UNIT-2 FOOD SAFETY — BASIC CONCEPTS

Structure

2.1 INTRODUCTION

Microorganisms are naturally found in foods since there is no environment where some type of microbes cannot live. It is important for us to understand that microbes can spoil the foods, cause food borne diseases and also some of them are useful as we have already studied in Unit 1. In this unit, we will learn about microorganisms, which are associated with food and are of concern with respect to food safety. In addition to microbes, there are physical and chemical agents which can also affect food safety. We shall also learn about these agents in this unit and focus on the importance of safe food.

Objectives

After studying this unit, you will be able to:

- define food safety and hazards,
- discuss the physical, chemical and biological hazards to food safety, and
- describe microorgnisms associated with food borne hazards.

2.2 FOOD SAFETY AND IMPORTANCE OF SAFE FOOD

Food safety has always been an important issue. The reasons for this are manifold. More than ever before, there is a strong consumer awareness of food quality and safety and this continues to increase. New risks and challenges are emerging as a

result of changes in the methods of food production at the farm and processing levels. Further challenges arise from the emergence and re-emergence of food-borne pathogens. Consumption patterns are changing and consumer demands regarding such issues as the variety and shelf-life of foods, as well as, the preservation techniques used are changing. International trade in food has also increased the risk of infectious agents being disseminated from the original point of production to locations thousands of kilometers away. The consequence of this is that there is an increased risk to human health, as well as, implications for international trade in food. As a result, there has recently been a realization in many countries of the need for an integrated approach to food safety.

Maintaining food safety and quality, you would agree, is essential in the entire chain of food production ranging from:

i) primary food production at the level of farmers

ii) primary food processing at the farm, dairy and abattoir and grain mills

iii) secondary food processing level such as canning, freezing, drying and brewing

iv) food distribution, both at the National and International level of import/export

v) food retailing and food catering, and

vi) domestic food preparation level.

While focusing on food and its safety concerns, an understanding of a few basic terms used in this context i.e. food safety, food quality, hazard and toxicity, is of utmost importance. Let us learn about them. We begin with food safety. Food safety is concerned with acute and chronic hazards that make food injurious to the health of the consumer.

Food safety can be defined in both absolute and relative terms.

- 'Absolute food safety' is the assurance that damage or injury from use of a substance is impossible.

- 'Relative food safety' is the assurance that damage or injury will not result from a food or ingredients used in a reasonable and customary manner and quantity.

An understanding of food safety is improved by defining two other basic concepts – hazard and toxicity. *'Hazard'* is the *relative probability that harm or injury will result when the substance is used in a proposed manner and quantity* while '*toxicity' is the capacity of a substance to produce harm or injury of any kind under any conditions*. Remember, assessment of whether a food or ingredient is safe should not be based on its inherent toxicity but on whether or not a hazard is created.

Next, let us understand what is meant by the term 'food quality'. *Food quality* refers to *the attributes that influence a products value to a consumer*. This includes both negative attributes such as spoilage, contamination, adulteration, food safety hazards and positive attributes such as the origin, colour, flavour, texture etc. Another term which is often used while talking about food safety is 'food hygiene'. *Food hygiene* refers to *all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain.*

After a comprehensive review of the different terms used in the context of food and its safety concerns, we will now focus on the importance of safe food and hazards which are a concern to food safety.

All of you are aware of the constituents of food and the fact that we need food for our survival. You may have also noticed that some of the foods are consumed as such while others require certain processing, before they are ready for consumption. Processing of certain foods develop constituents that might be toxic for human consumption. You might be wondering what these constituents are. The food processes that might lead to the development of potentially hazardous compounds in foods, or those that affect its nutritive value include use of agricultural and environmental chemicals, drugs, synthetic ingredients and fertilizers. The safety of foods, therefore, is of utmost significance and has gained a worldwide attention.

There are certain specific food safety concerns that differ markedly and include issues such as additives, drug residues, pesticides, irradiation, fertilizers and other growing aids, microbiological contamination, food toxicants, adulteration, misbranding etc. During recent years, newer challenges such as globalization of trade in food, urbanization, changes in life style, international travel and environmental pollution, all have further contributed to the concern for food safety. The new World Order and global environment for food trade places a considerable obligation on the part of both importing and exporting countries to ensure safety and quality of food.

Apart from all these, one of the major issues that require special focus is the consumer's attitude and knowledge about food safety. It is essential to acquire the know-how and skills necessary to understand and manage food safety hazards. Consumer confidence in the safety and quality of food supply is an important requirement and consumers are demanding protection for the whole food supply chain from the primary producer to the end consumer, often described as *'from farm or pond to the plate approach'*. However, it is interesting to note that most of the consumers are not concerned about microbiological contamination and food safety issues. Many households have unsafe food storage and preparation practices. Consumers rarely consider their own food practices a hazard. However, food industry is most concerned about the microbiological safety of its products and many quality control checks are made to ensure that foods are safe. An elaborate system known as *Hazard Analysis Critical Control Point (HACCP)* is being employed in recent years by many food industries to minimize the chances of contamination during processing. What is HACCP and what is its significance? We will learn about this in Unit 13 later in this course.

It is important to remember that an integrated approach on food safety and quality facilitates improved consumer protection, reduces incidence of food borne diseases, effectively stimulates the agriculture and the food processing industry and promotes domestic and international food trade and improves the economy. Promoting good manufacturing practices, educating food retailers and consumers about appropriate food handling are essential for promoting good nutrition and better health.

The discussion above reviewed the importance of safe food. But, how safe is our food? Do you know what is the biggest threat to food safety? Read the next section and find out.

2.3 FACTORS AFFECTING FOOD SAFETY

There are various factors affecting food safety, the biggest one being 'food hazard'. Food hazards means *biological, chemical or physical agent in a food, or condition of a food, with the potential to cause an adverse health effect.* If you look at the definition carefully, you would realize that food hazards are majorly four types biological, chemical, physical and allergens – as highlighted in Table 2.1 and Figure 2.1.

Table 2.1: Hazards associated with food

Physical	Biological	Chemical		Allergens
		Natural occurring poisons of biological origin	Chemicals or deleterious substances	
Glass Hair Metal Stones Plastic Parts of pests Insulation material Bone Fruit pits	Microbiological Pathogenic Bacteria • Spore-forming • Non spore-forming Parasites and protozoa Viruses	Mycotoxins, Algal toxins	Veterinary residues, Antibiotics Growth stimulants Plasticisers and packaging material Chemical Residues Pesticides Cleaning fluids, Allergens Toxic metals, Lead and cadmium, Food chemicals preservatives, processing aids, polychlorinated biphenyls (PCBs), printing inks, prohibited	Cereals containing gluten; i.e wheat, barely, oats etc. Crustaceans and product of these Eggs and egg products fish and fish products Peanuts,soyabean and products of these; Milk and milk products.

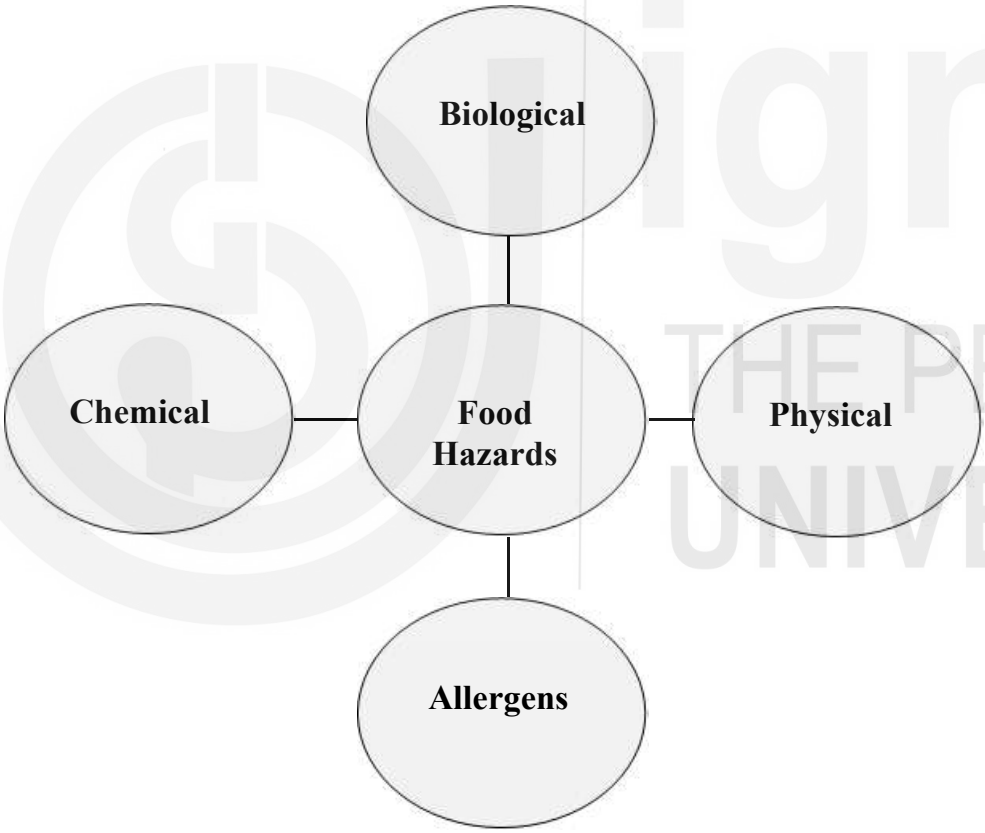

Figure 2.1: Types of Food Hazards

Let us get to know a more about these four hazards.

