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MEVE-003
Agricultural and Allied Sector

CHALLENGES TO AGRICULTURAL ENVIRONMENT HEALTH

4

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Block

4

CHALLENGES TO AGRICULTURAL ENVIRONMENT HEALTH

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BLOCK 4 INTRODUCTION

Block 4 deals with Challenges to Agricultural Environmental Health. It discusses about agricultural traceability as the process of gathering information, documenting those gathered information, maintaining it, and applying those information related to all the processes involved in the supply chain in a manner that guarantees to all the consumers and other stakeholders on the origin, location and life history of a product as well as assisting in crises management in the event of a safety and quality breach. The block also discusses food borne diseases resulting from the consumption of either food or water contaminated with viable pathogenic bacterial cells or spores. It also focuses on zoonotic diseases that are a major public health problem. Agriculturists, veterinarians, butchers, laboratory workers, hunters and many more occupational groups are at the higher risk of being affected by these diseases. Finally the block also discusses food loss and wastes and genetically modified organisms.

Unit 1 deals with Traceability in Agriculture and Food Supply Chain. It discusses that the factors like safety, functionality and sustainability have placed new demands for the development of traceable supply chains which assures completion of food traceability processes. These help in detecting and preventing food safety hazards for quality assured agricultural supply chain management system as traceability is a preventative strategy in food quality and safety management.

Unit 2 deals with Food Borne Diseases. Food borne illness is a significant public and environmental health problem which causes major economic and social effects. The unit discusses that there is a need to increase awareness pertaining to recognition of food spoilage, foodborne disease and its symptoms for management and development of effective food control measures.

Unit 3 deals with Disease Transmission between Humans and Animals. The unit discusses that all sections of the society are likely to be exposed to different zoonotic diseases. It also explains that agriculturists, veterinarians, butchers, laboratory workers, hunters and many more occupational groups are at the higher risk of being affected by these diseases. Further it discusses that with the increase in diagnostic techniques, better surveillance and monitoring systems, advanced trade and travel policies, ecological changes and increase human-animal interference new and emerging diseases are on the rise. Finally the unit summarizes that as these diseases are of great public health concern, prevention and control steps are to be taken to protect the human and as well as animal health.

Unit 4 deals with Food Losses and Waste. It discusses that the issue of global food losses and waste has received a lot of attention and has been given high visibility. According to estimates, almost one-third of food produced for human consumption is either lost or wasted globally. A lot of food is wasted or lost from the supply chain, from initial stage that is producing till the last stage of consumption in household. The unit also explains that food losses have bad and negative impacts on the environment. Finally the unit summarizes the ways for prevention of food losses and waste and the means of processing and preservation of food and reducing its negative effects. It also describes the coordinated efforts by FAO, UN agencies, international organizations by activities, projects, various initiatives on food losses waste reduction at global level.

Unit 5 deals with Genetically Modified Organisms: a multidisciplinary perspective. It discusses that artificial selection for specific, desired traits has resulted in a variety of different organisms. It also details that in recent decades, advances in the field of genetic engineering have allowed for precise control over the genetic changes introduced into an organism. The unit also explains the concerns of genetically modified food on the environment and human health.

UNIT 1 TRACEABILITY IN AGRICULTURE AND FOOD SUPPLY CHAIN

Structure

1.0 INTRODUCTION

Consumers today need fresh, nutritious and safe food. Demand for functional foods which offers health and nutraceutical benefits increases as the consumer rate increases. Food safety is a branch of science that describes handling, preparation, and storage of food in ways that prevent food-borne illness. The International Organization for Standardization defines traceability as: "*ability to follow the movement of a feed or food through specified stage(s) of production, processing and distribution*". ISO 22005:2007 comprehensively explains the principles and requirements for the design and implementation of a feed and food traceability system. From quantity-oriented agriculture to quality-oriented agriculture, as the priorities change, factors like safety, functionality and sustainability have placed new demands for the development of traceable supply chains which assures completion of food traceability process from farm to fork, implementing authenticity and diagnostic tests which helps in detecting and preventing food safety hazards and helps in preserving the identity and wholesomeness of novel foods, which has become an essential elements of quality assured agricultural supply chain management system as traceability is a preventative strategy in food quality and safety management.

1.1 OBJECTIVES

After reading this unit you should be able to:

- define traceability;

- understand the demand of traceability;
- describe the types of traceability;
- explain the technological innovations in traceability; and
- understand the consumer concerns regarding traceability.

1.2 CONCEPT OF TRACEABILITY

The documentation, gathering, upkeep and use of data identified with store network in a way that expedites certification to the buyer the area, life history and starting point of a product and furthermore helping in administration of basic circumstances on account of a quality and security infringement is known as agricultural traceability. It defines the straightforwardness of the inventory network alongside the utilization of obvious marking and records.

Traceability is so famous and widely used by various industries that it has become necessity to examine the concept, particularly in relation to agriculture and food. We can define agricultural traceability as the process of gathering information, documenting those gathered information, maintaining it, and applying those information related to all the processes involved in the supply chain in a manner that guarantees to all the consumers and other stakeholders on the origin, location and life history of a product as well as assisting in crises management in the event of a safety and quality breach.

Traceability provides communication linkage for identifying, verifying and isolating sources of noncompliance to agreed standards and customer expectations which adds to the quality management system. Traceability expands by and large quality administration framework's an incentive by supporting the correspondence linkage for perceiving, approving and isolating wellsprings of protest to measures set and client desires. There are six components of traceability constituting a consolidated agrarian and sustenance inventory network traceability framework:

(a) **Traceability of Product -** This comprises the actual area of a product at various levels in the store network for helping stock and co-ordinations administration, product review and appropriation of data to buyers.

(b) **Traceability of Process -** This assures the grouping and sorting of procedures that have influenced the product simultaneously with the development and postharvest activities. Connections are incorporated among the product and concoction, physical/mechanical, barometrical and ecological elements which make change esteem included products from crude materials; and the nearness or nonappearance of contaminants.

(c) **Genetic Traceability** – This describes the hereditary structure of the product. This contains data on the root and hereditarily altered fixings or materials/life forms and furthermore planting materials data which is utilized to make the crude product.

(d) **Inputs Traceability** – This contains starting point and sort of sources of info, for example, domesticated animals, synthetic splashes, compost, water system water, feed and the nearness of synthetic concoctions and added substances utilized for the security, upkeep and additionally transformation of the fundamental crude materials into prepared nourishment products.

(e) Disease and Irritation Traceability – This component tracks the study of disease transmission of bugs and biotic perils, for example, infections, microscopic organisms and developing pathogens that may cause nourishment sullying and ingested natural products from rural crude materials.

(f) Measurement of Traceability - This describes singular aftereffects of estimations along a constant anchor of alignments to reference benchmarks. Estimating and test hardware ought to be adjusted to estimation principles with the assistance of a reference standard affirmed to a national or global standard to achieve this. The other element of estimation of traceability relating to the property of the estimations created all through the store network and their association with the prerequisites for quality. Nature, administrator and geospatial and fleeting components to accomplish this, which influences the information quality, must be contained in the information. Information based proactive technique to sustenance wellbeing and quality administration can also be described as traceability. It is an instrument that can be used as a complementary to other quality administration projects, for example, Critical Control Points (HACCP) frameworks and Hazard Analysis. A vital quality of traceability chain administration is that it encourages the recognizable proof and seclusion of dangers and usage of powerful remedial activities amid a scene. In this way, like point evaluation and product testing, traceability autonomously can't carry security into the nourishment or taking care of process. At the point when considered as withdrawal from other quality regulatory frameworks, traceability is not at all a sufficient condition to satisfy the wellbeing necessities for the natural pecking order.

The advantages of incorporating traceability into the general quality farming administration framework are various, going from enhancements in product quality and security administration, emergencies administration in case of a wellbeing alarm, and reinforcing by and large agribusiness coordination. With increasing open examination of the nourishment production network and horticulture, numerous national and territorial new sustenance quality administrative mandates and several laws has been passed, which leaves the agribusiness and nourishment enterprises with few choice yet to actualize traceability frameworks as a feature of the general sustenance security and quality administration program. As horticulture keeps on encountering the polite refusal in terms of exchange and rivalry by other all the more monetarily profitable businesses, there are great motivations to trust that the worry about traceability will proceed in worldwide nourishment exchange. The look for practical mechanical developments for actualizing precise and dependable traceability frameworks is in this manner a critical test confronting horticulture in the new globalized economy.

1.3 DEMAND FOR TRACEABILITY

- Traceability's demand in horticulture has altogether extended over the most recent couple of years with expanding rate of nourishment related security dangers and alarms, (for example, foot-and-mouth malady, frantic dairy animals illness, microbial sullying of crisp deliver, dioxin in poultry). The presence of hereditarily adjusted living beings (GMOs) and requirement for personality safeguarding of GMO and non-GMO agrarian chains has additionally provoked refusing purchaser certainty on nourishment security and the expanding worry over capable contrary effects of agribusiness on earth along with natural decent variety.

- For instance, we check the tag on our favorite shirt or jeans or even pair of shoes and are able to trace it back to its original manufacturing country. But has one ever thought if "Maine Lobster" was actually captured off the coast of the Pine Tree State?

1.4 TYPES OF TRACEABILITY IN AGRICULTURE AND FOOD SUPPLY CHAIN

Implementing a traceability framework inside an inventory network requires all the necessary things required to connect the physical stream of products with the stream of data about them. Embracing uniform industry prerequisites for traceability, guarantees assertion about recognizable proof of the traceable things between parties. This reduces straightforwardness and coherence of data in the production environment.

External Traceability

This technology requires each and every traceable thing to be minutely recognized, and data to be shared between all influenced appropriation channel members. The distinguishing proof of products with the end goal of traceability may include:

- Unique product identification number; and
- Lot/batch number.

External traceability is divided into three processes that are common to all links in the chain:

- Reception of goods or captured data from vendors or a third party
- Internal traceability within the company using the initial data from third parties, adding data generated in the processes themselves
- Issuing and sharing information with customers or the next link in the chain.

From boat or fish farm to table external traceability helps in tracking a product and it's attributes through the detailed stages of the distribution chain. The simplest model used in external traceability is "one step back" and "one step forward". Besides, it enables to trace a product back to understand the custody chain of product, components and ingredients. Under this system, each partner in the supply chain is responsible for recording input and output data but not for information which may be some steps ahead or in the back of the supply chain. Tracing upstream means analyzing the supply chain towards the harvester or producer steps. Tracing downstream focuses on distribution and consumption. External traceability uses a set of tools that helps in traceability such as identifiers, carriers (Bar code and RFIDs) and readers. As seafood supply chains become longer, the demand for external traceability data increases by both regulators and consumers.

To keep up external traceability, the entity distinguishing proof numbers should be provided to conveyance channel members on product marks and corresponding electronic or paper business reports. The connection of products with the data is needed for traceability. External traceability allows following back, i.e., provider traceability and following forward, i.e., customer traceability.

Internal Traceability

Internal traceability requires that forms must be kept up inside an aim to connect parts of crude materials to those of the finished products. When a material is joined with another and prepared, repacked or reconfigured, the product should have its own Unique Product Identifier. The linkage should be kept up between this product and its unique material sources of information, (for example, seasonings, marinades, salt, bundling materials, etc.) to take care of traceability.

