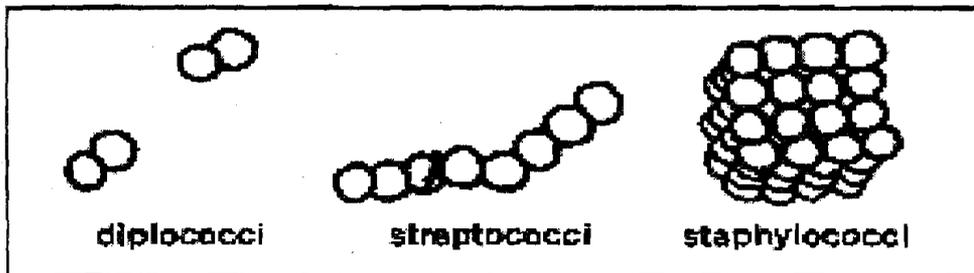


Fig. 8.2: Bacterial Cell Arrangements

### The replication of bacteria

Bacteria reproduce by a process called 'binary fission', one cell divides and becomes two (Fig. 8.3). Some can reproduce at a very rapid rate under proper conditions. If food and moisture are adequate and the temperature is right, certain bacteria can reproduce within as little as 20 minutes. Within 20 minutes, one cell becomes two and in 40 minutes, there will be four, and so on. In only eight hours, the original cell will have multiplied to nearly 17 million new bacteria. Of course, conditions don't remain favourable for such a rate of reproduction for long. If they did, we could be buried in bacterial cells.

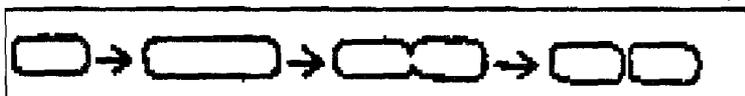


Fig. 8.3: Binary Fission

We must use a microscope capable of magnifying 500 times in order to see a single bacterial cell. However, if that cell is allowed to grow on suitable food or solid media, it will reproduce rapidly into a colony consisting of millions of cells. The colony is visible to the naked eye. Plate counting, a technique which makes it possible to determine the number of bacteria (colonies of bacteria grown from single cells) in a food sample without the aid of a microscope. An important thing to consider in the growth of bacteria is the ability of certain types to produce spores. A 'spore' is a dormant or resting state of a bacterial cell (Fig. 8.4). There are certain basic differences between the spores and the active or vegetative bacterial cells. The spores develop inside vegetative cells at the central, subterminal or terminal (at pole) positions with or without bulging of the cells (Fig. 8.4). Generally, these spores are formed only when environmental conditions are unfavorable for growth. Subsequently, these may be released in the environment as free cells. Spores are not easily killed. In fact, conditions that will quickly kill active bacteria have little or no effect on spores. A temperature of 72°C (pasteurization temperature) will kill bacterial cells within minutes, but bacterial spores can resist this temperature indefinitely. This is important to us since in all processing times for canned foods are calculated by using both the time and temperature required to kill bacterial spores. Bacterial genera producing spores are *Clostridium* and *Bacillus*.



Fig. 8.4: Bacterial Spores

### Environmental and nutritive requirements of bacteria

We know that the availability of oxygen is essential for survival of human beings and animals. However, in case of bacteria, the requirement of oxygen for growth varies greatly. Accordingly, bacteria may be placed into one of the three groups. The 'aerobic' bacteria thrive in the presence of oxygen and require it for their continued growth and existence. Other bacteria are 'anaerobic' and cannot tolerate gaseous oxygen, such as those bacteria that live in deep underwater sediments or some of those which cause bacterial food poisoning such as botulism. The third group is of 'facultative anaerobes', which prefer growing in the presence of oxygen, but can continue to grow without it.

Bacteria may also be classified on the basis of source of energy. There are two categories: 'heterotrophs' and 'autotrophs'. The 'heterotrophs' derive energy from the breakdown of complex organic compounds available from the environment. It includes 'saprobic or saprophytic' bacteria found in decaying material, as well as those that rely on fermentation or respiration. The other group is called 'autotrophs', which fix carbon-dioxide to make their own food source. They may be fueled by light energy (photoautotrophic) or by oxidation of nitrogen, sulfur, or other elements (chemoautotrophic).