2.3.1 Physical Hazards

Physical hazards include a variety of materials often referred to as extraneous materials. It may be defined *as any foreign material not normally found in a food, which may cause illness or injury to the individuals consuming/using the product.* They may cause injury, illness and others may never be noticed. Few of visible physical hazards are highlighted in Figure 2.2

Figure 2.2: Examples of physical hazards

Physical hazards, as you would realize, include non-living things in foods, such as stones, inedible stones, hair, glass, metal, wood, plastic, insulation material etc. These materials can become a part of foods from the environment.

Now, how do these get into foods that we eat? Well, there can be many ways. It could be from the environment in which the foods are grown or contamination could occur during processing and packaging e.g. iron fillings from worn out machinery, processing tea. Can you suggest any measure to screen such harmful products?

Yes, the use of electronic metal detector in many food processing operations can help in detecting and screening harmful metallic pieces. Inspite of availability of various mechanisms and technologies to prevent the risks caused due to physical contaminants, foreign / extraneous objects still represent one of the largest categories of complaints by consumers. Hence, it is the job of the government and industry to ensure that these risks are minimal and acceptable.

Let us look at the biological hazards next.

2.3.2 Biological Hazards

Among the biological hazards the major concern is from microorganisms. Few of the microbiological hazards are highlighted in Figure 2.3.

Biological hazards, as you can see in Figure 2.3, include bacterial, fungal, viral and parasitic organisms (protozoa and worms) and/or their toxins. There are many microorganisms, which are pathogenic to humans, but relatively few are associated with foods. These are highlighted in Table 2.2. These microorganisms that cause diseases are termed as *'food-borne pathogens'*. There are three types of food-borne disease from microbial pathogens*: infections, intoxications* and *toxic infections*. We will learn about these food borne diseases later in Unit 5. You would realize that diseases caused by these organisms are sometimes incorrectly called food poisoning.

Infections result from the ingestion of live pathogenic organisms which multiply within the body and produce disease. While intoxications occur when toxins produced by pathogens are ingested. You must remember that intoxications can occur even if no viable microorganisms are ingested. Can you suggest how this is possible? Well, this often occurs when foods are stored under conditions which allow the pathogens to grow and produce toxin. It is interesting to note that subsequent processing of food may destroy the microorganisms but not the toxin. So take care.

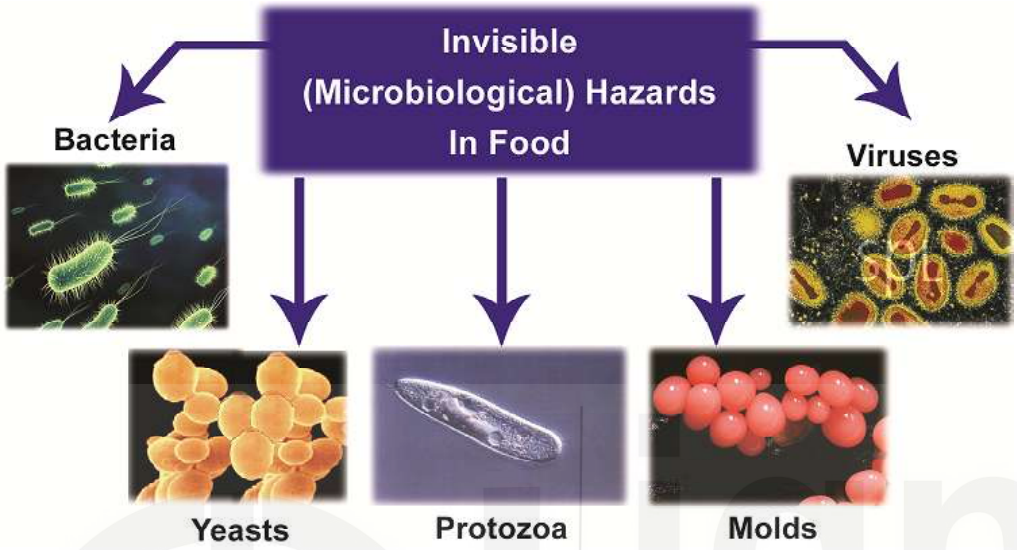

Figure 2.3: Biological hazards in foods

Table 2.2: Hazardous microorganisms and parasites along with their commonly affected foods

S.No	Organisms	Foods Implicated
1.	*Clostridium botulinum* types A, B, E, and F	Meat, fish, low or medium acid canned foods, home canned products
2.	*Salmonella* spp. *(Salmonella typhi: Salmonella paratyphi)*	Eggs, meat and meat products, bakery products, dairy products (esp. ice-cream)
3.	*Shigella* spp.	Shellfish, fruits and vegetables, chicken salad
4.	*Clostridium perfringenes*	Raw meat, poultry and their products
5.	*Staphylococcus aureus*	Custard, cream, bakery foods, poultry, ham, dairy products(especially. khoa)
6.	*Bacillus cereus*	Cereal dishes, puddings, mashed potatoes, sauces, soups
7.	*Vibrio cholerae 01, non-01* *Vibro vulnificus* *Vibrio parahaemolyticus* *Listeria monocytogenes*	Water, potatoes, eggs, asparagus, salads, seafood (shrimps, oysters, clams, crabs, lobsters and related shellfish), finfish, milk and milk products, raw meat and poultry products, fruit and vegetables, salads, seafood
8.	*Enterovirulent Escherichia coli* (EEC)	Cream pie, mashed potatoes, meat, poultry, dairy products like cheese
9.	*Campylobacter jejuni*	Dressed chicken, meat dishes, raw milk, raw poultry
10.	*Yersinia enterocolitica*	Dairy products, egg products, raw meat and poultry, raw vegetables

11.	*Brucella abortis; B suis*	Milk and milk products, raw meat
12.	*Viruses (Hepatitis A and E, Rotavirus, Norwalk virus group)*	Shellfish, raw fruits and vegetables, salads sandwiches, potatoes, lettuce, coleslaw
13.	*Entamoeba histolytica*	Water, raw fruits and vegetables
14.	*Diphyllobothrium latum*	Fish
15.	*Cryptosporidium paruum*	Raw fruits and vegetables, salads
16.	*Giardia lambea*	Water, lettuce, raw fruits and vegetables
17.	*Taenia saginata, Taenia solium*	Meat (beef and pork)
18.	*Trichinella spiralis*	Raw pork, meat products

Having looked at the biological hazards let us get to know the chemical hazards to food safety.

2.3.3 Chemical Hazards

A chemical hazard is *any chemical contaminant introduced in food system which may cause illness or injury to the individuals using the product*. Few of the chemical hazards includes pesticides and residues, veterinary residues, colours, cleaning chemicals, adulterants etc. which are highlighted in Figure 2.4.