For an internal traceability system to be successful, assigning of unique identification to specific batches is required. Maintaining separation of batches can be achieved in space or time, for example physical separation in separate units or specific production run times. A complete batch will depend on the nature of the product and production operation. The identity placed on a batch should be easy to read, and must convey all the required information to link the batch to relevant records.

1.5 TECHNOLOGICAL INNOVATIONS IN TRACEABILITY

For traceability, various symbols are used to identify parts and products. In the production control stage, identification symbols such as characters and 2-D codes are used to record the delivery status, production and procurement plans, shipment plan, achievement rates, inventory quantities and other information. For the proper implementation of this, technologies to accurately recognize identification symbols have become important.

Recently, horticulture is exceptionally learning serious and data driven. With declining terms of exchange influencing farming versus different businesses, mechanical advancements are important to reduce the exchange cost and encourage the production and predictable supply for the best quality, sheltered and traceable products based on consumer demand. Agriculturists, processors, advertisers, handlers, customers, the government and overall population have showed partner interest in security and cost-viability of worldwide agri-sustenance supply chains.

The driving force behind this expansion of traceability is clearly the breakthrough in IT technologies that has provided with high accuracy in marking and reading techniques and allowed comprehensive handling of sensitive information. This section emphasizes on the technological innovations that support the development and advancement of traceability systems.

To implement traceable agrarian supply chains, advancements in the mechanical domain are required for product distinguishing proof, process and natural portrayal, data catch, investigation, stock-piling and transmission, and additionally by and large framework mix. These innovations include equipment (for example, estimating gear, distinguishing proof labels and names) and programming (computer projects and data frameworks).

Product identification technology: An evident element of any traceable network is capacity to follow the legacy and track the physical area of the products in a much reliable way in the general store network. To achieve this, precise naming is basic. The least difficult innovation to find this is to add a tag to the fundamental crude material (e.g. the creature, plants or their corresponding parts) and to exchange that information on the tag to the scanner tag of the finished product. In the domesticated animals industry, the ear-tag is regularly utilized and often contains a progression of numbers as well as letter sets, which arrange particular data, for example, the breed, date of birth, their immunizations, etc.

The utilization of PCs and other data innovations have added to the advancement of electronic distinguishing proof (EID) frameworks, which incorporate electronic labels with chips and handheld scanners for perusing, removing and transferring the information to computers for investigation and stock-piling. An important quality of labels is that the materials must be impervious to unpleasant dealing with and nasty climate. Headways in material science have driven the improvement of labels that are immune to rough use and which can bear worse ecological conditions. Advancements in geo-spatial science and innovation, for example, radio recurrence innovation and versatile GPS beacons have the potential to gather and transmit information from labels to far off areas for capacity and examination. The easiest mark on a sustenance product often stores such data as the name of the product, its cluster number, and cost. Depending upon the market refinement and interest for data, other information that can be combined are product inception, taking care of and capacity conditions.

Quality and safety measurement technology

The achievement of traceability is estimated by the reliable conveyance of products to meet the demands of consumers and different partners, also the ability to find out the area of every product unit for viable review in case of a quality or security break. Exact data on the development and quality properties and security status of the product is required which must be estimated utilizing necessary instruments and strategies. Estimate (mass, measurements), immovability (freshness, crunchiness) dissolvable solids, causticity, season, etc., that are needed to determine the quality of a product are a portion of the physical, mechanical and concoction properties that may require estimation. To gauge the immovability of meaty products, research facility and online instruments, like the penetrometer, firmometer, contort analyzer, Instron machine, and Kiwifirm can be used. To quantify immovability and other internal quality properties, and to evaluate the nearness of dangerous physical protests inside products, nondestructive tests in light of power detecting, infrared and attractive reverberation imaging can be utilized. Models of these instruments are monetarily accessible from different makers and are presently utilized as a part of industry and research labs. Modern techniques and gear are available for compound examination of product tests, hardware surfaces and the air to learn the nearness of unsafe microbial contaminants.

Technology innovations in genetic analysis

To save the character of product supply chains and the interest for hereditary traceability advancement of techniques and estimation gadgets have emerged for the investigation of the hereditary constitutions and pollution of substances and other organic products. DNA tests in view of constant PCR have been produced to recognize and measure GMOs and other transgenic materials,. A decent synopsis of a few research facility displays at an ongoing Institute of Food Technology Meeting and Food Expo for estimating product traceability and security is provided by Giese.

Environmental monitoring technology

The quality steadiness and wellbeing of nourishment products is affected by environmental conditions like temperature and relative dampness, climatic arrangement of the air, including poisons, etc. To control frameworks, Instrumented natural chronicle gadgets, (for example, gas analysers and biosensors) for observing these parameters are accessible and can be coupled.

Technology innovations and developments in geospatial science

The joining of geographic data frameworks (GIS), remote detecting (RS) and worldwide situating frameworks (GPS) offers extensive open door for site-particular horticulture and the determination of information identified with the agribusiness products, on the ranch and through the ensuing taking care of activities. Set up together, these advances empower information to be remotely gathered on singular creatures, plants, and squares on a ranch, which can be prepared, transmitted and displayed as visual spatial data on the bio-physical properties of the square, yield and chose product characteristics. An essential element of these advances with respect to traceability is the likelihood to outline geospatial inconstancy of chose characteristics, for example, yield, product quality, creature development, and infection the study of disease transmission.

Software technology for traceability system integration

A coordinated framework made of unmistakable parts including information gathering utilizing norms estimation techniques, the investigation, stockpiling and transfer of the recorded data, and full in reverse and forward control framework that allows the following of the product history is termed as a viable traceability chain. These innovations depend on the use of proper data and PC framework, and which interfaces the traceability fasten to a focal database at the organization, national or universal level. The improvement and accessibility of full traceability frameworks that have been embraced in industry have been announced by numerous scientists and business organizations. A preliminary traceability activity has been portrayed by Calder and Marr in light of electronic recognizable proof (EID), which empowered full traceability of ranch creatures. An electronic information distinguishing proof tag (EDIT) that incorporates a transponder as a feature of a common ear tag, and a handheld, battery-fueled electronic per user or terminal, which furnishes ranchers with a completely coordinated traceable domesticated animal's administration instrument has been detailed by Harvey as of late. The electronic ear tag has the ability to record every one of the subtle elements of a creature's life from its hereditary and birth points of interest, to treatment and productions. Nations like Canada and

New Zealand have executed national dairy cattle recognizable proof projects utilizing different innovations that depend on the above standards include QualTrace, EQM (Enterprise Quality Management), and Food Trak are examples of traceability software programs that are available economically.

1.6 CONSUMER CONCERNS

Consumer concern is a term often used as a container notion. It is concerned about food safety, environmental and animal welfare of food production systems, and intrinsic moral objections against genetic modification. The need for action is created by these consumer concerns. For instance, for retailers and brands, it becomes more important that they are trusted as they invest in their good names and in procedures to maintain that good name. The concerns of the consumers should be known by their retailers to have an adequate response to these concerns.

Consumer concerns are often considered to be signs of a decrease in trust. The maintenance of trust in food is not only important for retailers, food industry, and the agricultural sector, but also is important for government, because basic trust in general is of importance for society. No co- operation seems possible without people trusting each other and no society can survive without co-operation.

One of the critical concerns in the promotion of food traceability systems is consumer familiarity. As of late, research features the wellspring of data as being critical and that the larger part of buyers will pay increasingly if there is an assurance on the source and production homes. A consumer survey data from four cities in China was used by authors to conduct a quantitative investigation of consumer concern about food safety and its impact on the consumers' familiarity with food traceability systems. Statistical analysis and a Probit model were used, and the results show a high level of consumer concern about food safety. In contrast, consumers' familiarity with food traceability systems is very low. The concern of consumers about food safety significantly influences their familiarity with food traceability systems. In addition to that, consumers' age, work experiences related to the food industry, and habit of asking for food receipts or invoices all have significant influences on their familiarity with food traceability systems.

The results of the examinations in the Souza-Monteiro and Caswell investigation of the United States and Canada demonstrate that traceability all alone isn't as esteemed as qualities prefer nourishment wellbeing affirmation and creature welfare. It has an incentive to shoppers when it is related with an alluring quality confirmation framework or assurance traits and that data is given before utilization.

As demonstrated by an EU study, the lion's share of buyers will pay more for higher quality meat and vegetables and would confide in them progressively if there is an assurance on the starting point and production hones. According to overviews, a vast larger part of buyers in the EU and US will pay a premium for products which highlight Country of Origin Labeling (COOL) and topographical marking and accreditations.

The direct contact between producer and consumer that formed the basis of trust has largely disappeared now. To establish that trust again we can do so by replacing personal confidence by institutionalized trust. Today, consumers are not aware of the production of food and it makes so difficult to get a clear picture of the circumstances in which production takes place.

1.7 LET US SUM UP

In the recent times, agriculture has become high knowledgeable and easily understandable. With reducing terms that affect agriculture than other industries, in order to lower the transaction costs and allow the production and constant supply of the best quality, safe and traceable products to fulfill demands of consumers new innovations are required in the field of technology. General public as well as the farmers, processors, marketers, handlers, consumers, have interests in the safety and cost-effectiveness of global agri-food supply chains. The rise of traceable rural supply chains is the outgrowth of a long queue of advancements in enhancing sustenance quality and security administration. Broadcast communications, programming improvement and carriers, security is the vital driver for traceability in enterprises, for example. In the recent times, traceability has risen as another list of value and reason for exchange agrarian products. The rising occurrence of sustenance related wellbeing risks and high-profiled unnerves for example, BSE, FMD, dioxin in poultry products, and microbial defilement of crisp create has catalyzed this improvement. Decrement in shopper certainty has been exacerbated by the presentation of hereditarily altered living beings, plants and creatures into the human life. The driving force behind rural traceability is to allow the full in reverse and forward following of a product and its life history (exercises) in the store network, from homestead to fork. The follow back to the first maker also follow forward to singular shoppers and in fact any progression in the store network, for compelling recognizable proof of products and administration of review when quality and security benchmarks are broken is what a decent traceability administration frameworks takes into account. Traceability fabricates trust, true serenity, and increment trust in the sustenance framework from a buyer point of view. Traceability is a piece of a general practical quality administration framework that can likewise aid nonstop change and minimization of the effect of security perils through fast assurance and disconnection of wellsprings of risks. For the cultivator and postharvest administrators for the cultivator and postharvest administrators. It also motivates quick and compelling review of products, and the assurance and settlement of liabilities. Mechanical advancements in the present days exist which can be connected to create and execute an incorporated rural traceability framework. Mechanical developments that can be connected in a traceability framework are advances in data and PC innovation for data frameworks administration; filtering and other computerized innovation for product recognizable proof, picture catch, stockpiling and show; nondestructive testing and biosensors for quality and wellbeing appraisal; and geospatial innovation (GIS, GPS, RS) for versatile resources following and site-particular tasks. A few business products and programming as of now exist, which can address the issues of most medium ranches and different agribusiness. Creating suitable traceability innovation for little scale ranchers, especially at all created nations, offers impressive difficulties and open doors for scientists and improvement professionals in this nourishment and agribusiness. DNA fingerprinting, nanotechnology for scaled down machines, retinal imaging, and their combination into harvest and domesticated animals ventures are the future developments in rising advances that have extensive possibilities for enhancing the speed and accuracy of traceability in learning based agribusiness. The term traceability is an interesting idea that advances archived straightforwardness in the manner in which we hone economical farming. Mechanical developments are applied in traceability to sound agribusiness rehearses so as to meet the consumer demands for dependable and open data about the source and life history of products in the human natural way of life. Ranchers, processors and handlers, and nourishment approach specialists should be aware of the future advancements around them to help them in executing fitting traceability frameworks for their ventures.