### Viewing of bacteria

Bacteria under microscope can be viewed in a smear (a film) prepared directly from a little amount of food item or a bacterial colony grown on an artificial media. The bacterial cells can be viewed easily under microscope once the smear is stained with special colouring reagents called stains. The most commonly used stain is the Gram's stain. On staining the smear with Gram's stains, the circular forms (cocci) or elongated shapes (rods) of bacteria which take pink/red colour are called as Gram-negative bacteria, while the blue/violet coloured as Gram-positive bacteria.

### Classification of bacteria

Depending upon their staining characteristics and shapes, bacteria have been classified into different broad groups (families), specific groups (genus) and closely related members within the groups (species).

#### A) Gram-positive bacteria

##### i) Cocci

The family *Micrococcaceae* includes two genera (singular-genus) of significance i.e., *Micrococcus* and *Staphylococcus*. Representative of both the genera can be isolated from wide range of foods, of these the micrococci are principally spoilers of salted foods. Members of the family *Streptococcaceae* are facultative anaerobes

and form non-motile cocci that occur typically in chains or tetrads depending upon the method of cell division. Three genera, *Streptococcus*, *Leuconostoc* and *Pediococcus* are involved in food spoilage and the foods involved include bacon, vacuum-packed meats and milk.

**ii) Endospore forming rods**

The genus *Bacillus* consists of species that are aerobic and facultatively anaerobic. *Bacillus* species are very commonly isolated from both raw and cooked foods.

**iii) Asporogenous rods**

*Lactobacillus* is the remaining genus comprising 'lactic acid bacteria'. Lactobacilli are non-motile rods that often occur in chains and they are anaerobic or microaerophilic (require small amounts of oxygen for growth). They cause spoilage of variety of foods, but like streptococci, they are used as starter organisms in the food industry.

**B) Gram-negative bacteria**

**i) Spiral and curved bacteria:** Only one genus, *Campylobacter* is significant in foods, being important cause of food poisoning.

**ii) Aerobic rods and cocci:** Most important genus in this group is *Pseudomonas*. Many species of this genus grow at low temperature causing food spoilage. Several species produce insoluble yellow, orange or blue pigments but these are not important in foods.

The genera *Acetobacter* and *Alcaligenes* occur particularly in dairy products and eggs causing spoilage problems while, genus *Brucella* cause food-borne illness in man either by contact with animals or typically, by consumption of unpasteurized milk.

**iii) Facultative anaerobic rods:** These Gram-negative, rod-shaped bacteria grow either under aerobic or anaerobic conditions. Two distinct families are recognized. The first, Enterobacteriaceae, contains eight genera of interest, namely, *Escherichia*, *Salmonella*, *Shigella*, *Enterobacter*, *Serratia*, *Proteus*, *Yersinia* and *Erwinia*. The second family, Vibrionaceae, contains only two genera of interest, *Vibrio* and *Aeromonas*.

All organisms in the family Enterobacteriaceae are either motile with peritrichous flagella or non-motile. There is only one species *E. coli*, in the genus *Escherichia*. It is important as an indicator of faecal pollution but many strains can cause food poisoning.

The members of genus *Salmonella* in the form of more than 2500 different serotypes are very important cause of food poisoning. The members of *Shigella* species are fairly related to salmonellae except that the former are non-motile and the latter are predominantly motile. Both genera are primarily associated with man and vertebrates, and *Shigella* organisms are again pathogenic to man causing food-borne infections.

*Yersinia* species is of no great significance in foods, but one species *Y. enterocolitica*, is now recognized as a cause of food poisoning in man. The remaining genera, *Serratia*, *Proteus* and *Erwinia*, are sometimes implicated in food spoilage. Only one species, *S. marcescens*, is included in *Serratia* and it is characteristically pigmented bright red. *Proteus* species are important in the spoilage of eggs and raw meats held at ambient temperatures whilest *Erwinia* species are involved in the spoilage of vegetables.

Family Vibrionaceae contains species that are typically motile with polar (at one end of the cell) flagella. *Vibrio* species is important in food since different strains cause food poisoning, food-borne infections and food spoilage while *Aeromonas* are sometimes involved in food spoilage as well as an important fish pathogen.

Genus *Flavobacterium* comprises of yellow-pigmented species that are regularly found on fresh meats and fish. However, their growth tends to be overgrown by other bacteria during spoilage of these foods. It has been implicated in the spoilage of milk and milk products.

### 8.2.2 Yeasts in Food

The yeasts are unicellular fungi that do not form a mycelium (filamentous branching growth) and therefore, exist as single cell. Yeast cells may be rounded (or) egg-shaped or elongated, the shape being relatively constant for a given species. Fungi differ from other plants in that they have no chlorophyll.