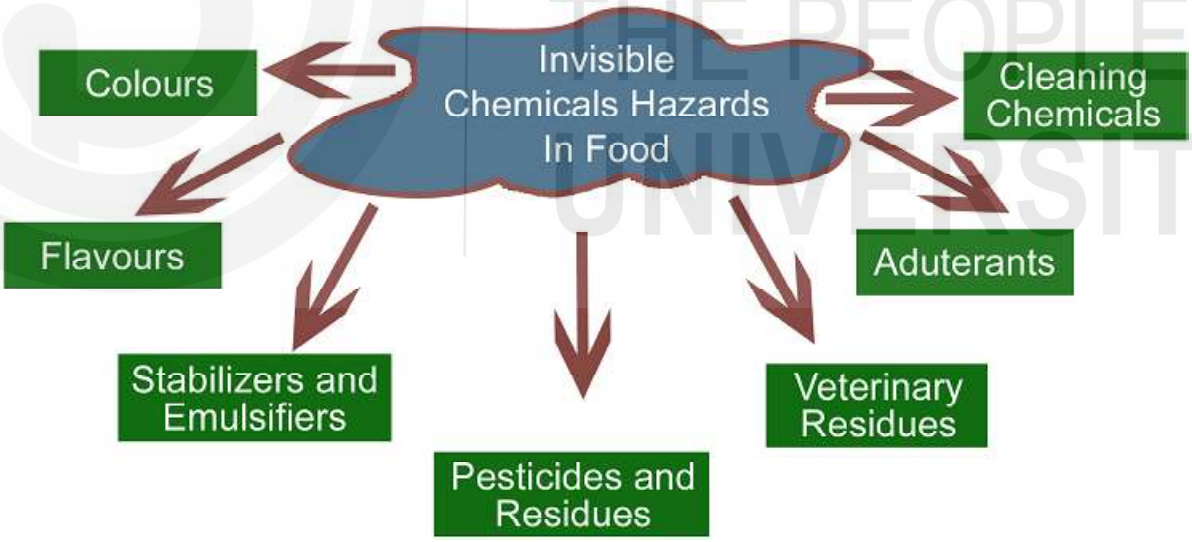

Figure 2.4: Examples of chemical hazards

Chemicals which cause a harmful response when consumed by animals or humans are said to be toxic. How do we know that a particular compound is toxic or not? It might surprise you that almost everything can be considered a toxicant, without regard for the origin of the substance. The factors which determine the toxicity are the dosage or the amount of exposure and potency of the chemical.

Food borne toxicants can be divided into 3 categories as shown in Table 2.3. The examples of the chemicals in each category are also indicated.

Table 2.3: Types of chemical hazards

Food Borne Toxicants		
Naturally Occurring Chemicals	**Unintentional Chemicals**	**Intentional Chemicals**
Found in plants, microorganisms and animals e.g. mycotoxins, histamine, mushroom toxins, shellfish toxins etc.	Lead, Polychlorinated biphenyls (PCBs) and paralysis products etc.	Food additives, pesticides, drugs

A detailed discussion on each of these three chemical food hazards, is presented in Unit 6, later in this course.

Next, let us move on to the fourth food hazard i.e., Allergens.

2.3.4 Allergense

Food allergens have become increasingly important because they can represent a serious health hazard to consumers. What these allergens are? Let us discuss in details. '*An allergens is normally, any harmless substance that cause as immediate allergic reaction in a susceptible person'*. Food allergens are almost always protein although other food constituents, such as certain additives are known to have allergenic (allergy-causing) properties.

These allergens when ingested cause food allergy in human. Do you know, what is food allergy? Basically food allergy is a potentially serious immune response to eating or otherwise coming into contact with certain food additives. Food allergy symptoms include: wheezing or breathing problems, stomach cramps, vomiting, diarrhea, hives, rashes or eczema, whereas, severe allergic reactions can cause death.

A food allergy occurs when the immune system:

- Identifies a particular food protein as danegerous and create antibodies against it.
- The next time the individual eats that food, immune system tries to protect the body against the danger by releasing massive amount of chemicals including Histamine.
- Histamine is a powerful chemical that can cause a reaction in the respiratory system, gasterointestinal tract, skin or cardiovascular system.
- In the most extreme cases, food allergy can be fatal. Although any food can provoke an immune response in allergic individuals, a few foods are responsible for the majority of food allergies.

Which foods and ingredients are known to cause hypersensitivity? Well these include: cereals containing gluten, milk and milk products (lactose containing), fish and their products, peanuts, soyabean etc. Some of allergens are highlighted in Figure 2.5

Figure 2.5: Food Allergens

So we now know that along with physical and chemical hazards the microorganisms present in food are the culprit. We shall briefly discuss the classification, morphology, growth and reproduction of a few important microorganisms in the next section. But for now, let us answer the questions given in the check your progress exercise 1.

Check Your Progress Exercise 1

1) Define the following terms:

   a) Food Safety

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   b) Food Hazards

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2) Differentiate between the terms 'toxicity' and 'hazard'?

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3) What are the common hazards to food safety?

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4) What is a physical hazard? How do harmful products enter food?

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5) How can you classify chemical hazards? Give examples.

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2.4 MICROORGANISMS IN FOODS

We shall now discuss the different types of biological hazards and the important microorganisms that can lead to food borne illnesses and eventually act as a major concern in food safety. In sub-section 2.3.2 we learnt that biological hazards include bacteria, viruses, moulds and fungi. Let us get to know them. We will begin with the most common and important one, i.e. bacteria.

2.4.1 Bacteria

Have you ever looked at the bacteria under the microscope? How do they look like? Yes, they look like the structures presented in Figure 2.6.

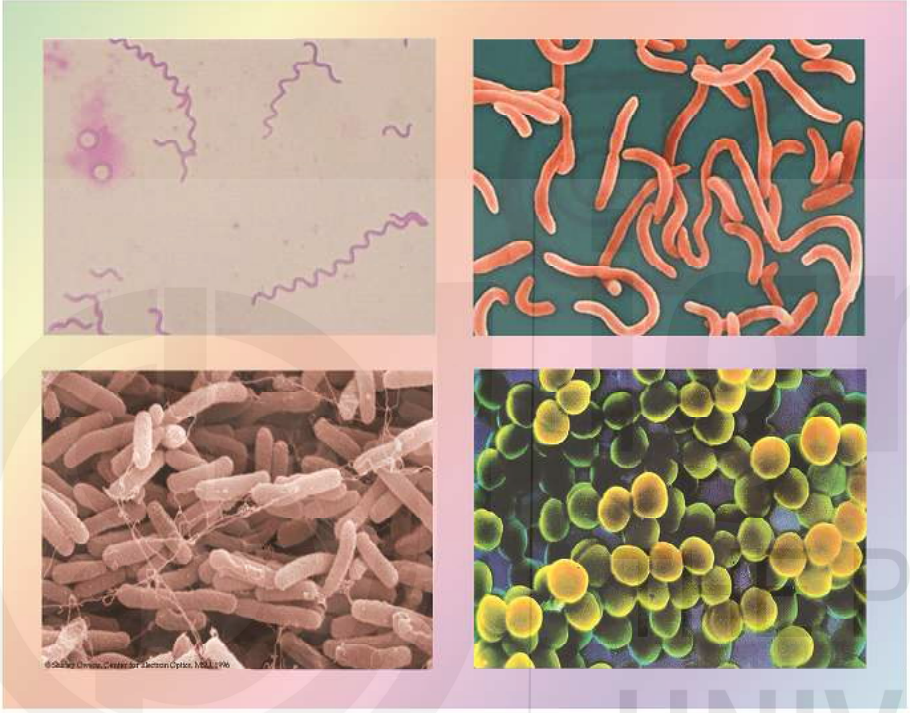

Figure 2.6: The bacteria

Bacteria are the organisms characterized by small size, approximately 0.5 to 2.5 μm in diameter and unicellular in nature. The major characteristics of bacterial cells are their size, shape, structure and arrangements. There are three distinct forms listed herewith and also highlighted in Figure 2.6:

- bacilli (singular, bacillus meaning little)
- cocci (singular coccus meaning berry) or cylindrical or rod-shaped cells; and
- spiral forms, curved rods or spiral cells.

The most common of all the three forms is the bacillus i.e. the rod-shaped bacteria, which is cylindrical and may vary considerably in length and breadth according to the species. The rod-like cells may be straight or slightly curved as can be seen in Figure 2.6. Next, comes the coccus and the least common form is the spiral in which the cell is curved spirally. Although these three forms are well recognized, there are variations of these shapes. The shape of each of the species of bacteria also does not always maintain a definite shape at all times. Some species even exhibit a variety of shapes.