Check Your Progress 1

Note: a) Write your answer in about 50 words.

b) Check your answer with those given at the end of the unit.

1. Explain the concept of traceability.

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1.8 KEY WORDS

Agricultural traceability: It is the process of gathering information, documenting those gathered information, maintaining it, and applying those information related to all the processes involved in the supply chain in a manner that guarantees to all the consumers and other stakeholders on the origin, location and life history of a product as well as assisting in crises management in the event of a safety and quality breach.

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1.10 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress 1

Your answers should include the following points:

Refer to Section 1.2

UNIT 2 FOOD BORNE DISEASES

Structure

2.0 INTRODUCTION

Foodborne diseases have been an issue for all societies since the beginning of humanity. The types, severity and impacts of these illnesses have changed through the ages and are still diverse across regions, countries and communities. Food borne illness is a significant public and environmental health problem which causes major economic and social effects .Food borne diseases in humans result from the consumption of either food and water contaminated with viable pathogenic bacterial cells or spores (in the case of infant botulism) or food containing toxins produced by toxigenic bacteria and molds. Food is produced in the primary industry sector (agriculture, aquaculture, fishing etc.) and continues through manufacturing and retail to be prepared and consumed by the public. Organisms causing food borne illness can enter this food production chain at any stage.

Food borne diseases are defined by the World Health Organization as "diseases of infectious or toxic nature caused by, or thought to be caused by the consumption of food or water". Till date more than 250 different food borne diseases have been described. Most of these diseases are infections, caused by a variety of bacteria, viruses, and parasites that can be food borne. Other diseases are poisonings, caused by harmful toxins or chemicals that have contaminated the food, for example, Staphylococcus toxin that has formed in a food or poisonous mushrooms. On the basis of mode of illnesses, these can be arbitrarily divided into three groups: intoxication or poisoning, infection, and toxic infection. These different diseases have many different symptoms, so there is no one “syndrome” that is food borne illness. However, the microbe or toxin enters the body through the gastrointestinal tract, and often causes the first symptoms there, so nausea, vomiting, abdominal cramps and diarrhea are common symptoms in many foodborne diseases. Foodborne diseases are still a major public health concern all over the world today. They are responsible for many cases of adult illnesses and some deaths, but more importantly, contaminated food is a source of the acute diarrhoeal diseases that claim the lives of enormous numbers of children every day. Keeping this in view this unit discusses the food born diseases and their effect on human health.

2.1 OBJECTIVES

After completing this unit, you will be able to:

- define and classify the food borne illness;
- describe the various causes and symptoms of food borne illness; and
- identify the strategies to control food borne illness.

2.2 OVERVEIW OF FOOD BORNE ILLNESSES

Food borne diseases are an important cause of morbidity and mortality, and a significant impediment to socioeconomic development worldwide. Food borne illnesses are infections or irritations of the gastrointestinal (GI) tract caused by food or beverages that contain harmful bacteria, parasites, viruses, or chemicals. The GI tract is a series of hollow organs joined in a long, twisting tube from the mouth to the anus. Common symptoms of foodborne illnesses include vomiting, diarrhea, abdominal pain, fever, and chills. Most food borne illnesses are acute, meaning they happen suddenly and last a short time, and most people recover on their own without treatment. Rarely, foodborne illnesses may lead to more serious complications. Food borne diseases are a major public health problem. They result from eating foods that contain substances which are either infectious or toxic in nature. In the previous session you have learned about microbial and chemical food contamination.

Box 1

Food hazard

In HACCP, “hazards” refer to conditions or contaminants in foods that can cause illness or injury. It does not refer to undesirable conditions or contaminants such as:

- Insects,
- Hair,
- Filth,
- Spoilage,
- Economic fraud and
- Violations of regulatory food standards not directly related to safety.

2.3 CLASSIFICATION OF FOODBORNE DISEASES

Foodborne diseases are usually classified on the basis of whatever causes them. Accordingly they are divided into two broad categories: food poisoning and food infections**.** Each of these categories is further subdivided on the basis of different types of causative agent.

2.3.1 Food poisoning

Food poisoning can be from chemical or biological sources. If we eat food that contains harmful chemicals, or biological toxins (poisons) from plants, animals or microorganisms, that food can make us sick. Some common sources of food poisoning are caused by contaminants already in the food when the raw materials are harvested, for example:

- Bacterial toxins produced by bacteria such as *Clostridium botulinum* and *Clostridium perfringens*, which are commonly found in the natural environment, e.g. in soil.
- Chemical toxins, e.g. insecticides sprayed onto growing crops.
- Heavy metals, e.g. lead and mercury, particularly in fish caught near chemical processing facilities.
- Certain toxic plant tissues, e.g. poisonous mushrooms.
- Toxic animal tissues, e.g. the poison glands of certain fish, crabs, etc.

Chemical food poisoning can also occur if foodstuffs have been in contact with toxic chemicals during food production, processing, storage and handling. The symptoms of food poisoning can range from mild headache to severe flu-like symptoms. The most common signs and symptoms are nausea, stomach cramps, diarrhoea, fever, chills and vomiting. A person with food poisoning may have any combination of these symptoms depending on the cause or the agent involved. The illness may begin from 1 to 72 hours after eating the food.

2.3.2 Food infection

Food infection occurs as a result of ingestion of pathogenic microorganisms with food. The ingested microorganisms multiply in the gut and can cause diseases like diarrhoea, typhoid fever and cholera; intestinal parasites can cause diseases such as amoebiasis and taeniasis (tapeworm disease); and **zoonotic** foodborne diseases (i.e. those that are transmitted to humans from other animals), e.g. anthrax and bovine tuberculosis. Food-borne diseases may be classified as:

Food-Borne Intoxications

Food-borne intoxications are caused :

1. Due to naturally occurring toxins in some foods, including
   - i. Lathyrism (beta-oxalyl amino-alanine)
   - ii. Endemic ascitis (Pyrrolizidine alkaloids)
2. Due to toxins produced by certain bacteria, including
   - i. Botulism

   ii. Staphyloccal toxins
3. Due to toxins produced by some fungi, including
   i. Aflatoxin
   ii. Ergot
   iii. Fusarium toxins
4. Due to toxins produced by some algae, like
   i. Planktonic dinoflagellates
   ii. Diatoms

Food-Borne Infections

Food-borne infections include:

1. Bacterial infections such as
   i. Salmonellosis
   ii. Shigellosis
   iii. *E. coli* diarrhoea
   iv. Cholera
   v. Streptococcal infection
   vi. Brucellosis
   vii. Listeriosis
2. Viral infections such as:
   i. Viral gastroenteritis
   ii. Hepatitis A
3. Parasitic infections such as
   i. Taeniasis
   ii. Trichinellosis

Check Your Progress 1

Note: a) Write your answer in about 50 words.
b) Check your answer with those given at the end of the unit.

1. Classify food borne diseases?

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....

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2. List down various types of food borne illness?

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....

....

2.4 TYPES OF MICROBIAL FOODBORNE DISEASES

Food borne diseases in humans, result from the consumption of either food or water contaminated with viable pathogenic bacterial cells (or spores in the case of infant botulism) or food containing toxins produced by toxigenic bacteria and molds. On the basis of mode of illnesses, these can be arbitrarily divided into three groups: intoxication or poisoning, infection, and toxico-infections.

2.4. 1 Intoxication

Illness occurs as a consequence of ingesting a preformed bacterial or mold toxin because of its growth in a food. A toxin has to be present in the contaminated food. Once the microorganisms have grown and produced toxin in a food, there is no need of viable cells during consumption of the food for illness to occur. Staph food poisoning is an example.

2.4.2 Infection

Illness occurs as a result of the consumption of food and water contaminated with enteropathogenic bacteria or viruses. It is necessary that the cells of enteropathogenic bacteria and viruses remain alive in the food or water during consumption. Viable cells, even if present in small numbers, have the potential to establish and multiply in the digestive tract to cause the illness. Salmonellosis and hepatitis A are examples.

Table 2.1 Infection and intoxication

Infection	Intoxication
Microorganisms gains access to the food	Microorganisms produce toxins in the food
↓	↓
Consumption of the contaminated food item	Food item might be heated to the point the microbes are killed
↓	↓
Microorganisms multiply and infect the digestive system and causes illnessd	Heat resistant toxins are ot destroyed
	↓
	Toxins cause intoxication/ poisoning

2.4.3 Toxicoinfection

Illness occurs from ingesting a large number of viable cells of some pathogenic bacteria through contaminated food and water. Generally, the bacterial cells either sporulate or die and release toxins to produce the symptoms. *Clostridium perfringens* gastroenteritis is an example. In addition to the pathogenic microorganisms associated with foodborne illnesses, some bacterial species and strains normally considered nonpathogenic can cause gastroenteritis, especially in susceptible individuals. They are designated as opportunistic pathogens. They are normally required to be alive and present in large numbers when consumed through a contaminated food.

2.5 CAUSES OF FOODBORNE ILLNESSES

The majority of food borne illnesses is caused by harmful bacteria and viruses. Some parasites and chemicals also cause foodborne illnesses. Table 2.2 gives the group of food borne pathogens.

i) Bacteria

Some harmful bacteria may already be present in foods when they are purchased. Raw foods including meat, poultry, fish and shellfish, eggs, unpasteurized milk, dairy products and fresh produce often contain bacteria that cause foodborne illnesses. Bacteria can contaminate food making it harmful to eat at any time during growth, harvesting or slaughter, processing, storage and shipping. Foods may also be contaminated with bacteria during food preparation in a restaurant or home kitchen. If hot food is not kept hot enough or cold food is not kept cold enough, bacteria may multiply. Bacteria multiply quickly when the temperature of food is between 40 and 140 degrees Fahrenheit. Bacteria multiply more slowly when food is refrigerated and freezing food can further slow or even stop the spread of bacteria. However, bacteria in refrigerated or frozen foods become active again when food is brought to room temperature. Cooking food thoroughly kills bacteria.

Salmonella is found in many foods, including raw and undercooked meat, poultry, and dairy products and seafood. Salmonella may also be present on egg shells and inside eggs. *Campylobacter jejuni* is found in raw or under-cooked chicken and unpasteurized milk. *Shigella* spreads from person to person. These bacteria are present in the stools of people who are infected. If people who are infected do not wash their hands thoroughly after using the toilette, they can contaminate food that they handle or prepare. Water contaminated with infected stools can also contaminate produce in the field. *Escherichia coli (E. coli)*, which includes several different strains among them only a few cause illness in humans. *E. coli* O157:H7 is the strain that causes the most severe illness. Common sources of E. coli include raw or undercooked hamburger, unpasteurized fruit juices and milk and fresh produce. *Listeria monocytogenes* is found in raw and undercooked meats, unpasteurized milk, soft cheeses and ready-to-eat deli meats and hot dogs. *Vibrio* may contaminate fish or shellfish. *Clostridium botulinum* may contaminate improperly canned foods and smoked and salted fish. The following are examples of bacterial hazards found in food:

Table 2.2 Bacterial hazards found in food

Microorganism	Hazard
Clostridium botulinum (sporeformer)	Causes an intoxication that affects the central nervous system and causes shortness of breath, blurred vision, loss of motor capabilities and death.
Listeria monocytogenes (nonsporeformer)	Causes an infection with mild flulike symptoms. Severe forms of listeriosis are possible in people with weakened immune systems, causing septicemia, meningitis, encephalitis and stillbirths.