Bacteria thrive on many different types of food. But most yeasts can live only on sugars and starches. From these, they produce carbon-dioxide and alcohol. Thus, they have been useful to man for centuries in the production of certain foods and beverages. They are responsible for the rising of bread dough and the fermentation of wines, whisky, brandy and beer. They also play the initial role in the production of vinegar.

#### The most common genera of yeasts encountered in and on foods are:

*Brettanomyces*, *Candida*, *Debaryomyces*, *Endomycopsis*, *Hansenula*, *Kloeckera*, *Kluyveromyces*, *Mycoderma*, *Rhodotorula*, *Saccharomyces*, *Saccharomycopsis*, *Torulopsis* (*Torula*), *Schizosaccharomyces*, *Trichosporon*.

Some yeasts are psychophilic and so they can grow at relatively low temperatures. In fact, the fermentation of wines and beer is often carried out at temperatures near 40°F. Because some kinds are psychophiles, they can create a spoilage problem in meat coolers and other refrigerated storage areas.

Unlike bacteria, which multiply by binary fission, yeasts reproduce by a method called 'budding'. A small knob or bud forms on the parent cell, grows and finally separates to become a new yeast cell (*Fig. 8.5*). Although this is the most common method of reproduction, yeasts also multiply by the formation of spores.



Fig. 8.5: Budding of Yeast

Because yeasts can grow under conditions of high salt or sugar content, they can cause the spoilage of certain foods in which bacteria would not grow. Examples are honey, jellies, maple syrup and sweetened condensed milk. Foods produced by the bacterial fermentation process, such as pickles and sauerkraut, can also be spoiled by yeasts which interfere with the normal fermentative process. Certain yeasts are pathogenic, however yeast infections are much less common than bacterial infections.

### 8.2.3 Molds in Food

The term mold is used to describe 'multicellular' fungi, which forms a filamentous branching growth known as a mycelium. The mycelium is composed of individual filaments called 'hyphae'.

Probably the best-known microorganisms, molds are widely distributed in nature and grow under a variety of conditions in which air and moisture are present. They are also plants and a part of the fungi family. Nearly everyone has seen mold growth on damp clothing and old shoes. So, many may find it hard to believe that mold is a microorganism. However, the mold we see with the naked eye is actually a colony of millions of mold cells growing together. Molds vary in appearance. Some are fluffy and filament-like, others are moist and glossy and still others are slimy.

Some of the most common genera of molds associated with foods are listed below:

*Alternaria*, *Aspergillus*, *Botryti*, *Byssochlamys*, *Cephalosporium*, *Cladosporium*, *Collecotrichum*, *Fusarium*, *Geotrichum*, *Helminthosporium*, *Monilia* (*Neurospora*), *Mucor*, *Penicillium*, *Rhizopus*, *Sporotrichum*, *Thamnidium*, *Trichothecium*.

Unlike bacteria, molds are made up of more than one cell. Vegetative cells sustain the organism by taking in food substances for energy and the production of new cell material. Reproductive cells produce small "seed" cells called 'spores'. Unlike bacterial spores, mold spores are the source of new mold organisms.

Molds produce a stem consisting of several cells. Together, these cells form a "fruiting body". The fruiting body produces the spores, which detach and are carried by air currents and get deposited to start new mold colonies whenever conditions are favourable (*Fig. 8.6*). Mold spores are quite abundant in the air. So, any food allowed to stand in the open soon becomes contaminated with mold if adequate moisture is present. Some types of molds are also psychrophiles and can cause spoilage of refrigerated foods.

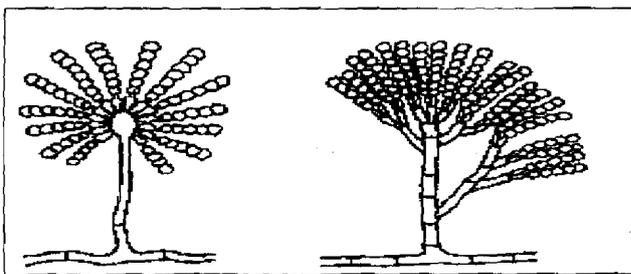


Fig. 8.6: Mold Fruiting Body

Molds are important to the food industry. Among their many contributions, the important ones are the flavour and colour they add to cheeses and the making of soy sauce. They also play a role in the making such chemicals such as citric and lactic acids and many enzymes. Probably the best known use of molds is in the drug industry, where they help produce antibiotics such as penicillin. Molds can also cause problems in food products. Certain kinds of molds can produce toxins in food, which are called as 'mycotoxins'. The presence of mycotoxins in food has recently assumed greater importance because of the growing awareness among consumers about their harmful effects on consumption of moldy food.