Next, let us look at the arrangement and structure of bacterial cells.

The arrangement of bacterial cells

The bacterial cells are arranged in a characteristic manner according to the species. The cocci exist either singly, or in pairs or in long chains depending upon the manner

in which they divide and then adhere to each other after division, whereas, the bacilli can be seen as a single cell, in pairs or in short or long chains. The length of cocci chains is an identifiable characteristic but in case of bacilli, it is not so.

The spiral bacterial cells sometimes adhere together in S-shaped strands, (vibrios), spirilla (singular, spirillum) are actually like spirals and spirochetes, which are different from spirilla which possesses flexible cell walls.

Next, let us study about the bacterial cell structure.

The bacterial cell structure

A typical bacterial cell is shown in Figure 2.7. Like other living cells, a bacterial cell essentially has an outer wall or a membrane, cytoplasm and nuclear material. The outer part of the bacterial cell is made up of cell wall, cytoplasmic membrane and slime layer. The cell wall gives shape to the cell and it is made up of proteins and complex carbohydrates or polysaccharides, large amounts of fat or lipid may also be present. Apart from giving protection to the cytoplasm, the cell wall also plays a role in cell division. It also regulates the passage of various materials between the external and internal environment. The slime layer is like a jelly which surrounds the bacteria. In some bacteria, the slime becomes very thick and covers the bacteria. It is known as a *capsule*. The slime layer gives some protection to the bacteria against invasion.

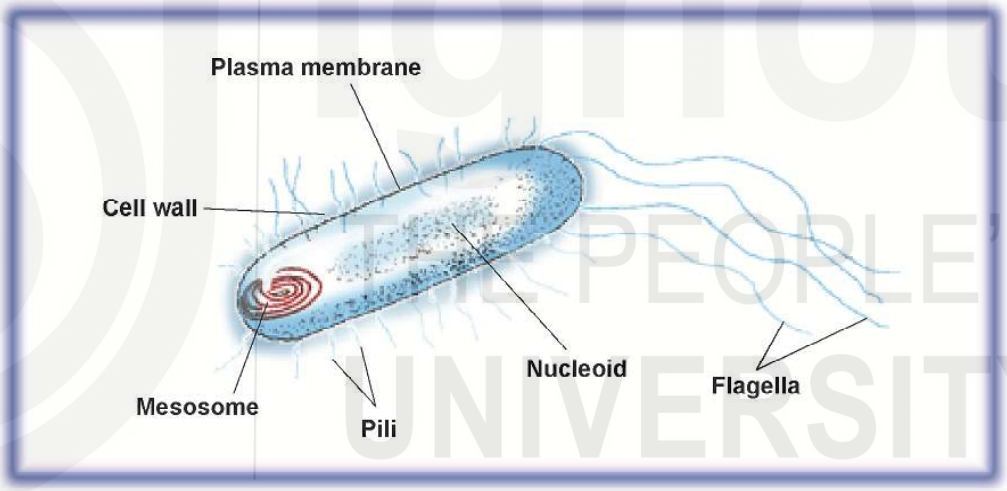

Figure 2.7: The structure of bacterial cell

The cytoplasmic membrane, which is inside the cell wall, initiates the cell division and also controls the entrance of food into cells and clearing the waste products. The cytoplasm is a complex substance containing the nuclear body, which is rich in deoxyribonucleic acid (DNA), ribosomes, which consists of ribonucleic acid (RNA), combined with protein and a fluid portion which contains various dissolved nutrients. The nuclear body is involved in reproduction while ribosomes are involved in protein synthesis.

Many bacteria can swim by the means of small appendages called 'flagella' (flagellum, singular) as illustrated in Figure 2.7. In bacteria, this is the only means of locomotion. They are usually several times the length of the cell body but are extremely thin. The flagella of the motile bacteria are distributed over the surface depending on the bacteria. In some cases, they may be found all over the surface of the cell or they may be restricted to one or both ends.

Having learnt about the structure of the bacteria cell, next we will look at the growth mechanism of bacteria i.e. how does the bacteria multiply?

The growth of bacteria

The growth of bacteria can be defined as *an increase in mass of bacteria per unit volume of medium*. The bacteria divides by *binary fission* i.e. a division of cell produces two new cells, which are assumed to be nearly identical in all relevant properties.

Under favourable conditions of moisture, pH, nutrition and temperature, the growth of bacteria takes place. There are several factors like exhaustion of food supply, accumulation of waste products etc. which can limit the growth of bacteria. The growth of bacteria is generally expressed as a growth curve in which there are four principal stages viz. (1) lag phase, (2) logarithmic or exponential phase, (3) the stationary phase, and (4) the death phase. A few viable cells from a culture incubated in a suitable medium at the optimum temperature generally go through these four phases. Figure 2.8 shows a hypothetical bacterial growth curve, depicting the four phases. The growth/ increase in the number of bacteria is calculated as CFU/ml, i.e. Colony Forming Units or the total number of colonies formed per ml of the medium in which the bacterial cells were originally inoculated.

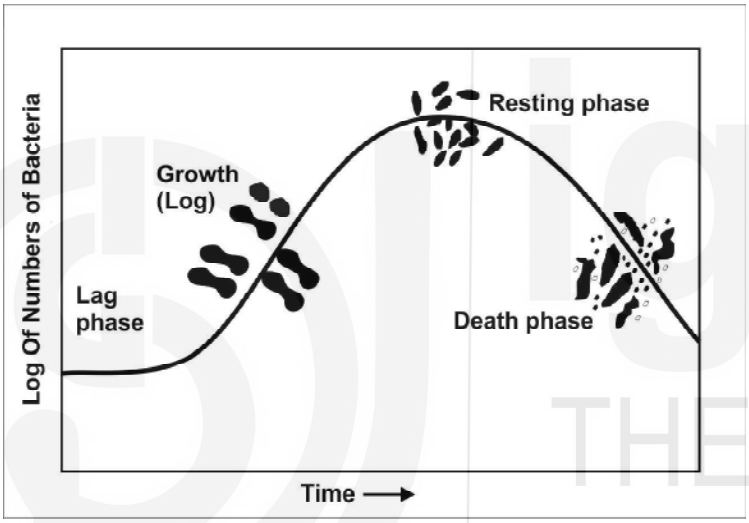

Figure 2.8: Four phases of bacterial growth

Let us discuss these phases in detail.

- *Lag phase:* During the initial *lag phase* i.e. in a period of one to few hours, there may be little or no increase in the cells. But when the growth begins, due to cell division, the cells may proliferate rapidly at regular intervals.
- *Logarithmic (Log phase):* In this phase, the cells multiply logarithmically i.e. one cell dividing to 2 cells and then 2 cells to 4 cells etc. as you can see in the Figure 2.8. The average generation time is mostly constant for a given species under similar conditions.
- *Stationary (resting) phase:* As indicated in Figure 2.8, in this phase, after rapid growth, the cell multiplication gets stagnant due to the exhaustion of nutrients or accumulation of waste products or any other facts. The stationary phase can be maintained for hours or days by the majority of the cells remaining viable without further growth or by balance between the death of some cells and the continued division of others.
- *Decline* or *death phase:* In this phase, the cell death occurs due to build up of toxic waste products, when the medium is not changed, as it has become incapable of supporting further growth.

We have looked at the growth of bacteria above, while on the topic of bacteria, you may have also heard about endospores. What are these? Let us find out next.

The endospore

Some bacteria like *Bacillus* or *Clostridium* produce resting structures known as *endospores*, which are produced within the cell, one spore is formed within a single bacterial cell. These are the highly resistant bodies. The endospore is physiologically dormant and it can resist extremely unfavourable conditions, both physical and chemical, like heat, UV light and chemicals. When conditions are favourable, these spores will germinate and produce fresh vegetative cells. This process of sporulation is a mode of reproduction. Endospores can be quite harmful.

Before moving on to the discussion on other microorganisms, let us quickly review what we have learnt so far.

Check Your Progress Exercise 2

1) Fill in the blanks:

   i) The three distinct forms of bacteria are....., ... and ..... .

   ii) ..... is a resting structure produced within the cell and can resist extremely unfavourable conditions.

   iii) The ingestion of live pathogenic organisms which multiply and produce disease is referred to as .....while ingestion of toxins produced by pathogens is ..... .

   iv) A complex substance containing a nuclear body is ..... .

   v) The only means of locomotion in bacteria is ..... .