Salmonella spp. (nonsporeformer)	Causes an infection with the following symptoms: nausea, vomiting, abdominal cramps, diarrhea, fever and headache. Death is possible in people with weakened immune systems.

Source: Adams and Moss (2008).

ii) Virus

Viruses are present in the stools or vomitus of people who are infected. People who are infected with a virus may contaminate food and drinks, especially if they do not wash their hands thoroughly after using the toilette. Common sources of foodborne viruses include:

- food prepared by a person infected with a virus
- shellfish from contaminated water
- produce irrigated with contaminated water

Common foodborne viruses include:

- Norovirus, which causes inflammation of the stomach and intestines
- hepatitis A, which causes inflammation of the liver.

iii) Parasites

Cryptosporidium parvum and *Giardia intestinalis* spread through water contaminated with the stools of people or animals who are infected. Foods that come into contact with contaminated water during growth or preparation can become contaminated with these parasites. Food preparers who are infected with these parasites can also contaminate foods if they do not thoroughly wash their hands after using the toilette and before handling food. *Trichinella spiralis* is a type of roundworm parasite. People may be infected with this parasite by consuming raw or under-cooked pork or wild game.

iv) Mold

Molds are microscopic fungi that can live on plants and animals. Most molds spoil foods. Some form toxins that can cause illness. Molds can grow in a wide range of foods Unlike bacteria, mold can growing foods that are high acid and low moisture. Freezing does not destroy molds. Some molds cause allergic reactions and respiratory problems. And a few molds, in the right conditions, produce mycotoxins (or poisons) that can make you sick. Mycotoxins are produced by certain molds found primarily in grain and nut crops, but are also known to be on celery, grape juice, apples, and other produce. However, not all molds are harmful.

iv Chemicals

Chemical hazards can be separated into three categories:

- Naturally occurring chemicals.
- Intentionally added chemicals.
- Unintentionally or incidentally added chemicals.

Chemical hazards are

- Harmful chemicals that cause illness may contaminate foods such as fish or shellfish, which may feed on algae that produce toxins, leading to high concentrations of toxins in their bodies.
- Certain types of wild mushrooms.
- Unwashed fruits and vegetables that contain high concentrations of pesticides.

Types of Naturally Occurring Chemical Hazards:

- Mycotoxins (e.g., aflatoxin)
- Scombrotoxin
- Ciguatoxin
- Shellfish toxins
- Paralytic shellfish poisoning (PSP)
- Diarrheic shellfish poisoning (DSP)
- Neurotoxic shellfish poisoning (NSP)
- Amnesic shellfish poisoning (ASP)/Domoic Acid

Chemical hazards

- Amnesic shellfish poisoning (ASP)/Domoic Acid

Table 2.3 Group of food borne pathogens.

Flatworms	**Roundworms**
Flukes	*Trichinella*
Fasciola	*Ascaris*
Fasciolopsis	*Anisakis*
Paragonimus	*Pseudoterranova*
Clonorchis	*Toxocara*
Tapeworms	
Diphyllobothrium	
Taenia	
Pseudoterranova	
Protozoa	**Fungi—mycotoxin producers**
Giardia	Aflatoxins
Entamoeba	Fumonisins
Toxoplasma	Alternaria toxins
Sarcocystis	Ochratoxins
Cryptosporium	
Cyclospora	

Bacteria	**Viruses**
Gram positive	Hepatitis A
Staphylococcus	Small round structured viruses (SRSVs)
Bacillus cereus	Rotaviruses
B. anthracis	**Prions**
Clostridium botulinum	Creutzfeldt-Jakob disease (new variant form)
C. perfringens	**Toxigenic phytoplanktons**
Listeria monocytogenes	Paralytic shellfish poison
Mycobacterium paratuberculosis (?)	Domoic acid
Gram negative	*Pfiesteria piscicida*
Salmonella	Ciguato
Shigella	
Escherichia	
Yersinia	
Vibrio	
Campylobacter	
Aeromonas	
Brucella	
Plesiomonas	

Table 2.4 Microbial Foodborne Diseases and Causative Pathogens

Type of Disease	Causative Microorganism	Microbial Group	Major Symptom Type
Intoxication			
Staph poisoning	Sta. aureus strains	Bacteria, Gm+[a]	Gastric
Botulism	Clo. Botulinum strains	Bacteria, Gm+	Nongastric
Mycotoxin Poisoning	Mycotoxin-producing mold strains, e.g. *Asp. flavus*	Molds	Nongastric
Infection			
Salmonellosis	Over 2000 Salmonelia Serovars (except *sal. typhi and sal. paratyphi*)	Bacteria, Gm-[a]	Gastric
Campylobacter enteritis	Camphylobacter jenuni and *Cam. Coli* strains	Bacteria, Gm-	Gastric
Yersiniosis	Pathogenic strains of *Yer. enterocolitica*	Bacteria, Gm-	Gastric
Enterohemorrhagic	*Esc. Coli* 0157:H7	Bacteria, Gm-	Gastric and nongastric

Escherchia coli Colitis			
Nonhemorrhagic *Escherchia coli* Colitis	Shiga-like toxin (verotoxin) producing *Esc. Coli* strains such as *Esc. Coli* 026:H11	Bacteria, Gm-	Gastric
Listeriosis	*Lis. Monocytogenes* (pathogenic strains)	Bacteria, Gm+	Gastric and nongastric
Shigellosis	Four Shigella species (e.g., *Shi. Dysenterie*)	Bacteria, Gm-	Gastric
Vibrio *Parahaemolyticus* Gastroenteritis	Pathogenic strains of Vib. *parahaemolyticus*	Bacteria, Gm-	Gastric
Vibrio vulnificus Infection	*Vib. Vulnificus* strains	Bacteria, Gm-	Gastric and nongastric
Brucellosis	Brucella abortus	Bacteria, Gm-	Gastric and Nongastric
Viral infection	Pathogenic enteric viruses (e.g., Hepatitis A virus)	Viruses	Gastric and nongastric
Toxicoinfection			
Clostridium Perfringens Gastroenteritis	*Clo. Perfringens strains*	Bacteria, Gm+	Gastric
Bacilus cereus Gastroenteritis	*Bac. Cereus strains*	Bacteria, Gm+	Gastric
Escherchia coli Gastroenteritis	Enteropathogenic and enterotoxigenic Esc. coli strains	Bacteria, Gm-	Gastric
Cholera	Pathogenic strains of Vib. *Cholerae*	Bacteria, Gm-	Gastric
Gastroenteritis by Oppotunist Pathogens			
Aeromonas Hydrophilia Gastroenteritis	*Aer. Hydrophila* strains	Bacteria, Gm-	Gastric
Plesiomonas Shigelloides Gastroenteritis	*Ple. Shigelloides* strains	Bacteria, Gm-	Gastric

[a] Gm+, Gm-: Gram-positive and –negative, respectively.

Source: Adams and Moss (2008).

2.6 SYMPTOMS

Foodborne illness can result in minor symptoms such as nausea and vomiting, although some cases result in hospitalization and even death. General symptoms of foodborne illness include severe gastric distress, with accompanying diarrhea or vomiting, or both. Table 2 shows symptoms, incubation times (time from consumption of the contaminated food to onset of symptoms), and sources of different foodborne pathogens that most often cause illness in the United States.

The difference in the range of symptoms may be due to the severity of the contamination of the food, the virulence or strength of the pathogen, the amount of contaminated food ingested by the consumer, and whether the consumers fall into the highly susceptible or immune compromised population. The term immune compromised refers to individuals with feeble immune systems, such as persons battling various illnesses, infants, pregnant women, and the elderly.

Symptoms of foodborne illnesses depend on the cause. Common symptoms of many foodborne illnesses include

- vomiting
- diarrhea or bloody diarrhea
- abdominal pain
- fever
- chills

Symptoms can range from mild to serious and can last from a few hours to several days. C. *botulinum* and some chemicals affect the nervous system, causing symptoms such as

- headache
- tingling or numbness of the skin
- blurred vision
- weakness
- dizziness
- Paralysis

Complications

Foodborne illnesses may lead to dehydration, hemolytic uremic syndrome (HUS) and other complications. Acute foodborne illnesses may also lead to chronic or long lasting health problems. When the affected person does not drink enough fluids to replace those that are lost through vomiting and diarrhoea, dehydration can result. When dehydrated, the body lacks enough fluid and electrolytes minerals in salts, including sodium, potassium, and chloride to function properly. Infants, children, older adults, and people with weak immune systems have the greatest risk of becoming dehydrated.

Signs of dehydration are:

- excessive thirst
- infrequent urination
- dark-colored urine
- lethargy, dizziness, or faintness

Signs of dehydration in infants and young children are:

- dry mouth and tongue
- lack of tears when crying
- no wet diapers for 3 hours or more
- high fever

- unusually cranky or drowsy behaviour
- sunken eyes, cheeks, or soft spot in the skull

Also, when people are dehydrated, their skin does not flatten back to normal right away after being gently pinched and re-leased. Severe dehydration may require intravenous fluids and hospitalization. Untreated severe dehydration can cause serious health problems such as organ damage, shock, or coma a sleeplike state in which a person is not conscious.

2.7 STRATEGIES FOR CONTROL OF FOOD BORNE ILLNESS

The contamination of food is influenced by multiple factors and may occur anywhere in the food production process. However, most of the foodborne illnesses can be traced back to infected food handlers. Therefore, it is important that strict personal hygiene measures should be adopted during food preparation. To prevent foodborne infections in children, educational measures are needed for parents and care-takers. The interventions should focus on avoiding exposure to infectious agents and on preventing cross-contamination. Good agriculture practice and good manufacturing practice could be adopted to prevent introduction of pathogens into food products. In order to control foodborne viral infections, it is important to increase awareness of food handlers regarding the presence and spread of these viruses. In addition, standardized methods for the detection of foodborne viruses should be utilized and laboratory-based surveillance should be established for early detection of outbreaks. To prevent food-related zoonotic diseases, collaboration between public health, veterinary and food safety experts should be established. This collaboration will help in monitoring trends in the existing diseases and in detecting emerging pathogens. It will help in developing effective prevention and control strategies. The control strategies should be based on creating awareness among the consumers, farmers and those raising farm animals. The improvement of farming conditions, the development of more sensitive methods for detection of pathogens in slaughtered animals and in food products, and proper sewage disposal are other intervention strategies. Hygienic measures are required throughout the continuum from "farm to fork". Proper processing of food is necessary to ensure the reduction or elimination of the growth of harmful microorganisms. Pasteurization of milk and dairy products and hygienic manufacturing processes for canned foods will help reduce the cases of food-borne illnesses. Foodborne illnesses also play an important role in new and emerging infections. Various new pathogens have emerged due to changing dynamics of food industry. It is important to monitor and investigates the foodborne illnesses in order to control and prevent them.