## 8.2.4 Viruses in Food

A virus is the smallest infectious particle that can only be seen by an electron microscope but not by an ordinary microscope used for viewing bacteria, yeast and fungi. Bacteria and fungi have genetic material in the form of deoxyribonucleic acid (DNA) as well as ribonucleic acid (RNA), whereas, a virus possess either DNA or RNA. That's why, unlike bacteria and fungi, the viruses neither can multiply at their own in foods or in a culture media nor can produce toxins. As such, the food items merely act as vehicles for their transfer. Some of the viruses causing jaundice can potentially be transmitted through food like Hepatitis A virus, and through water such as Hepatitis E virus. All such viruses that are known to be transmissible through food and remain cause of concern to human health, originate from the human or animal intestine, and ultimately reach the food or water through faecal contamination. There has been speculation that more than 50 per cent of the outbreaks of unknown etiology are due to viruses. It is estimated that more than 100 different viruses are excreted in the faeces of human being.

Foodborne viruses can be classified into two main categories on the basis of their origin. They are: (a) Those which reach food and water through environmental sources. The viruses originate in most cases from the intestinal tract of humans, and the contamination of food occurs during its production, processing, storage and transportation. As such, the contamination of food is of secondary nature (b) Those which occur in food on account of carrier or diseased status of food animals themselves. This results in what is usually referred to as primary contamination of food. Most foodborne viruses are transmitted through man-to-man cycle and infection normally takes a faecal-oral route. Among various enteric viruses, the major causes of gastroenteritis in man are hepatitis A, hepatitis E and rota viruses.

There are many documented incidences in which international trade in products derived from the animal resulted in the introduction of animal diseases like FMD (Foot and Mouth Disease) into the animal population of those countries that were free from this disease. The outbreak of Bovine spongiform encephalopathy (BSE), a slow neurodegenerative viral disease caused by infectious protein particles (prions) in United Kingdom in the year 1988-89, has led to a historic devastating economic impact due to mass slaughter of infected cattle and public health outcry on account of human deaths. The disease resulted from feeding the offals (particularly the bone and meat meal and brain) derived from infected cattle to cattle and sheep.

## 8.2.5 Parasites in Food

'Parasites' are organisms that derive nourishment and protection from other living organisms known as 'hosts'. Parasites are of different types and range in size from tiny, single-celled, microscopic organisms (protozoa) to larger, multi-cellular worms (helminths) that may be seen without a microscope.

Parasites may be transmitted from animals to humans, from humans to humans, or from humans to animals. Several parasites have emerged as significant causes of foodborne and waterborne disease. These organisms live and reproduce within the tissues and organs of infected human and animal hosts, and are often excreted in faeces. It is difficult to pinpoint the precise mode of transfer of the infective agent to the host. Contamination may occur from hand to food or directly from

polluted water. As well, if an animal was infected, the parasite may be present deep in the meat, for example trichinosis, cysticercosis. People may become infected if they eat undercooked meat or fish, if they drink untreated water or use it in food preparation or if uncooked foods (salads) are contaminated by a food handler. The illnesses they can cause range from mild discomfort to debilitating illness and possibly death. Some parasites that are commonly transmitted through food and water include *Giardia duodenalis*, *Cryptosporidium parvum*, *Cyclospora cayetanensis*, *Sarcocystis*, *Toxoplasma gondii*, *Trichinella spiralis*, *Taenia saginata* (beef tapeworm) and *Taenia solium* (pork tapeworm).

### Check Your Progress 1

- 1) Six major groups of microorganisms are ....., ....., ....., ....., ....., and .....
- 2) Raw as well as cooked foods are frequently spoiled by a bacterial species called .....
- 3) The unicellular form of the fungi is known as.....
- 4) Bacteria reproduce by a process called.....
- 5) A dormant or resting and highly resistant state of a bacterium is known as .....
- 6) Bacteria multiply by binary fission, whereas, yeasts by a method called .....
- 7) The term mold refers to multicellular .....that form a filamentous branching growth called ....., which is composed of individual filaments called .....
- 8) Most foodborne viruses are transmitted through ..... route.
- 9) Among various enteric viruses, the major causes of gastroenteritis in man are.....