2) List the different parts of a bacterial cell. Give the functions of cell wall.

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3) Describe the stages of bacterial growth.

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2.4.2 Fungi

Fungi exhibit a wide range of different forms, which includes moulds, yeasts and mushrooms. The important forms are yeasts, which are unicellular and the moulds, which are filamentous and multi-cellular. Mushrooms in addition to being filamentous and multi-cellular, have a definite fruiting body, which is quite prominent. Let us get to know about these different fungi. We start with yeast.

2.4.3 Yeasts

The yeast cells, in general, are round, egg-shaped, cylindrical or filamentous. The yeast cells are generally much larger than the bacterial cells, which range from 3-5

µm wide by 5-10 µm long and they exist as single cells. The reproductive processes in the case of yeast cells are by the process known as *budding*. Although in certain yeasts, the process is by way of *fission* as in bacteria. The budding process involves the bulging of protoplasm outwardly and as the bulge grows in size, it separates from the parent cell after attaining maturity as illustrated in Figure 2.9.

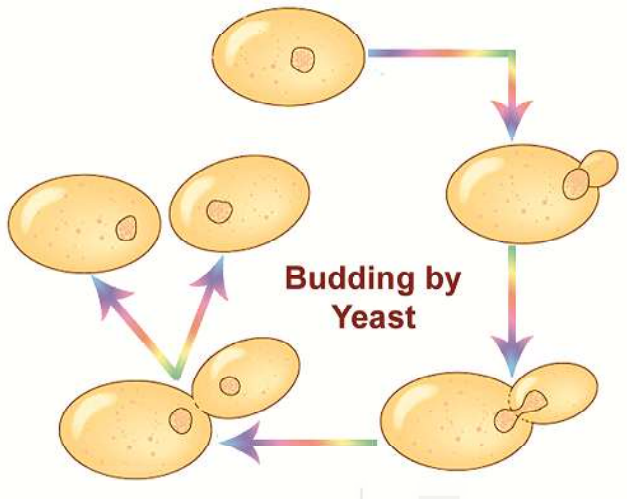

Figure 2.9:The budding process of the yeast

Some types of yeasts reproduce sexually also and are known as 'true yeasts'. In this process, the cells serve as ascus (sac). Here the nucleus undergoes division without the participation of the cell wall forming spores within the ascus. The spores of yeast are also resistant to some adverse conditions but get destroyed at temperatures above 60°C, whereas, the bacterial spores you learnt earlier are quite resistant to higher temperature. Next let us get to know about the moulds.

2.4.4 Moulds

The term mould is used to describe certain multi-cellular fungi consisting of a filamentous branching growth known as a mycelium, which is composed of individual filaments called 'hyphae' (singular, hypha) as illustrated in Figure 2.10. Depending on the location, the aerial mycelium carries fertile hyphae which acts as a reproductive organ while the remainder of the mycelium absorbs food and moisture necessary for growth.

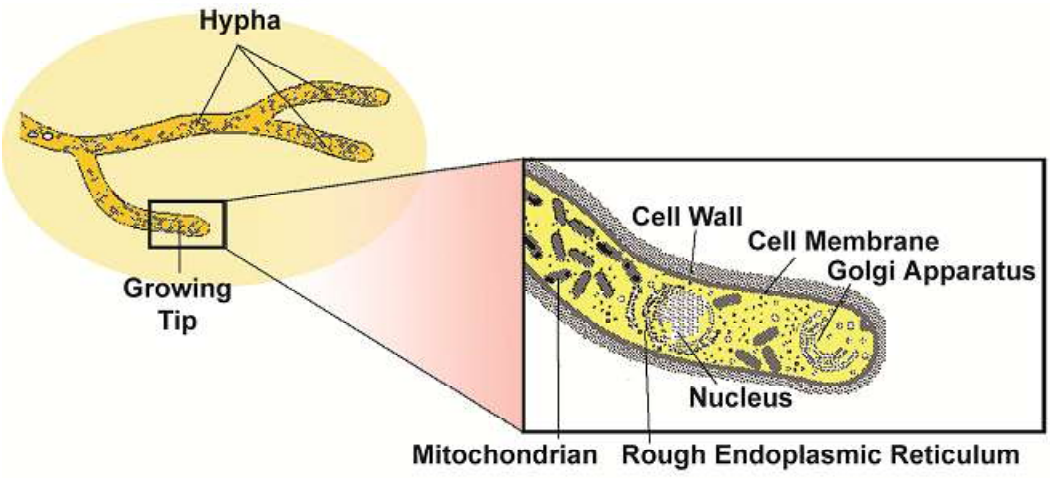

Figure 2.10: The hyphae

In moulds, reproduction is mainly by sexual spores. Based on the manner and type in which the spores are formed, moulds are classified as:

i) Phycomycetes

ii) Ascomycetes

iii) Basidiomycetes

iv) Fungi Imperfecti

Let us discuss each of the class in detail.

i) *Phycomycetes*

The moulds belonging to the group of phycomycetes contain several genera. These moulds produce hyphae, which are not divided into typical uninucleate cells and thus have no cross walls (septa). These non-septate hyphae have nuclei scattered throughout their length. Phycomycetes, which are commonly found on food, are members of the sub-class zygomycetes. The two most commonly found genera of this group are genus *Mucor* and genus *Rhizopus*. These moulds possess hyphae that although apparently alike, are able to conjugate and form a zygospore (sexual spores) as shown in Figure 2.11(a).

Species of *Mucor* genus are present in soil, organic matter, fruits, vegetables, stored grains and other foods. *Mucor* species plays a role in the fermentation of foods and have a commercial value as you may recall reading earlier in Unit 1. They sometimes cause spoilage of foods. Species of *Rhizopus* are commonly associated with the spoilage of stored foods (e.g. spoilage of bread by *R.stolonifer*).

ii) *Ascomycetes*

These moulds have septate hyphae and multiply asexually by separation at the tips of fertile hyphae (conidiophores) to produce spores known as 'conidia', formed either singly, in chains or in irregular clusters on the condiophores. In the ascomycetes, the sexual spores are termed as 'ascopores'. These are formed following the union of two cells from the same mycelium or from two different mycelia. A number of ascospores, usually eight, are subsequently formed within a sac known as 'ascus'. Figure 2.11(b) illustrates the ascus with 3 ascospores. The organisms of importance which belong to this group of genus are *Claviceps, Neurospora, Sclerotina* and *Byssochlamys.*

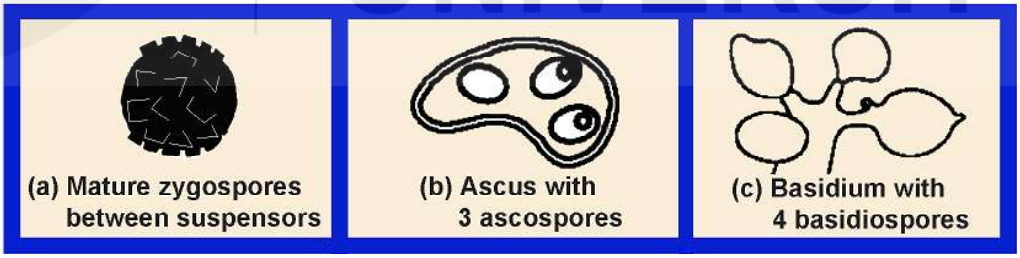

Figure 2.11: Mould spore types

iii) *Basidiomycetes*

This group also contains septate hyphae and forms spores, usually, four in number as shown in Figure 2.11(c). Most of the edible mushrooms belong to this class and the spores are produced in a club-shaped structure known as 'basidium'. The spores are called *basidiospores*.

Most of the edible species of mushrooms are the members of the genus *Agaricus*. In America, the commercial production is dominated by the species *Agaricus bisporus.* In East Asia, especially in Japan, *Lentinus edodes*, which is grown on tree tops, is popular. In India, the oyster mushrooms are increasingly accepted as a source of food and considered a delicacy.

iv) *Fungi imperfecti*

This group of fungi is known as the fungi imperfecti, as the sexual stage of reproduction of many strains are yet to be discovered. Fungi imperfecti produces characteristic conidiophores and conidia. The organisms of importance of this class are *Alternaria, Aspergillus, Fusarium, Penicillium, Botrytis, Cladosporium* etc. The *Aspergillus* and *Penicillium* species are most commonly found and are the significant storage fungi responsible for the spoilage of foods.