2.8 SEQUENCE OF EVENTS IN A FOOD BORNE DISEASE

For a foodborne disease to occur, several events have to happen in sequence. Understanding these sequences are helpful to investigate the cause (source and means of transmission) of a foodborne disease. It also helps recognize how the sequence can be broken in order to stop a foodborne disease. Initially, there has to be a source of a pathogen. Next, the pathogen has to contaminate a food. Consumption of the food contaminated with a pathogenic virus can lead to viral infection. For bacterial pathogens (and toxicogenic molds) the contaminated food has to support growth and be exposed for a certain period of time at a suitable temperature to enable the pathogens to grow. However, for some potent pathogens (such as *Esc. coli* O157:H7), growth may not be necessary to cause a foodborne infection. For intoxication, growth should reach a sufficient level to produce enough toxins so that when the food is consumed, the individual develops the symptoms. For bacterial infection, viable cells of a pathogen need to be consumed in sufficient numbers, which vary greatly with pathogens, to survive stomach acidity, establish in the digestive tract, and cause illness. For toxicoinfection, viable cells should be consumed either in very high numbers (for those that cannot multiply in the digestive tract, such as *Clo. perfringens*) or in reasonable numbers (for those that can multiply in the digestive tract, such as *Vibrio cholerae*) so that toxins released by them in the digestive tract can produce the symptoms.

Check Your Progress 2

Note: a) Write your answer in about 50 words.

b) Check your answer with those given at the end of the unit.

1. Explain the concept of traceability.

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2. Describe sequence of events leading to a food borne disease.

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2.9 LETS SUM UP

Foodborne diseases are a widespread and growing public health problem, both in developed and developing countries. In 2000 the World Health Assembly recognized that the prevention and control of foodborne diseases is an important public c health issue. The direct and indirect economic costs associated with foodborne disease are known to be high, but actual quantitative estimates are difficult to obtain. It is essential to have the best possible estimates of the economic costs that are based on the cost benefit analysis of measures so that policy makers can take measures to prevent incidence of foodborne disease. Though the socioeconomic impact of foodborne diseases is very high, there are limited effective measures to reduce them. Moreover the burden due to foodborne disease is not fully understood. According to WHO, food safety should be considered as an integral part of the primary health care delivery system. To prevent both ongoing transmissions of diseases and similar outbreaks in the future, strengthening of food safety policies and programmes, acquisition of epidemiological data for risk assessment of foodborne pathogens should be done. There is a need to increase awareness pertaining to recognition of food spoilage, foodborne disease and its symptoms and development of effective food control measures.

2.10 KEY WORDS

Contamination: The presence of an infectious, chemical, or physical agent or substances in or on water, milk, and food that has the potential to cause harm, including illness or injury.

Epidemic: The occurrence of more cases of disease than expected in a given area or among a specific group of people during a particular period of time.

Infection: The entry and development of multiplication of an infectious agent in the body of man or animals. Infection is not synonymous with infectious disease: the result may not be apparent or manifest.

Pathogen: An organism capable of causing disease.

Vector: An animate intermediary in the indirect transmission of an agent that carries the agent from a reservoir to a susceptible host.

2.11 REFERENCES AND SUGGESTED FURTHER READINGS

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2.12 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress 1

1. Your answers should include the following points:
   - Food borne diseases are divided into two broad categories: food poisoning and food infections**.**
   - **Food poisoning** can be from chemical or biological sources.
   - **Food infection** occurs as a result of ingestion of pathogenic microorganisms with food.
2. Food-borne infections include:

   Bacterial infections such as

   i. Salmonellosis

   ii. Shigellosis

   iii. *E. coli* diarrhoea

   iv. Cholera

   v. Streptococcal infection

   vi. Brucellosis

   vii. Listeriosis

Viral infections such as:

i. Viral gastroenteritis

ii. Hepatitis A

Parasitic infections such as

i. Taeniasis

ii. Trichinellosis

Answers to Check Your Progress 2

1. Your answer should include following points:

   Symptoms of foodborne illnesses depend on the cause. Common symptoms of many foodborne illnesses include:

   - vomiting
   - diarrhea or bloody diarrhea
   - abdominal pain
   - fever
   - chills

2. Your answer should include following points:

   - Source of a pathogen.
   - Pathogen has to contaminate a food
   - Consumption of the food contaminated with a pathogen

UNIT 3 DISEASE TRANSMISSION BETWEEN HUMANS AND ANIMALS

Structure

3.0 INTRODUCTION

Since ancient times, animals have shared an area in the lives of human, pets as companion, wildlife for hunting or as food animals. These animals apart from providing benefits to people are responsible for spreading many diseases. These diseases are known as zoonotic diseases. The term ‘zoonosis’ was coined in 1885, by a German physician, Rudolf Virchow. The Joint Expert Committee of WHO and FAO (1959) defined the zoonoses as “those diseases and infections which are naturally transmitted between vertebrate animals and man”. Every year people fall sick due to such diseases. More than 200 diseases are now recognized as zoonoses and the list is still increasing due to better diagnostic facilities and newer human— animal interactions. Due to these interactions and changes brought about in the ecological system throughout the globe, there is emergence and reemergence of zoonotic diseases. Zoonotic diseases not only constitute a major public health problem but also prevent the efficient production of food of animal origin besides hindering the international trade in animal products thereby causing heavy economic losses. Almost all the sections of the society are likely to be exposed to different zoonotic diseases. Agriculturists, veterinarians, butchers, laboratory workers, hunters and many more occupational groups are at the higher risk of being affected by these diseases.The world zoonoses day is celebrated on the **6th of July** every year to create awareness among public and to educate them the preventive and control measures on exposure. This chapter deals with various aspects of important zoonotic diseases.

3.1 OBJECTIVES

After studying this unit you should be able to:

- define zoonoses and explain its significance;
- classify zoonoses on various bases;
- describe the routes of transmission;
- explain the role of animals and birds in disease transmission;
- explain the factors influencing emergence and reemergence of zoonotic diseases; and
- describe the methods of prevention and control.

3.2 CLASSIFICATION OF ZOONOSES

Zoonotic diseases can be classified on various basis but the common bases are as follows-

3.2.1 On the Basis of Etiological Agents

a) Bacterial (e.g. Brucellosis, leptospirosis, listeriosis)

b) Viral (e.g. Rabies, Japanese encephalitis)

c) Rickettsial and Chlamydial (e.g. Q fever, Scrub typhus, ornithosis)

d) Mycotic (e.g. Dermatophytosis, Cryptococcosis, Histoplasmosis)

e) Parasitic (e.g. Toxoplasmosis, Visceral larva migrans, Hydatidosis).

3.2.2 Based on Transmission Cycle

This classification has lot of educational value and is based on the type of life cycle of the infective organism.

(1) ***Direct zoonoses***. These zoonotic diseases are perpetuated in nature by only a single vertebrate species. Zoonotic diseases **transmitted directly from the infected to the susceptible host** by contact (anthrax, brucellosis), vehicle (food taeniasis, air-tuberculosis) or mechanically by a vector,

without undergoing any development of pathogen or propagation in the course of transmission are classified under direct zoonoses. **Examples:** Bovine and ovine brucellosis by contact, Anthrax by contact and touch, Rabies by bite, Ringworm by touch, Salmonellosis by vehicle.

Direct zoonoses can be any one of the following type:

(a) ***Direct-anthropozoonoses:*** The lower vertebrates (domestic and wild animals) are the reservoir hosts for many infectious zoonotic pathogens and these reservoirs transmit infections to the human beings by accidental exposures or direct contact with infected population or contaminated materials. Eg. Rabies, anthrax.

(b) ***Direct-zooanthroponoses:*** Zoonotic diseases transmitted from human beings to the lower vertebrates animals by direct contact with infected person or contaminated materials. Eg:Diphtheria, Tuberculosis

(c) ***Direct-amphixenoses*:** Zoonotic diseases maintained in nature either in animal population or in human population are transmitted in both directions by direct contact with infected population or contaminated materials. Eg: Streptococcosis, Staphylococcosis

(2) ***Cyclozoonoses***. These zoonotic diseases require two or more vertebrate hosts to complete transmission cycle of an infectious agent. Depending upon the involvement of man, it can be obligatory or non-obligatory. Eg. Japanese encephalitis, Hydatidosis, Bovine cysticercosis, Trypanosomiosis, Nairobi sheep disease, Leishmaniosis.

(a) ***Obligatory cyclozoonose:.*** In these diseases, man is essential or compulsory host for completion of life cycle. e.g. *Taenia solium, Taenia saginata*

(b) ***Non-obligatory cyclozoonoses:*** Man is an accidental or non essential host in the completion of the life cycle. Many a times, these zoonoses form *cul-de-sac* in man.e.g. Hydatidosis (*Echinococcus granulosus*).

3. ***Metazoonoses***. In this, both vertebrate and invertebrate species are involved in the completion of the life cycle. In the invertebrate hosts (biological vectors), infectious agent may multiply (propagative), develop (developmental) or both (cyclopropagative). Depending on the number of vertebrates or invertebrates involved in the perpetuation of the cycle, metazoonoses have been further divided into four subgroups.

a. ***Metazoonoses type I:*** One vertebrate and one invertebrate host. e.g. Yellow fever, plague

b. ***Metazoonoses type II:*** One vertebrate and two invertebrate hosts. e.g. Paragonimiasis

c. ***Metazoonoses type III:*** Two vertebrate and one invertebrate hosts. e.g. Clonorchiasis

d. ***Metazoonoses type IV:*** It is the type of transovarian life cycle of zoonotic pathogen in ticks and transmission to human beings. e.g. Tick-borne encephalitis.

4. ***Saprozoonoses.*** The diseases which require a non-animate object (food, soil, clothing, water, grass, plants etc) as reservoir or source of an infectious agent for completion of life cycle in addition to vertebrate or invertebrate

host. An infectious agent may propagate (histoplasmosis), develop (*Ancylostoma brazilliense*) or develop and propogate (fascioliosis) in an inanimate site. It is subdivided into 3 types -

(a) ***Saproanthropozoonoses:*** Zoonotic infections are normally transmitted between lower vertebrates and fomites and involvement of human population is only accidental. e.g. Cutaneous larva migrans, Ancylostomiasis.

(b) ***Saproamphixenoses:*** These diseases can persist independently in nature in man and animals but are transmitted through inanimate objects. eg. Histoplasmosis, fungal infections

(c) ***Saprometanthrapozoonoses:*** These diseases require vertebrate host, invertebrate host and inanimate object for completion of transmission cycle. e.g. Fascioliasis.

3.2.3 Based on Reservoir Hosts

a) ***Anthropozoonoses***. Zoonotic diseases primarily transmitted from the lower vertebrate animals to human beings are called anthropozoonotic diseases. These are diseases of domestic and wild animals which occur in nature independent of man. Human beings get infected through occupational contact or food. Humans are generally dead end host (dead end for the pathogen as further man to man or man to animal propagation does not occur). Socio-cultural barriers may influence the transmission of these zoonoses rather than biological barriers.e.g. Brucellosis, Anthrax,Leptospirosis, tularemia, Rift valley fever, hydatidosis, rabies.

b) ***Zooanthroponoses***: Zoonotic diseases transmitted from human beings to the lower vertebrate animals are called zooanthroponotic diseases.e.g. Tuberculosis (Human type), amoebiasis, diphtheria (Human type).

c) ***Amphixenoses***: Zoonotic diseases which may be transmitted in either direction, i.e. human beings to animals or animals to human beings called amphixenotic diseases.The infection can persist independently in human and animal population. e.g. Streptococcosis, non-host specific salmonellosis, staphylococcosis.