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## 8.3 FOODBORNE ILLNESSES

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Food may carry organisms as such or their toxic metabolites (poisons) called 'toxins', to the sensitive consumers. The ingestion of viable bacteria along with the food leads to their lodgment and establishment in consumer's organs. This is termed as 'food infection'. On the other hand, ingestion of toxins already synthesized by bacteria or fungi in the food (i.e., preformed toxins) brings about poisoning syndromes in the consumers, is called as 'food intoxication' and the toxins affecting the gastrointestinal tract are called 'enterotoxins'. There are yet other types of organisms which can infect intestine when ingested along with the foods and produce toxins *in situ* (at the site itself) to bring about the symptoms of poisoning. This situation is called 'toxi-infection'. These three categories are better covered by popular terms as 'foodborne infections and intoxications' (or) 'foodborne illnesses' or 'food poisoning'. Therefore, it becomes evident that foodborne illnesses result from eating food contaminated with bacteria, the poisons bacterias produced, by viruses, parasites, or chemicals in the food. The common symptoms of food poisoning include diarrhoea, vomiting, fever, malaise,

headache, nausea and dizziness. However, these symptoms may vary according to the individual and the organism responsible for the foodborne illnesses. These foodborne illnesses can be classified into three categories:

- 1) Foodborne Infections
- 2) Foodborne Intoxications
- 3) Toxin-mediated Infections.

### 8.3.1 Foodborne Infections

Disease-causing microorganisms when eaten along with a food, may lead to the infection which is manifested in the form of food poisoning with fever, known as food borne infection. Food infection occurs when food contains a large number of living harmful bacteria which grow in the human intestinal tract. Symptoms usually occur between 4 to 48 hours after ingestion of food and may last for two to four days (even death occurs). Common symptoms are stomach upset with violent diarrhoea, cramps, fever, nausea and vomiting (*Fig 8.7*).

### 8.3.2 Foodborne Intoxications

When living microorganisms multiplies in or on a food and produces a 'chemical waste/toxin' or if the food containing toxin is eaten, it leads to food borne intoxication. Ingestion of such 'preformed' toxins present in food usually causes tissue damage in the intestinal tract, while some may affect the nervous system (*Fig 8.7*). The symptoms (violent nausea and vomiting, headache, dizziness and cramps, usually without fever), may vary in their nature but they are usually severe and occur quickly than food infection (One to eight hours after eating). The illness could be one or a combination of these symptoms that may last for several days, and could be fatal in some cases.

### 8.3.3 Toxin-mediated Infection

It is a combination of infection and intoxication, caused when a living microorganism is consumed with food. The organism inside the human body produces a toxin that causes the illness. It is different from intoxication since the toxin is produced inside the human body but not in the food (*Fig 8.7*).

***The different ways to prevent foodborne illnesses are:***

- 1) The World Health Organization's Golden Rules for Safe Food Preparation:
  - Keep and serve hot foods as hot and cold foods as cold
  - Cook the foods thoroughly
  - Eat cooked foods immediately
  - Store cooked foods carefully
  - Reheat cooked foods thoroughly
  - Avoid contact between raw and cooked foods
  - Wash hands repeatedly
  - Keep all kitchen surfaces meticulously clean
  - Protect foods from insects, rodents, and other animals
  - Use pure water.
- 2) Train the food handlers.
- 3) Create quality consciousness among food industry workers, managers and consumers.
- 4) Involvement of veterinarian in quality control of foods of animal origin.