2.4.5 Viruses

Till the presence of viruses was demonstrated by *Iwanowski* in 1892, bacteria were considered the lowest forms of life. Viruses are called as *'obligate intracellular parasites'*, since they are unable to carry out any of the typical life functions until they are inside a host cell. Once inside the host cell, they thrive and direct the host cell to produce more viruses. As long as the virus is outside the host cell, it is known as *'vision'*.

The viruses are minute when compared to bacteria. Except for a few, viruses like the cow pox virus, used in vaccination against small pox is 0.3 μm, whereas, the smallest type, like the foot and mouth disease virus is about 0.01 μm. Note, they are so small that they cannot be seen under an electron microscope.

The viruses consist of a protein layer, capsid, surrounding nucleic acid comprising either RNA or DNA. The important characteristic of viruses is that they are host-specific. Most viruses infect only one species, either animal or plant or else only very closely related species. The mammalian viruses do not affect any plant e.g. the polio virus infects humans and monkey and does not affect other animals, whereas, the tobacco mosaic virus, which attacks plants, does not affect humans.

Viruses are killed in a few minutes under pasteurization temperature i.e. 62°C for 30 minutes. They are affected by general disinfectants like phenols, formaldehyde, halogens and cresols. To a certain extent, soaps and detergents inactivate them and UV light destroys all viruses. They are not affected by antibiotics unlike bacteria.

Viruses are known to cause illness although they do not grow on foods or produce toxins in foods. Food items merely act as a vehicle for their transfer. They are the intestinal or enteric type and are food borne. They spread from the hands of human carriers and from water to foods. The presence of viruses in foods, especially the shell fish grown in sewage polluted water, could be the significant route of illness in man. Other foods like fruits and vegetables contaminated by faeces and salad preparations using contaminated vegetables have been implicated in several outbreaks of food borne diseases. The hepatitis A virus, which causes jaundice, spreads through foods but the etiology is difficult to establish, as it has a long incubation period, ranging from 15-50 days.

Having looked at viruses, we move on to parasites, which are the last of the biological hazards discussed in this section.

2.4.6 Parasites

Parasite, as you may already know, is *a plant or animal that at some stage of its existence obtains its nourishment from another living organism called the host*.

Several foods act as carriers of parasites, which may cause illness when ingested. The parasitic infections of foods may occur due to contamination of food by a food handler directly or by polluted waters. In many parts of the world, the consumption of under-cooked meat and fish are popular. The problem of contamination with parasites can occur when the food preparation is made with polluted water and under-cooking

prevents the parasites from destruction. Amoebic infection is the most important parasitic infection through contaminated food. Let us learn about the different parasites.

A) *Amoeba: Entamoeba histolytica*, a protozoan, is the cause of amoebiasis, which is very common in a tropical country like India. Figure 2.12 illustrates *entamoeba histolytica*. About 15% of the population suffers from this disease. The disease is transmitted at 60°C through infected cyst. It remains viable only in moist form and gets destroyed at 60°C and at freezing conditions beyond 24 hours.

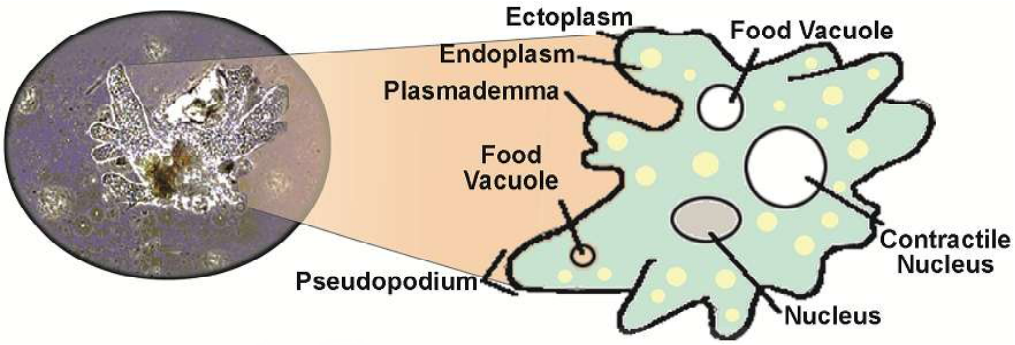

Figure 2.12: The Amoeba

The foods like vegetables from fields irrigated with sewage polluted water are the vehicles of transmission. They get contaminated with amoebic cysts through polluted water and infected handlers. Viable cysts have been found on the hands and under the finger nails of the carriers. The common pests like flies, cockroaches and rodents may also harbour the cysts and contaminate food and drinks. The symptoms of diarrhoea occur from several days to 4 weeks after ingestion of the contaminated food. The prevention of amoebiasis is by using food procured from reliable sources, preparing food in potable water and adequate cooking and proper storage after preparation. Use of filtered / boiled water, disinfection of uncooked vegetables with an aqueous solution of iodine around 200 ppm or acetic acid (5-10%) or full strength vinegar are the recommended measures to minimize the problem.

B) *Giardia:* The disease giardiasis is caused by the flagellated protozoan *Giardia lamblia* illustrated in Figure 2.13. This disease occurs in the areas where poor sanitary conditions prevail and it affects mostly children. The cyst of this organism is absorbed through the intestinal walls and the affected person excretes Giardia cysts in faeces.

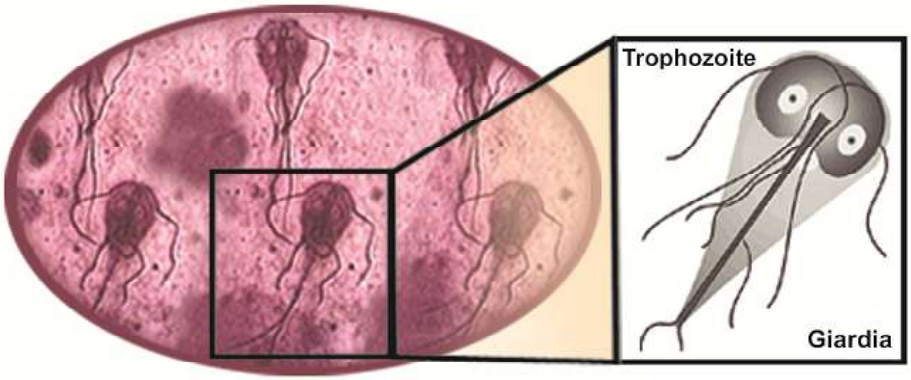

Figure 2.13: Giardia

The cysts get transferred to food when contaminated water is used for washing the vegetables. Consumption of such food containing the cysts leads to infection. The incubation period ranges between 2-25 days and the symptoms include discomfort, nausea and diarrhoea. Infected persons may simply be the carriers and may not always

exhibit symptoms. The disease can be prevented by adopting good personal habits and proper faecal disposal methods and protecting the water supplies from faecal contamination.

C) *Trichinella:* The disease trichinosis is caused by the nematode, *Trichinella spiralis*. Figure 2.14 illustrates the nematode. It is one of the commonly found parasitic food borne infections in the populations consuming principally the undercooked pork.

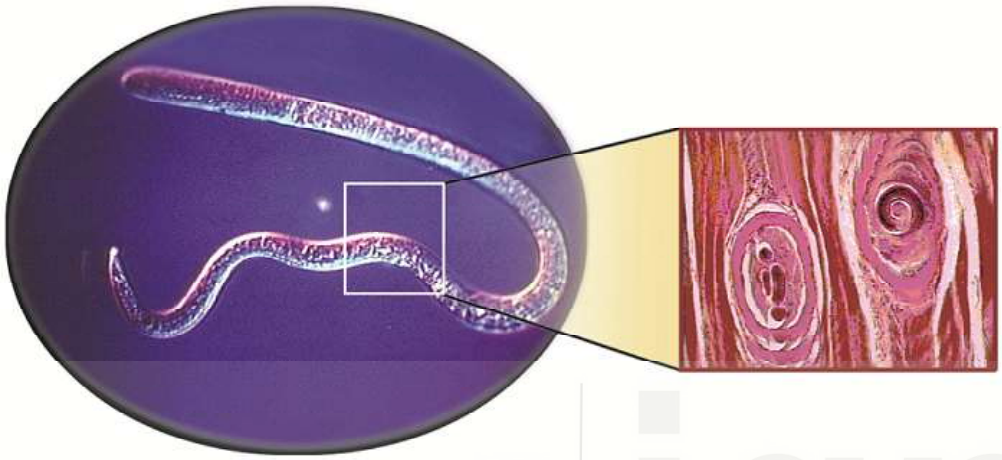

Figure 2.14: Trichinella spiralis

The parasite enters the human host in the form of larvae, which are released and enter the duodenum, producing larvae which gain entry into the blood stream and encyst in the muscle. The symptoms appear normally 2 days to one week after ingestion of the contaminated food with the larvae. The symptoms include fever, abdominal pain, nausea, vomiting and diarrhoea. In some cases, oedema of face and hands is also observed. The prevention of trichinosis is ensured when the food is thoroughly cooked to a temperature of 60°C, which destroys the larvae. The meat has to be cooked till it imparts a grey colour. The parasite is also destroyed when held at temperatures below –25°C or lower, for 10 days.