3.3 TRANSMISSION OF ZOONOSES

These zoonoses may be transmitted though horizontal (most common) or vertical mode of transmission. The entry of pathogens may be through various routes such as ingestion (salmonellosis), contact (brucellosis), inhalation (tuberculosis), iatrogenic (tetanus) or coitus (brucellosis).

3.3.1 Routes of Transmission

Transmission of zoonoses from the reservoir or source of infection to a susceptible host occurs in many different ways. The diseases may be transmitted from animals to humans or cross-sectionally among members of a group in direct as well as indirect way.

(A) ***Direct transmission***

Transfer of infectious agents from the infected animals to the susceptible human population by direct contact without involvement of intermediate vectors.

1. *By direct contact.* Some diseases are transmitted by direct contact between the source of infection and the susceptible host. e.g. Leptospirosis, dermatophytosis, vibriosis, anthrax, foot and mouth diseases, cow pox, orf..

2. *Droplets or Droplet nuclei.* Droplets or droplet nuclei carry infectious organisms which get transmitted to the susceptible host through sneezing, coughing or through contact with the mucous membrane. e.g. Tuberculosis, common cold, diphtheria.

3. *Contact with soil.* Exposure of susceptible tissues to disease agent present in soil or decaying matter. E.g. anthrax, hookworm infection, tetanus.

4. *Bite of an animal.* Animal bites or scratches by infected animals transmit some zoonotic diseases.e.g. Rabies.

5. *Transplacental / vertical transmission:* Transmission of infection from one generation to other i.e. from mother to offspring. E.g. Toxoplasmosis, Hepatitis-B virus.

(B) ***Indirect transmission***

Transmission of infectious pathogens from the infected to the susceptible host by an intermediate vector (animate or inanimate).

1. ***Vector-borne transmission:*** A vector, usually an arthropod or any living carrier (e.g. snail) transmits an infectious agent to a susceptible host either mechanically or biologically.

(a) ***Mechanical transmission:*** An infectious agent is mechanically transmitted without any development or multiplication of the infectious agent on or within the vector. e.g. Amoebiasis, serum hepatitis, cholera.

(b) ***Biological transmission****:* An infectious agent undergoes growth, multiplication or both in vector before transmitting the disease. The time period between ingestion and transmission of infectious agents is referred to as **'extrinsic incubation period'**.

Biological transmission is of four types-

(i **Propagative type:** The infectious agent merely multiplies in the vector, but does not grow. e.g. Plague bacilli in rat fleas.

(ii) **Cyclo-propagative type:** The infectious agent undergoes both growth and multiplication in the vector. E.g. Malaria parasites in mosquitoes.

(iii) **Developmental type:** The infectious agent undergoes only development but no multiplication.e.g. Microfilaria in mosquitoes.

(iv) **Transovarian type:** The agent is transmitted vertically from one generation to other. e.g. Tick borne encephalitis.

2. ***Vehicle-borne transmission:*** Vehicle borne transmission implies transmission of infectious pathogens between infected and susceptible host through non-living things or substance (food, water, blood, body fluids, serum, plasma, tissues, and organs).Infectious agent may be transmitted mechanically or biologically (developmental, propagative or cyclopropagative) through the vehicle. e.g. Water - Hepatitis A virus, Meat - Salmonellosis, *Trichinella spiralis,* Milk -Tuberculosis, brucellosis, Fish - *Diphyllobothrium latum, Vibrio parahaemolyticus,* Blood - Hepatitis B virus, Organ - Cytomegalo virus in kidney transplants.

3. ***Air borne transmission:*** It occurs through transmission of infectious pathogens between infected and susceptible host through dust and droplet nuclei in the air. The droplet nuclei are the minute particles formed either by coughing, sneezing, in laboratory, slaughterhouse or autopsy room. These droplet nuclei do not settle down easily and therefore remain suspended in the air for a long time with farther dissemination. e.g. Tuberculosis, Q-fever. Dusts are larger droplets expelled during talking, coughing or sneezing but settle down along with dust. e.g. Streptococcal infection, fungal spores.

4. ***Fomite-borne infections:*** Transmission of infectious agents through inanimalte objects i.e.fomites (soil, clothes, towels, cups, glasses, spoons, door handles, lavatory chains etc.). e.g. Diphtheria, typhoid fever, skin infections.

3.3.2 Transmission Cycles

Zoonotic diseases are maintained in the nature by propagating through three main transmission cycles.

a) ***Sylvatic cycle****:* The cycle in which the pathogen is confined to wild vertebrates in forests and propagates among wild animals. The agent gets transmitted to humans when he enters the forest ecosystem as hunters / forest rangers or to domestic animals that stray in the forest. Eg. Kyasanoor forest disease, monkey pox etc.

b) ***Synanthropic cycle:*** The pathogens occur and propagate in domestic animals via synanthropic animals like rodents, birds and lizards which exist in association with humans or around human dwellings. Thus, man gets exposed to diseases maintained in the synanthropic cycle. Eg. Plague, tularemia etc.

c) ***Human cycle:*** These infections persist in nature in man to man cycle and can also pass from man to animals. Eg. Human tuberculosis though the transmission from man to animals is rare.

Check Your Progress 1

Note: a) Write your answer in about 50 words.

b) Check your answer with those given at the end of the unit.

1. Explain Metazoonosis. Describe with suitable example.

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2. Write in brief the major routes of transmission.

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3. Describe briefly the maintenance of a zoonotic agent perpetuating in s . sylvatic animals.

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3.4 ROLE OF DOMESTICATED, DOMICIALATED, WILD AND COLD BLOODED ANIMALS IN TRANSMISSION OF ZOONOSES

Many animals kept as household pets may act as a source of infection for their owners. The role of domestic animals in the epidemiology of many zoonoses such as rabies, leptospirosis, *Toxocara* infections etc is highly important. Cats act as reservoirs for toxoplasmosis and cat scratch disease. Domestic animals harbour many infectious diseases in subclinical form. The role of domicialated animals (animals that live in close association with human dwelling (e.g. rats, rodents, mice, bandicoots, badger etc.) in transmission as well as maintenance of zoonotic diseases is worth mentioning. Pulmonary or bubonic plague is an excellent example wherein rodents act as source/reservoir for plague bacilli. Other diseases such as leptospirosis, tularaemia, rabies, murine typhus, Q fever etc. also have rodents as reservoirs. Among the most important wild vertebrates involved in zoonoses are rats, mice and monkeys. Wild mammals play a role in zoonoses chiefly as reservoir hosts of arthropod-borne infections. Monkeys may be reservoirs of yellow fever, monkey pox and other viruses.

Wild ungulates, mule, deer, white-tailed deer, wapiti and bison have known to harbor*Sarcocystis*. Other important zoonotic infections reported from wild mammals include toxoplasmosis in captive animals; brucellosis in raccoons; leptospirosis in zoo animals; yersiniosis in wood mouse, tuberculosis in farmed deer; brucellosis and tuberculosis in bison; brucellosis, yersiniosis, tularemia, listeriosis and leptospirosis in field hares and salmonellosis in opossums. *Salmonella* spp., *Campylobacter jejuni*, *Mycobacterium avium* have been isolated from wild birds. *Yersinia* spp. were isolated from feces of black-headed gulls and swallows.

The wild birds especially migratory birds play a crucial role in the transmission of zoonotic infections. Tick vectors of diseases such as tick typhus, Crimean haemorrhagic fever, Q fever and tularemia could be recovered from birds flying between Africa and Europe or Asia. It is speculated that the introduction of Kyasanoor forest disease into India was due to migratory birds and a tick vector, *Haemophysalis spinigera*. Important cold-blooded vertebrates involved in zoonoses epidemiology are various fishes, lizards, snakes, toads, turtles and frogs. *Erysipelothrixinsidiosa* in marine fishes**;***Clostridium botulinum* type E, *C. septicum*, *C. sporogenes* and *C.perfringens* in fishes; *Listeria monocytogenes*, *Vibrioparahaemolyticus* in fish and fish products are some of the examples.

3.5 FACTORS CAUSING EMERGENCE OR RE-EMERGENCE OF ZOONOSES

The emergence, re-emergence, and spread of microbial threats are driven by a complex set of factors.Emerging zoonoses are defined as "diseases that are caused either by an apparently new agent or by a previously known organism that appears in places or in species in which it was previously unknown". A re-emerging disease is considered a known or endemic disease that either shifts its geographical setting or expands its host range, or significantly increases its prevalence. The factors responsible for its emergence can be

- **Microbial adaptation and change:**The pathogens under selective pressure may undergo changes and become more virulent or better adapted to people, or it may undergo changes that affect transmission patterns. Some may acquire resistance against antimicrobial products.Changes at molecular level (such as influenza virus undergoing genetic drift (minor changes) and shift (major changes)can evolve new strains resulting in increased epidemics in human population.

- **Change in immunological status of population:** Immunocompromised persons become more susceptible to some opportunistic and zoonotic pathogens. The susceptibility of hosts further aggravates due to malnutrition in less or underdeveloped countries.

- **Ecological changes and agricultural growth:** Environmental and social changes such as ecological changes caused by human activities like agriculture and modification of agricultural practices, migration, urbanization, deforestation, dam building, human demographic and behavioral changes, travel and trade, technology and industry as well as natural disasters like floods and earthquakes can lead to disease emergence.For instance, the deforestation in state of Karnataka and the grazing by cattle of this deforested areas led to the emergence of Kyasanoor forest disease. Irrigation being associated with the emergence of leptospirosis and Japanese encephalitis. A favorable warmer climate can allow vectors to survive and provide a much longer transmission period.

- **Movement of human population and changes in human behavior:** ranging from societal upheavals that causes people to leave urban areas to simple changes in food preferences. For example, the popularity of prewashed greens can facilitate some outbreaks of *E coli* O157:H7.

- **Rapid industrialization and urbanization:** Technologic and industrial changes in food production can contribute to disease emergence by increasing the concentration, movement, and mixing of animals. The development of large-scale farms and food-processing facilities has led to the exposure of greater numbers of people to a contaminated food source. Increased mobility of people, animals, and goods allows diseases to spread quickly. Viruses that formerly died out after affecting small numbers of animals and/or people can now find many susceptible hosts within a short period. The SARS coronavirus spread to 30 countries on 6 continents within months of the initial outbreak.

- **Increasing international trade in live animals and food:** It has led to increase in food borne zoonotic infections both in developed and developing countries.
- **Economic development and land use:** Deforestation and changing land use have disrupted the ecological habitats which in turn has changed the reservoirs abundance and transmission dynamics. Wild life has come closer to animals and humans thus enhancing the spread to new hosts and newer geographical area.
- **Breakdown of public health measures and deficiencies in public health infrastructure:** Breakdowns in public health measures such as sanitation and vaccination also increase the spread of disease.

3.6 PREVENTION AND CONTROL OF ZOONOSES

As zoonoses cause great public health problem, some basic preventive and control approaches can help minimize the effect on human and animal population. For food borne zoonoses, hazard management and good hygiene practices are seen as best approach. Similarly, vector borne zoonoses require elimination of vectors and breaking the transmission cycle of the infectious agents. Prevention means inhibiting the disease causing agent in the area or a definite population or in an individual while control refers to steps taken to reduce a disease problem to a tolerable level and maintain it at that level.