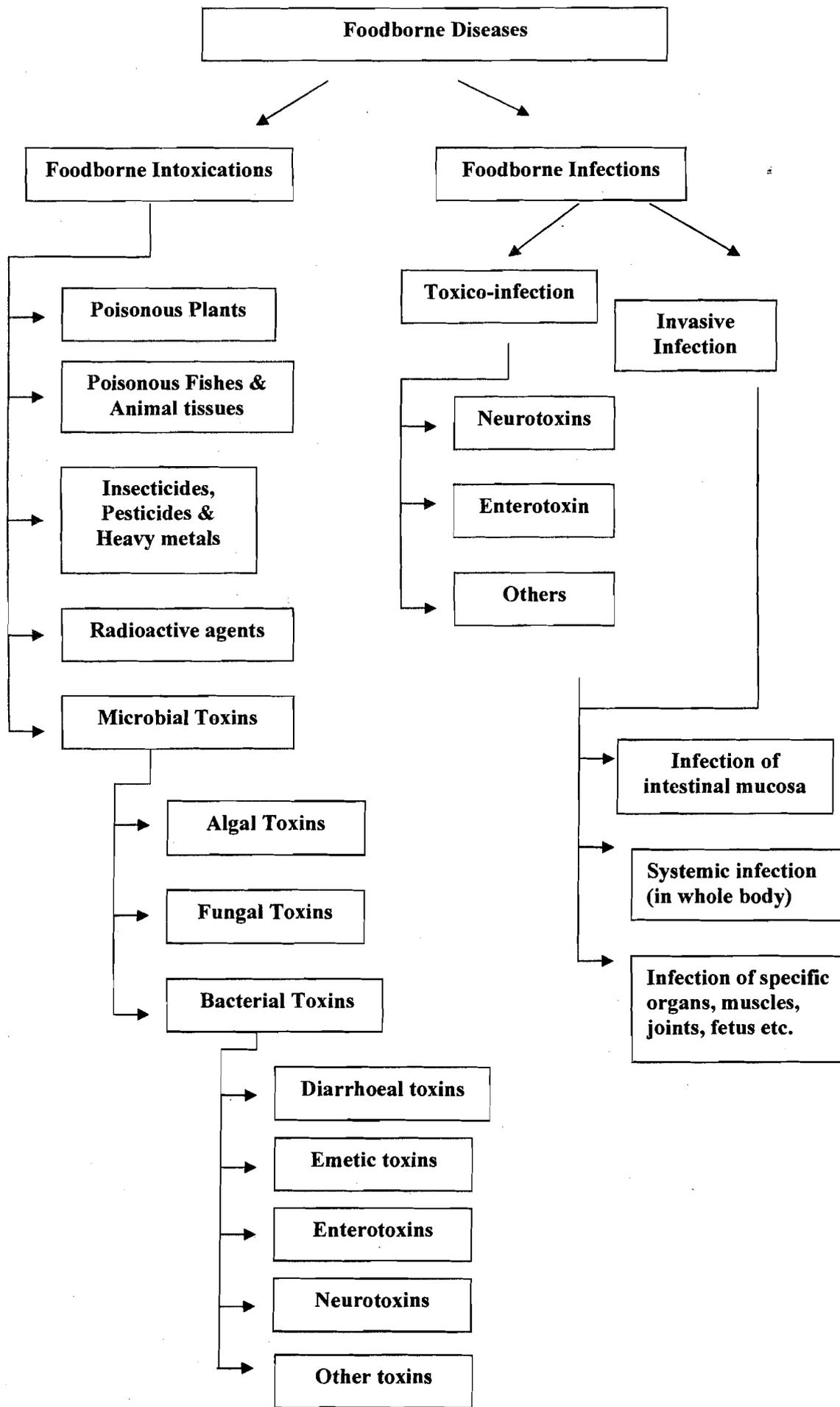


Fig. 8.7: Classification of Food borne Diseases

### 8.3.4 Important Foodborne Diseases

There are a large number of diseases which are caused by various microorganisms. Only the important foodborne diseases are discussed in the following table in special reference to their causative agent, symptoms, food source and method of their prevention.