With this, we end our discussion on the biological hazards.

Check Your Progress Exercise 3

1) Fill in the blanks:

   a) The different forms of fungi are..... , ... and ..... .

   b) The reproductive process of yeast is termed as..... .

   c) Mycelium is composed of individual filaments called as..... .

   d) Viruses are called .....parasites, as they are unable to carry out typical life functions until they are inside a host cell.

   e) .....is the protein capsule of the virus.

   f) ..... is a disease caused by a flagellated protozoan.

2) Classify moulds and explain how they differ in reproductive process.

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3) Give an example to show that viruses are host-specific.

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4) How are viral diseases spread?

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5) List some ways by which parasitic infections may occur.

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6) Name a few diseases which are caused due to parasitic infections.

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In the section above, we learnt about the microorganisms in food. Globalization in world's food supply has resulted in the introduction of new pathogens and hazards into human and animal population. What are these recent concerns to food safety? We will learn about this interesting aspect in the next section.

2.5 RECENT CONCERNS OF FOOD SAFETY

The rising worldwide human travel and global distribution of food is facilitating the introduction and flow of pathogens and other hazards into human and animal populations. Further, global sourcing can also move pathogens and toxins from areas in which they are indigenous to places in which they have not previously existed. Food safety issues such as debate over organic foods, genetically modified foods, the incidence of bovine spongiform encephalopathy (BSE), dioxin-contaminated foods are causing heightened consumer concern about food safety worldwide today. What are these concerns all about? Let us find out.

2.5.1 Prions

In recent times, *Bovine Spongiform Encephalopathy* (BSE) and *Creutzfeldt-Jakob Disease* (CJD) have been the highly publicized food safety hazard. You may recall reading about the mad-cow disease and large number of diseased cattle being destroyed in the UK, or about the ban on British beef worldwide. Why was this action being taken? What was the hazard? The hazard was from the Prions (pronounced pree-ahns). Prions entered the public's consciousness during the mad cow epidemic that hit England in 1986. What are Prions? *Prions, the cause of BSE and CJD, are an entirely new source of food borne diseases.* Prions, is the abbreviation of proteinaceous particles. The word 'Prion' was coined by *Dr. Stanley Prusiner* to indicate that this disease was caused by a "proteinaceous infectious agent." Prions, in fact, are modified forms of

a normal protein called as *PrPC*. The protein that causes this and all other prion diseases is called PrPSC, which stands for *prion protein of scrapie*. Prions enter cells and apparently convert normal proteins found within the cells into prions just like themselves. The proteins accumulate in the brain causing holes or plaques and the subsequent clinical symptom leading to death. The medical term for the prion diseases is "spongiform encephalopathies," in acknowledgement that the sick brains are riddled with holes and have taken the form of sponges. Transmissible spongiform encephalopathy in animals and humans are caused by prions. Prions, therefore, can be infectious and can cause infectious diseases. The second and potentially more troubling aspect is that, like other infectious agents, prions can jump species' barriers and cause deadly diseases in humans. Only time will tell how big a problem the prions will be both as the agents of dreadful diseases of the human nervous system and as vectors of diseases from other species.

BSE was first confirmed in cattle in 1986 in UK. It is commonly accepted that BSE was first caused in Britain when cattle were fed carcass meal from scrapie infected sheep. Since 1999, other countries in Europe e.g., Belgium, Denmark, France, Germany, Ireland, Italy, Netherland, Portugal etc. have reported confirmed cases of BSE. Humans contracted the non-classic form of CJD, called new variant CJD (vCJD) after consuming cattle meat, in particular, the nervous tissue.

Let us get to know about these illnesses.

Bovine Spongiform Encephalopathy (BSE)

Bovine spongiform encephalopathy (BSE), is commonly known as *mad-cow disease*. It is a progressive neurological disorder of cattle that results from an infection by an unconventional transmissible agent. BSE is one of a group of diseases that affect a number of different mammals. These diseases, known as Transmissible Spongiform Encephalopathies (TSEs), or Prion Diseases, result from the build-up of abnormal prion proteins in the brain and nervous system. BSE attacks the brain and central nervous system of the animal and eventually causes death. Research has shown that TSEs have two characteristics in common: they can be transmitted between animals, and they cause the same spongy decay of brain tissues. A commonly occurring prion disease is *scrapie*. The symptoms commonly associated with it are disorientation, clumsiness and occasionally, aggressive behaviour towards other animals and humans.

What caused the disease? Most experts agree that the BSE was spread by cattle eating feed that contained meat-and-bone meal (MBM), which contained BSE infected parts of other grazing animals. MBM is produced in a process called rendering, this is where otherwise unused meat products are taken from the animal carcass and turned into cattle feed. Cattle can contract BSE if they are fed infected brain tissue. Thus, it is presumed that BSE was transmitted to cattle through their animal feed.

Creutzfeldt-Jakob disease (CJD)

The most commonly known disease in prion diseases group among humans is Creutzfeldt-Jakob Disease (CJD). This is a rare and fatal form of dementia and mainly occurs in individuals between the ages of 40 and 80. In 1996, scientists discovered a new strain of CJD that occurs predominantly in younger people.

More recent evidence has shown that the protein that accumulates in the brains of individuals with this new form of CJD is similar to the protein found in cattle infected with BSE, rather than that found in classical CJD. Because of this newly discovered difference, the new illness in humans is known as variant CJD or vCJD. The occurrence of a new form of CJD in the UK, where there is a high incidence of BSE, suggested that there might be a direct link between the two diseases. Some cases that have

developed vCJD are known to have eaten BSE-infected meat. Like BSE in cattle, vCJD is always fatal in people.

How does an individual get infected by vCJD? As discussed earlier, a victim of vCJD becomes infected through consumption of cattle products contaminated with the BSE agent. What are the symptoms and consequences? Generally, vCJD patients show atypical clinical features with prominent psychiatric or sensory symptoms, with delayed onset of neurological abnormalities, including ataxia within weeks or months, dementia and myoclonus late in the illness.

Next, who are the most at risk of this disease? The risk to travelers (who visit the countries where outbreaks of BSE have taken place) and importers (who import beef and beef products from countries where vCJD cases have been reported) is the most. As far as travelers are concerned, the risk can be controlled by avoiding beef and beef products altogether or by selecting solid muscle pieces of beef with less chance of contamination and avoiding calf brains and burgers and sausages. Milk and milk products are reported to be safe, as these pose no risk for transmitting the BSE agent.

The countries that import beef and beef products from countries where cases of vCJD have been reported need to exercise control measures to ensure that the disease is not transmitted to the importing country. Severe restrictions need to be imposed on importation of live ruminants, such as cattle, sheep and goats and certain remnant products from countries where BSE is known to exist. Avoiding beef and beef products altogether by selecting solid muscle pieces of beef with less chances of contamination and avoiding calf brains and burgers and sausages can control entry of infected foods.

Having looked at the concern from prions, next let us critically analyze the use of genetically modified foods.

2.5.2 Concerns of Genetically Modified (GM) Foods

The benefits of genetically modified foods have been discussed earlier in Unit 1, section 1.3. However, in the context of genetically modified foods, concern from environmental, food safety and ethical angles have been raised. Further, concerns related to nutrient aspect of GM foods, elimination, loss, reduction or increase in micronutrients due to genetic modification and increase in anti-nutritional factors need to be addressed.