- **Detection of zoonotic disease in human and animal populations, identification of vectors, estimating the extent of infection and recognizing the influencing environmental factors.** This will enable to determine the endemic foci and plan the interventions needed to control.
- **Elimination of reservoirs:** Adopting isolation of sick, test and slaughter policy, depopulation or mass immunization can help prevent the susceptible population. It however, is impractical where the reservoirs are wild animals.
- **Elimination/control of vectors**: This can be done by applying planned insecticide spray campaigns.
- **Reducing contact potential:** by increasing herd immunity, bio-security measures, disinfection and sanitation and niche filling (presence of one organism within the niche can prevent its occupation by another organism)
- **Increasing host resistance:** by genetic selection of animals and chemoprophylaxis and immunization of animals and man. However, it may not be possible for every zoonotic disease.
- **Consumer safety**: Strict regulations and inspections e.g. meat inspection, adoption of food preservation methods and pasteurization of milk are must in case of food and food products. **The Food Safety and Standards Authority of India (FSSAI) e**stablished in 2011 under Food Safety and Standards, 2006 lays down science based standards for articles of food

and to regulate their manufacture, storage, distribution, sale and import to ensure availability of safe and wholesome food for human consumption.

- **Hazard analysis critical control point (HACCP):** management system also addresses issues regarding food safety through analysis and control of various biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product. These systems help in controlling food-borne zoonotic diseases.
- **Health education and public awareness:**
- Health workers, private practitioners, doctors and veterinarians and non-governmental organizations play an important role in spreading awareness and educate people about hygiene and sanitation particularly in rural community.

Check Your Progress 2

Note: a) Write your answer in about 50 words.

b) Check your answer with those given at the end of the unit.

1. Explain emerging and re-emerging zoonotic diseases giving suitable examples? What are the possible reasons for the occurrence of such diseases?

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2. What strategies can be adopted in general to prevent and control a disease in a population?

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3.7 IMPORTANT ZOONOTIC DISEASES

Some of the important zoonotic diseases broadly classified on the basis of etiological agents are discussed as follows

3.7.1 Bacterial Diseases

Several bacteria have been reported to cause disease in humans. The list has been increasing with the emergence and reemergence of some of them. Newer diagnostic tools have also led to identification of undiagnostic causative agents which has further added to the increasing figures. Public education, awareness and availability of diagnostic facilities within reach in the developing countries is must for knowing the true incidence of diseases and thus help in the prevention and control of such diseases.

I. Leptospirosis

Disease is also known as Autmnal fever, Cane cutter's disease, Canicola fever, Harvest fever, Infectious jaundice, Mud fever, Rice field worker's disease, Seven day fever, Swamp fever, Swine herd's disease, Walter fever, Weil's disease.

Leptospirosis is caused by a Group -1 spirochete of genus *Leptospira*. *Leptospirainterrogans* is parasitic and potentially pathogenic species. Leptospires can survive for weeks in soil and water frequently contaminated by urine of carriers, particularly if the pH is alkaline. In India, the disease is prevalent in almost all the species of domestic animals and in several rodent species. The common serotypes distributed among domestic animals include *L. hardjo* in case of cattle and sheep, *L. pomona* and *L.tarassovi* in pigs, *L. pomona* in horses and *L.icterohaemorrhagiae* and *L. canicola* in dogs. The mouse, vole, rat, mongoose, shrew, jackal, dog, pig, cat and cattle are the important reservoirs. In the animals, the pathogen survives well and shed in urine (mainly in herbivores). Fish, reptiles and birds have also been incriminated as carriers. The disease in animals is manifested by fever, jaundice, haemoglobinuria, abortion, still birth, repeat breeding and loss of milk production. Transmission of *Leptospira* occurs through contact with an environment contaminated by urine, aborted fetus and uterine discharge of reservoir host or other infected animals. *Leptospira* can also enter through abraded skin and mucous membrane during bathing or swimming in lake, river or canal polluted with the urine of infected animals. *Leptospira* are excreted in the urine of infected animals for a long time, often for an entire life time in case of rodents. Venereal transmission also occurs in rodents. Man is considered as "dead end host" but transplacental transmission has been reported.

The disease may manifest in human in two phases. First phase is septicaemic and second phase is due to immune response. In second phase (also known as *Weil's syndrome*) exhibit mild fever as blood infection disappears due to action of phagocytes, IgM and complement. The symptoms may gradually worsen leading to kidney and liver failure. Liver failure results in jaundice. Widespread haemorrhages occurs leading to anaemia, coma and finally death. "Red eye" (conjunctival suffusion due to immune reaction) is a constant and characteristic feature. The farm workers, sewer workers, fishermen and miners are at high risk of infection. Combinations of different approaches like rodent control, sanitation, proper management and immunization have been used to eradicate the disease from dairy and piggeries. Monovalent and multivalent vaccines are available for animal use. In man, the disease control measures include personal hygiene, sanitation, education and immunization.

II. Plague

The diseases also known as Black death, Mad rat disease, Mahamari (in northern India).

Plague is caused bya bacterium, *Yersinia pestis*. The disease has a history of causing pandemics but the global transmission has been low in recent years. A wide variety of species get affected (man, camel, deer, dog, cat, donkey, antelope, rabbit, rat, squirrel) with the disease. Rodents, mostly of genus- *Rattus* and *Bandicota* serve as the primary host. The black rat (*Rattus rattus*) and oriental rat flea (*Xenopsylla cheopis*) species are important reservoir and are responsible for disease transmission. Infected dogs (don't show any sign of illness) and cats (show signs of illness) act as indicator animals, and their seropositivity may be indicative of plague prevalence in an area. Human and animals get infected accidentally through interruption of rodent-flea-rodent cycle. The disease among rats spreads by feeding on their dead companions. Similarly, other animals also get infection through bite of infected fleas, through ingestion of contaminated hay and eating the infected rodents. Most of the animals including dogs, sheep and goats do not show any clinical symptoms of plague. However, rats develop intense haemorrhagic inflammation (*buboes) and infected cats characteristically show profound illness with swelling on the submandibular lymph nodes, swelling below the eyes, general lethargy, profuse sneezing with purulent exudate and rise in body temperature.

In humans, the transmission cycles may be:

(i) Domestic rodent— rat flea — man

(ii) Wild rodents — rat flea/direct contact — man

(iii) Wild rodents — rat flea — domestic rodent — rat flea — man

(iv) Man — human flea (*Pulex irritans*) — man

(v) Man — man by droplet infection

(vi) Through infected animals, particularly the rats during skinning and trapping.

(vii) Use of unlaundered, dirty clothings infested with fleas.

(viii) Bites of ticks, lice and bed bugs

(ix) Bites and scratches of infected cats.

In India, 3 species of the rat fleas namely *Xenopsylla cheopis*, *X. astia*, *X. brasiliensis* and gerbil flea - *Nosapsyllus nilgeriensis* act as vectors of the disease.

In humans, the disease manifests itself in three forms:

i) Bubonic plague - most prevalent form and characterized by intense haemorrhagic inflammation (*bubo) usually occurring in the groin(s) as flea-bites are common on the lower extremities.

ii) Pneumonic plague which is now rare but highly fatal disease involving the lungs.

iii) Septicemic plague characterized by rapidly progressive fever, hypotension and high mortality that is the terminal stage of both bubonic and pneumonic plague.

iv) Unusual forms are the *meningeal form* predominantly exhibited by fever and neck rigidity and the *cutaneous form* manifested by pustule, eschar, carbuncle or ecthyma gangrenosum accompanies a buboes.

Preventive and control measures include i) reduction of rodent and eradication of vectors, vaccination, isolation and immediate treatment of affected persons and health education.

III. Anthrax

Disease is also known asCharbon, Malignant pustule, Miltsiekte, Milzbrand, Ragpicker’s disease, Sang de rate, Splenic fever, Woolsorter’s disease.

Anthrax is caused by bacterial pathogen, *Bacillus anthracis*. The disease mainly affects domestic herbivores (cattle, sheep, goats and horses). Disease is characterized by sudden death, exudation of tarry uncoagulated blood from the mouth, nares and anus which is a characteristic symptom of this disease. Lesions found in this disease are splenomegaly, gelatinous infiltration of subcutaneous and subserous tissues, and malignant pustule or scab formation on skin. Anthrax spores are transmitted by contact with infected carcasses, hides, hairs or bone meal. In humans, the disease is manifested in cutaneous form which is the most most common form. Herbivores including domestic animals (cattle, sheep, goat and buffalo) as well as many wild species are highly susceptible to anthrax. Pigs, equines, dogs and camels are moderately susceptible; however, carnivores and birds are generally highly resistant to anthrax. Man is moderately resistant. The pathogen present in the body fluid of infected host when comes in contact of atmospheric air, forms highly resistant spores under favourable conditions which remain viable for about 40-60 years in contaminated soil and about 200±50 years in the bones of dead hosts. Disease transmission in herbivores, anthrax is mainly transmitted by ingestion of contaminated fodder/improperly processed feed (meat meal, bone meal, meat scraps), and also by inhalation of spores (particularly during wallowing) which may be dispersed in the environment by fomites or the wind. Carnivores get infected from ingestion of infected carcass/contaminated meat or through direct contact / indirect contact.

In man, transmission is through exposure to anthrax spores either through:

a. Direct contact of skin with infected animal (during animal husbandry and agricultural operations leading to close contact) or carcass (during post-mortem examination, rendering, slaughtering, dressing and removal and handling of hides and wool).

b. Inhalation of spores in dust clouds created from handling of dry hides, skins, bone, blood meal, meat meal etc. (leads to pulmonary anthrax).

c. Ingestion of meat from animals that have died of anthrax (leads to intestinal anthrax). Man to man transmission is rare

In animals, symptoms of the disease includes severe mucosal congestion leading to haemorrhages from mouth, anus and nares (pathognomic), high fever (40-41.6^{0}C in cattle), dyspnoea, generalized oedema , excitement or depression, anorexia, convulsions, staggering gait, diarrhoea/dysentery, abortion, blood stained milk and absence of rigor mortis. In herbivores, per acute form of the disease is highly fatal. The gastro-intestinal form is most common. Cutaneous anthrax can occur through bite of mechanical vectors or wound contamination; however, death usually occurs before carbuncles/scab develops.

In humans, incubation period varies from 10-24 hours. Clinically, the disease has three forms.

a. ***Cutaneous form (malignant pustule/eschar)*** caused by spores entering the skin through cuts and abrasions. The form is often self limiting and exhibited by the papule that becomes increasingly necrotic and later ruptures to painless, black scar or carbuncle surrounded by an oedematous zone.

b. ***Pulmonary form (wool sorter's disease)***caused by inhalation of airborne spores while handling raw wool, hides, bones, blood meal and meat meal. The form is characterized by fever, dyspnoea, pneumonia, emphysema and cardiac failure. Septicaemia is highly fatal causing death in few hours.

c. ***Intestinal form*** caused by ingestion of spores present in infected meat, milk or other foodstuffs. The characteristic scab or malignant carbuncle mostly occurs in the oropharynx, stomach, duodenum and upper ileum. The most common symptoms are nausea, vomiting, anorexia, fever, abdominal pain, watery to bloody diarrhoea and tenderness in right upper and lower quadrants. Prevention can be achieved by vaccinations of people at high risk. Proper disposal of carcass should be done.