**Table 8.1: Important Foodborne Diseases: Symptoms, Food involved and Prevention**

Causative agent and type of illness	Symptoms & onset time	Common foods	Prevention
<i>Staphylococcus aureus</i> Strains - A, B, C1, C2, C3, D and E (Bacterial Intoxication)	Nausea, vomiting, abdominal cramps, headache, may be fever (2 - 6 hrs)	Foods that are prepared with human contact (carrier), cooked or processed foods	Wash hands and practice good personal hygiene. Cooking will not inactivate the toxin
<i>Clostridium perfringens</i> (spore forming) (Bacterial Toxin-mediated infection)	Intense abdominal pain and severe diarrhoea, no vomiting, no fever (8-22 days)	Soil contaminated foods, spices, gravy, improperly cooled foods (especially meats and gravy)	Properly cook, cool, and reheat foods
<i>Clostridium botulinum</i> (spore forming) Strains- A, B, C, D, E and F (Bacterial Intoxication)	Vertigo, double vision, difficulty in breathing and swallowing, headache (12-36 hrs), fatal if not treated	Improperly canned foods, vacuum packed refrigerated foods; cooked foods in anaerobic mass, soil contaminated foods	Properly heat processed and anaerobically packed foods, do not use home canned foods in food services
<i>Mycotoxins</i> (Aflatoxin, Patulin, Ochratoxin A, Luteoskyrin, Roquefortine etc.) (Intoxication)	<u>Acute onset</u> -hemorrhage, fluid buildup, possible death. <u>Chronic</u> -cancer from small doses over time	Moldy grains-corn, corn products, peanuts, pecans, walnuts, and milk	Purchase food from a reputable supplier; keep grains and nuts dry; and protect from humidity
<i>Cryptosporidium parvum</i> (Parasitic Infection- protozoa)	Severe watery diarrhea within 1 week of ingestion, low grade fever, severe intestinal distress	Contaminated water; food contaminated by infected food handlers	Use potable water supply; practice good personal hygiene and hand washing
<i>Giardia lamblia</i> (Parasitic Infection- protozoa)	Diarrhoea within 1 week of contact, abdominal cramps, fatty stool Beaver fever or Back packer's disease	Drinking contaminated water, cyst formed foods	Potable water supply; good personal hygiene and hand washing, filtration to remove cyst
<i>Toxoplasma gondii</i> (Parasitic infection- protozoa)	Fever, headache, rash, can be transmitted from mother to unborn during pregnancy, stillbirth, blindness	Ingestion of raw or insufficiently cooked meats containing tissue/ cysts	Cooking of meat at recommended temperatures, keep out of the danger zone, wash hands and foods

Causative agent and type of illness	Symptoms & onset time	Common foods	Prevention
<i>Trichinella spiralis</i> (Parasitic infection from a Nematode worm)	Nausea, vomiting, diarrhoea, sweating, muscle soreness (2-28 days)	Primarily undercooked pork products and wild game meats (bear, walrus)	Cooking of foods
<i>Entamoeba histolytica</i> ( <i>Amoebiasis</i> ) (Parasitic infection)	Diarrhoea of varying severity, amoebic dysentery (several days to 4 weeks, fatalities not uncommon)	Water contaminated with sewage, moist food contaminated with human faeces	Protect water supplies, cleanliness in food preparation, ensure proper disposal of human excreta
<i>Taenia saginata</i> (parasitic infection-beef tapeworm)	Abdominal pain, hungry feeling, vague, discomfort (incubation period-several weeks)	Raw or insufficiently cooked beef containing live larvae	Use meat processed under veterinary inspection, cook beef thoroughly, avoid eating raw smoked beef
<i>Taenia solium</i> (parasitic infection-pork tapeworm)	Varies from a mild, chronic digestive disorder to severe malaise with encephalitis, may be fatal	Raw or insufficiently cooked pork containing live larvae	Use meat processed under veterinary inspection, cook pork thoroughly
<i>Diphyllobothrium latum</i> (Parasitic infection- fish tapeworm)	Usually none, anaemia in heavy infection (3-6 weeks)	Raw or insufficiently cooked fish containing live larvae	Cook fish thoroughly, avoid eating raw or smoked fish
Rotavirus (Viral Infection)	Diarrhoea (especially in infants & children), vomiting, low grade fever; (1-3 days onset; lasts 4-8 days)	Sewage contaminated water; contaminated salad ingredients, raw seafood	Good personal hygiene and hand washing; proper food handling practices
<i>Hepatitis A</i> (Viral Infection)	Fever, nausea, vomiting, abdominal pain, fatigue, swelling of the liver, jaundice (15-50 days)	Foods that are prepared with human contact; contaminated water	Wash hands and practice good personal hygiene; avoid raw seafood
<i>Polio virus types I, II, III</i> (Poliomyelitis) (Viral infection)	Fever, vomiting, headache, pain in muscle groups, paralysis (Incubation period is 5-35 days)	Milk, possibly other beverages and prepared foods, contaminated water	Personal cleanliness, adequate heating of foods, disinfection of water, prevention of contact of flies with foods

**Check Your Progress 2**

- 1) Define foodborne illness.  
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- 2) Classify different food borne illnesses.  
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- 3) Give the three names of microorganisms which are responsible for following type of food poisoning.
  - i) Foodborne Infections.....
  - ii) Foodborne Intoxications .....
  - iii) Toxin-mediated Infections .....
  