Issues of concern to environment include the capability of the GM organism to escape and introduce the engineered gene into wild population (cross breeding) through pollen drift leading to loss of biodiversity. The transgenic material from GM maize cultivated by a farmer could be transferred in non-GM maize cultivated in the neighbouring farmer's field without his knowledge. There could be the possibility of development of resistance in the target organism. This is particularly true for cotton crop insects.

Concerns from the health angle include toxicity, allergenicity, nutritional imbalance, possible gene transfer such as antibiotic resistant gene to gut flora which could adversely affect the therapeutic efficacy of orally administered antibiotics, unintentional effects in the form of acquisition of new traits or loss of existing traits and use of unapproved varieties like Star Link maize. Concerns of ethical nature have been raised from vegetarian groups on using animal genes in plants.

Thus, the risk and uncertainties surrounding the process of genetic engineering and the resulting GM product has resulted in considerable public debate and consumer groups have been vociferous in demanding labeling of GM products. In India, the Policy on GM foods is under active consideration by the Government at the highest level and is likely to emerge soon.

Like prions, dioxin-contaminated foods are causing consumer concern. What are dioxins? Let us find out.

2.5.3 Concern of Dioxin-Contaminated Foods

Dioxin has been discovered in chickens. In 1998, unacceptable levels of dioxin were found in milk produced in the North of France. The source of this contamination was several incinerators that had polluted the surrounding grazing land. Dioxin spewing out of the incinerator plants settled on the grass. It then got chewed by the cows where it was concentrated mainly in their fat deposits and from there into their milk.

What are dioxins and why are they harmful and a concern for food safety? *Dioxin and related compounds, i.e. polychlorinated dibenzo-p-dioxin (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs), are halogenated aromatic compounds which are industrial pollutants that persist in the environment.* In addition to cancer, dioxins have been linked to adverse human health effects such as developmental, immunologic and endocrine toxicity. The major environmental sources of dioxin and dioxin-like compounds (referred to simply as "dioxins") are emissions from combustion, incineration, any industrial processes using chlorine, paper mills, fireplaces, grass fires etc. The aerial transport of these emissions is the primary pathway dioxins enter the terrestrial environment and food chain.

How do dioxins enter the human diet? Dioxins are lipophilic (fat-loving) compounds which accumulate in the fat of animals. Hence, the types of foods which tend to have the highest dioxin concentrations are dairy products, meat and poultry, eggs, fish and animal fats. Green vegetables, fruits and grains, on the other hand, are the types of foods with the lowest dioxin concentrations

How do foods and animals become contaminated with dioxin and related compounds? Deposition of airborne dioxins onto plant and soil surfaces, and subsequent ingestion of this contaminated vegetation and soil by food animals, is considered the primary pathway by which dioxins enter the food chain. The levels produced in this way are considered background levels. Fish become contaminated due to airborne dioxin deposition into the water and also from contaminated soil or industrial waste washed into rivers and lakes, leading to high sediment concentrations. Inhalation and water pathways are not considered significant sources of exposure for terrestrial animals. Contamination above background levels can occur if food animals are fed products which are adulterated, either by natural or unnatural means, with high concentrations of dioxins.

You will get to learn more about dioxins later in Unit 6 on Food contaminants. The discussion above presented a brief review on the recent concern on food safety. A study on food hazards would not have been completed without a review on these recent concerns.

Check Your Progress Exercise 4

1) What are 'prions'? Name any two diseases caused by prions.

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2) What are the health-related concerns of GM foods?

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3) What are 'dioxins' and comment on their food safety risks?

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2.6 LET US SUM UP

In this unit, we looked at the concept of food safety and the importance of safe food and the hazards which are a concern to food safety.

Then we studied about some of the important microorganisms, their structure, mode of reproduction and diseases spread by them. We also discussed about favourable and unfavourable conditions that affect the growth of these microorganisms.

The last part of the unit focused on recent concerns of food safety. Prions, dioxin-contaminated foods and concerns related to genetically modified foods were highlighted in this section.

2.7 GLOSSARY

Budding : the asexual reproductive process of yeast involving the bulging of protoplasm outwards and its separation from the cell, on maturation.

Endospore : resting structure of bacteria.

Flagella : small appendages, which help the bacteria to swim.

Food quality : the attributes that influence a products' value to a consumer.

Infections : these occur on the ingestion of live pathogenic organisms which multiply within the body.

Intoxications : these occur on ingestion of toxins that are produced by pathogens.

Mycelium : filamentous branching growth of multicellular fungi.

Scrapie : an old disease, recognized in sheep and goats for more than 250 years. In 1982, it was first identified as a prion disease.

Toxicity : the capacity of a substance to produce harm or injury of any kind under any conditions.

2.8 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) a) Food safety can be defined in absolute and relative terms. Absolute food safety is the assurance that the damage or injury from use of a substance

is impossible. Relative food safety is the assurance that damage or injury will not result from a food or ingredients used in a reasonable and customary manner and quality.

b) A biological, physical or chemical agent in a food, or a condition of food, with a potential to cause an adverse health effect is referred to as a food hazard.

2) Hazard is the relative probability that harm or injury will result when a substance is used in a proposed manner and quantity while toxicity is the capacity of a substance to produce harm or injury of any kind under any conditions.

3) Physical, chemical and biological hazards are the three common hazards to food safety.

4) Physical hazard is any foreign material not normally found in a food, which may cause illness or injury to the individual consuming / using the product. Examples include stone, button, hair etc. The harmful products enter food through the environment in which the foods are grown, during processing and packaging.

5) Chemical hazards can be classified into:

- Naturally occurring chemicals such as mycotoxins, histamine
- Unintentional chemicals such as lead, polychlorinated biphenyls (PCBs)
- Intentional chemicals such as food additives, pesticides.

Check Your Progress Exercise 2

1) i) bacilli, cocci, spiral
   ii) Endospore
   ii) infections, intoxications
   iii) cytoplasm
   v) flagella

2) The bacterial cell consists of a cell wall, membrane, nucleus, flagella. The functions of cell wall are that it gives shape to the cell, protects cytoplasm and has an important role in cell division and it regulates the passage of materials.

3) The stages of bacterial growth are:

- Lag phase- It is an initial phase where there may be little or no increase in the cells.
- Log phase- The cells multiply logarithmically i.e., one cell dividing to 2 cells and then 2 cells to 4 cells etc.
- Stationary phase- The cell multiplication gets stagnant due to the exhaustion of nutrients or accumulation of waste products.
- Death phase- The cell dies in this phase, as the medium becomes incapable of supporting further growth.

Check Your Progress Exercise 3

1) a) moulds, yeasts, mushrooms
   b) budding
   c) hyphae
   d) obligate intracellular

e) Capsid

f) Giardiasis

2) Moulds can be classified into:

- Phycomycetes – Produce non-septate hyphae and are able to conjugate and form a zygospore.
- Ascomycetes – Produce septate hyphae and multiply sexually, forming ascospores.
- Basidiomycetes – Produce septate hyphae and forms spores, termed as basidiospores.
- Fungi Imperfecti – Produce condiophores and conidia and multiply sexually.

3) The polio viruses which attack humans and monkeys do not affect any plant and other animals and tobacco mosaic virus which attacks plant, does not affect humans.

4) Viral diseases spread from the hands of human carriers and water to foods e.g. shellfish, fruits and vegetables contaminated by feces and salad preparations using contaminated vegetables.

5) Parasitic infections may occur by contamination of food directly or by water and undercooked meat and fish.

6) Amoebiasis, Giardiasis and Trichinosis are caused due to parasitic infections.

Check Your Progress Exercise 4

1) Prions or proteinaceous infectious particles are modified forms of a normal protein which accumulate in the brain causing holes or plaques, leading to death. The two diseases are Bovine Spongiform Encephalopathy and Creutzfeldt - Jakob disease.

2) The health related concerns of GM foods include toxicity, allergenicity, nutritional imbalance, possible gene transfer such as antibiotic resistant gene to gut flora which could adversely affect the therapeutic efficacy of orally administered antibiotics, unintentional effects in the form of acquisition of new traits or loss of existing traits. Concerns of ethical nature have also been raised from vegetarian groups on using animal genes in plants.

3) Dioxins are halogenated aromatic compounds which are industrial pollutants that persist in the environment. The health risks include cancer and adverse human health effects such as developmental, immunologic and endocrine toxicity.