- 4) List the golden rules of World Health Organisation for safe food preparation.  
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**8.4 LET US SUM UP**

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Microorganisms are small living forms of life, which we cannot see with the naked eye. These are present on animals, people and even in the air we breathe. Microorganisms have a direct impact on our daily lives. Some are helpful. They aid our bodily processes by helping break down complex foods into simpler substances. Some called germs, are harmful to us by the role they play in causing diseases. The numbers and types of microorganisms present in a food or food products are influenced by various conditions like general environment from where the food was originally obtained, microbiological quality of the food in its raw or unprocessed state, sanitary conditions under which the product is handled and processed, and adequacy of subsequent packaging, handling, and storage conditions.

The bacteria are the most important in relation to food but fungi also have significant role. Some of the bacteria are highly desirable in certain foods, while others bring about spoilage or cause food poisoning in human. The viruses known to be transmissible through foods and related to human health, come from the human or animal intestine. Several parasites have emerged as significant causes of foodborne and waterborne disease. The parasites live and reproduce within the tissues and organs of infected human and animal hosts, and food and water come contaminated with the excreta of the infected human or animals.

The foodborne illnesses result from eating food contaminated with bacteria, the poisons bacteria produce, viruses, parasites, or chemicals in the food. The common symptoms of food poisoning include diarrhoea, vomiting, fever, malaise, headache, nausea and dizziness. However, these symptoms may vary according to the individual and the organism responsible for the foodborne illnesses. These foodborne illness can be classified into three categories, foodborne infections, foodborne intoxications and toxin-mediated infections.

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## 8.5 Key words

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- Microorganisms** : Small living forms of life that cannot be seen with the naked eye.
- Binary fission** : The reproductive process by which a bacterial cell divides into two.
- Aerobic bacteria** : Those bacteria which require oxygen for their growth and existence.
- Anaerobic bacteria** : Those bacteria which grow in the absence of oxygen.
- Facultative anaerobes**: Those microbes which prefer to grow in the presence of oxygen, but can continue to grow without it.
- Heterotrophs** : Microbes that derive their energy by breaking down complex organic compounds present in the environment.
- Saprophytic bacteria** : Those bacteria that are found in decaying material, as well as those that rely on fermentation or respiration.
- Autotrophs** : These bacteria fix the carbon dioxide to make their own food source.
- Budding** : This is the process by which yeasts reproduce or multiply.
- Spore** : The dormant or resting state of a bacterium, which is more resistant.
- Foodborne infection** : Refers to the ingestion of viable bacteria along with the food leading to their lodgment and establishment in consumer's organs.
- Foodborne intoxications** : Refers to food poisoning caused by the ingestion of pre-formed toxins of bacteria or fungi in the food.
- Toxi-infection** : Refers to the food poisoning in which the infective agent ingested along with food produce toxin at the site of infection (intestine).

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## 8.6 SOME USEFUL BOOKS

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Jay M. Jay, (2003). *Modern Food Microbiology*, CBS Publishers & Distributors,

Frazier, W. C. (1995). *Food Microbiology*, McGraw-Hill Publishing Company, 1995.

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## 8.7 ANSWERS TO CHECK YOUR PROGRESS

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### Check Your Progress 1

- 1) bacteria; fungi; viruses; algae; protozoa; rickettsia
- 2) *Bacillus*
- 3) yeasts
- 4) binary fission
- 5) spore
- 6) budding.
- 7) fungi; mycelium; hyphae
- 8) faecal-oral route.
- 9) Hepatitis A; hepatitis E; rota viruses.

### Check Your Progress 2

- 1) Food borne illness is defined as illness caused by consumption of the food contaminated with bacteria or toxins from bacteria, virus, parasite or chemicals.
- 2) Foodborne infection, foodborne intoxication, toxin-mediated infection.
- 3) i) *Listeria, Salmonella, Campylobacter jejuni*  
ii) *Staphylococcus, Clostridium botulinum, Aspergillus flavus.*  
iii) *Bacillus cereus, E.coli, Clostridium perfringens.*
- 4) The golden rules of World Health Organisation for safe food preparation are enlisted below:
  - Keep and serve hot food as hot and cold food as cold.
  - Cook the food thoroughly.
  - Eat cooked food immediately.
  - Store cooked food carefully.
  - Reheat cooked food thoroughly.
  - Avoid contact between raw and cooked food.
  - Wash hands repeatedly.
  - Keep all kitchen surfaces meticulously clean.
  - Protect food items from insects, rodents, and other animals.
  - Use pure water.