IV. Brucellosis

Disease in man is known as Undulant fever, Malta fever, Gibraltar fever, Mediterranean fever, Mediterranean remittent fever. In animals, synonyms of the disease are Contagious abortion, Abortus fever, Infectious abortion and Epizootic abortion. In cattle, disease is also known as Bang's disease and in male sheep, the other name is Ram epididymitis. Brucellosis is a worldwide prevalent zoonotic disease caused by members of the Genus-*Brucella* which has six major species, of which four have zoonotic potential. The disease is caused by *Brucella abortus* in cattle, *B.melitensis* in sheep and goat, *B. suis* in swine, *B. canis* in dogs, *B.ovis in* sheep and *B. neotomae* in desert wood rat. *B. ovis* and *B.neotomae* are not known to be pathogenic to man. The disease causes huge economic loss. Of different species, *B. abortus* is the most widely spread species.

The disease shows high incidence and prevalence in animals of organized farm as compared to village herds. In man, *B. abortus* and *B. suis* infections occur mostly as an occupational disease while *B. melitensis* infection is primarily foodborne, associated with consumption of unpasteurized dairy products. Among all the species, *B. melitenesis* is the most prevalent species in man and causes more severe disease. The prevalence of brucellosis in man is higher in countries experiencing high occurrence of disease in sheep and goats.

Major source of infection are infected animals that excrete the organisms intermittently for many years. Infected bull remains fertile and excretes organisms during acute phase which may cease or become intermittent. The major route of infection in animals is through the mucous membranes of oropharynx, upper respiratory tract and conjunctiva. The disease in animals is characterized by abortion (usually in third trimester of pregnancy), retained placenta, orchitis, epididymitis and temporarily impaired fertility.Humans get infected byingestion of contaminated food, milk and water, inhalation, direct or indirect contact with infected material, accidental inoculation in conjunctiva or skin, and even through intact skin. Consumption of unpasteurized milk and contaminated dairy products prepared from unpasteurized milk constitute an important cause of brucellosis. In humans, the disease may be mild and self-limiting, or severe with prolonged incubation period (usually 1-3 weeks, may be several weeks to months).The disease may run an acute or a chronic course. In acute form of the disease, the symptoms range from lethargy, headache, muscular or articular pain, lack of sleep, anorexia, weakness, fatigue, night sweating, chills along with low grade fever (around 99^{o}F). The temperature may show an undulating pattern, hence, the name '*undulant fever*'.

Complications include toxaemia, thrombopenia, endocarditis and others. The chronic form of disease in man persists or recurs over a period of 6 months or more. Complications may be include thromobophlebitis, epididymorchitis, spondylitis and peripheral arthritis, particularly of hip, knee and shoulder but others may also be involved.

For effective control of the disease, test and segregation/slaughter policy should be adopted. Vaccination of animals with suitable vaccine in cattle, sheep, goats and pigs and adoption of hygienic measures can protect the persons at occupational risk.

V. Tuberculosis

Synonyms of the disease are Acnitis, Consumption, Great white plague, Great white scourge, Lupus vulgaris, Pearl disease, Pott's disease, Pthisis, Rajayakshman - the king of diseases (in Hindu texts), Scrofula, Scrofuloderma, Tuberculous caseous pneumonia, Yakshma.

Tuberculosis (TB) is one of the most widespread infectious diseases and leading cause of death due to single infectious agent among adults in the world. In the recent years, the disease has shown an increase in incidence as a co-infection with HIV (human immunodeficiency virus).

The tubercle bacilli that cause tuberculosis in animals and man belong to the genus – *Mycobacterium* and this genus has four species namely, *M. tuberculosis, M. bovis, M. africanum, M. microti* and *M. avium*. Various animal species play an important role in the maintenance of *M. bovis* in wildlife communities and the spread to domestic animals. Badgers (*Meles meles*), brushtail possums (*Trichosurus vulpecula*), deer (*Odocoileus virginianus*), bison (*Bison bison*) and African buffalo (*Syncerus caffer*) are examples of wildlife that are maintenance hosts of *M. bovis*. *M. tuberculosis* mainly affects man whereas *M. bovis* infects bovines mainly, other domestic and wild animals, and also in man. The tubercle bacilli from infected persons are effectively transmitted to the susceptible persons mainly through respiratory route. The transmission of *M. bovis* from animals to man takes place due to:

(i) Direct exposure to infected animal/carcass during work at farm/abattoir/ clinical (occupational exposure).

(ii) Ingestion of contaminated or unpasteurized milk, or raw or inadequately cooked meat from infected animals; and at times, contact with contaminated articles or dust.

Symptoms in animals are emaciation, cough, dry and harsh body coat, dull and sunken eyes, and sometimes diarrhea with capricious appetite, fluctuating body temperature, and at times, snoring due to involvement of retropharyngeal lymph node (generalized TB). In cutaneous form of the TB in animals, there is lumpy swelling, sometimes indicated by cording, occurs on the lower part of the front legs and rarely on hind legs.

In humans, clinical form of TB has 3 stages:

(i) ***Primary tuberculosis:*** The lung infection results in the formation of the tubercle which consists of a central core containing bacilli and enlarged macrophages, and an outer wall made up of fibroblasts and lymphocytes.

The centers may break down into necrotic, caseous lesions and gradually heal by calcification.

(ii) ***Secondary tuberculosis:*** The dormant bacilli from primary case can become reactivated. In chronic tuberculosis, the bacilli drain into the bronchial tubes and upper respiratory tract. The patient shows violent coughing, greenish or bloody sputum, fever, anorexia, weight loss, extreme fatigue, night sweats and chest pain.

(iii) ***Extrapulmonary tuberculosis:*** The tubercle bacilli may disseminate rapidly to other organs, as regional lymph nodes, kidneys, long bones, genital tract, brain and meninges.

Prevention includes pasteurization of milk. Vaccination of animals and routine screening of livestock at regular intervals should be made mandatory.

VI. Campylobacteriosis

Disease is also known by various other names likeAvian vibrionic hepatitis, *Campylobacter* enteritis, Vibrionic abortion and Vibrionic enteritis

Campylobacteriosis is one of the leading causes of bacterial gastroenteritis caused by members of the genus *Campylobacte*r which has mainly four species of zoonotic importance. *C. jejuni, C. coli, C. lari and C. upsaliensis*. *Campylobacter jejuni* has now become the most frequently reported organism from cases of bacterial gastroenteritis in humans in many countries The organisms are widely distributed in nature with most of their species adapted to intestinal tract of warm-blooded animals and birds. The food and companion animals, birds and wild animals act as reservoir hosts. Birds form the largest single reservoir for *C. jejuni* while pigs are the main host for *C. coli.*

In animals, the disease is transmitted by:

(i) Ingestion of contaminated water and feed

(ii) Direct contact with carriers (human and animals). The disease is highly contagious and readily spreads in the herd, especially in poultry flock.

In humans, the disease can be transmitted through direct contact (especially in occupationally exposed individuals, and also from kittens or pups to man) or indirectly through consumption of contaminated food, milk and water. The disease has an incubation period of 2-5 days and it is characterized by watery diarrhoea to dysentery, malaise, headache, nausea and vomiting, usually accompanied with fever and severe abdominal cramps. The illness lasts for 3-5 days followed by convalescent shedding of the organisms. Prevention can be achieved by good hygiene and sanitation.

VII. Colibacteriosis

Disease is also known as Colibacillosis, Gut oedema of swine and White Scours. The disease is caused by *Escherichia coli* (Group 5, Subgroup 1, Family - Enterobacteriaceae) is divided into 5 virulence groups as: (a) enteroaggregative (EAEC), (b) enterohaemorrhagic (EHEC), (c) enteroinvasive (EIEC), (d) enteropathogenic (EPEC), and (e) enterotoxigenic (ETEC). The infections are widespread in ruminants as *E. coli* is a normal inhabitant of intestinal tract. The spread of infection among animals is throughcontaminated feed and water.

The infected animals or asymptomatic carriers can transmit the disease by contact. In man, infection occurs through consumption of contaminated food and water, direct contact of infected man or carrier and also through mechanical means including insects and domestic fly. The affected persons generally suffer with profuse diarrhoea leading to weakness and dehydration, accompanied with abdominal pain, severe cramps, and at times, vomiting. Pathogenic strains of *E. coli* cause infantile diarrhoea, which are the greatest single cause of diarrhoea and mortality among babies. The EHEC strains are responsible for hemolytic Uremic Syndrome characterized by hemolytic anaemia, thrombocytopenia and acute renal failure and hemorrhagic colitis. A large proportion of traveller's diarrhoea cases are due to ETEC strains. Strict hygienic measures, proper cooking of foods, environmental sanitation and health education constitute important preventive steps.

VIII. Listeriosis

Disease is also known by the names of Circling, Caprine bacterial encephalitis (in case of goats), Listerial abortion.

Listerosis is an emerging zoonotic disease caused mainly by *L. monocytogenes.* The organism is unbiquitous and can survive food-processing and refrigeration of contaminated meat and dairy products. Listeriosis has been reported from almost all species of domestic animals as well as from many species of poultry, fish, wild animals and rodents. Sheep is the most commonly affected species. Animals are affected by disease due to ingestion of food (silage) and water contaminated with faeces, saliva, nasal secretions, milk and aborted material from infected animals. In man, the primary route is food borne transmission. Human listeriosis may be exhibited as meningitis or encephalitis. Other conditions in man include septicaemia, abortion in pregnant woman, still birth or infection of the newborn, headache, vomiting, fever, malaise, pneumonia and conjunctivitis. The meningitis is characterized by high temperature, stiffness of neck, often ataxia, tremors, seizures and fluctuating consciousness. The onset is sudden and death may follow within 24-48 hrs. Listeriosis can be prevented in man by taking care during handling of the abortion cases in humans as well as in animals, avoiding consumption of contaminated food-stuffs and avoiding cross-infections especially in hospitals among infants.

IX. Glanders

Glanders is an infectious disease that is caused by the bacterium *Burkholderia mallei*. The disease primarily affects horses but can also affects donkeys and mules. Other mammals such as goats, dogs, and cats can also contract the disease naturally. Humans are affected through contact with tissues or body fluids of infected animals. The bacteria also enter the body through cuts or abrasions in the skin and through mucosal surfaces such as the eyes and nose. Inhalation of infected aerosols or dust rarely also transmits the infection. No human to human transmission is reported. Clinical manifestations in man commonly include fever with chills and sweating, muscular pain, chest pain, muscle rigidness, headache, nasal discharge and sensitivity to light. Generally four types of infection occur viz. localized or cutaneous form exhibited as ulcers at the site, pulmonary form showing pneumonia, pulmonary abscesses, and pleural effusion), bloodstream or septicemic infection which is fatal and chronic infection manifested by multiple abscesses within the muscles and skin of the arms and legs or in the lungs, spleen, and/or liver. Veterinarians, abattoir workers and equine attendants are at risk. Prevention of the disease in humans involves identification and elimination of the infected animal.

3.7.2 Viral Zoonoses

Viral diseases among domestic animals cause high morbidity and mortality leading to substantial economic losses in the form of loss of milk yield, and poor quality of wool and mutton to animal breeders in our country. These diseases as zoonoses further add a burden as public health hazard.

I. Rabies

Rabies is one of the most common and highly fatal zoonotic diseases. It is a disease of almost all warm blooded animals. The disease was first recognized in dogs in Hon Kong in 1857. In India, it has been recognized since the Vedic period (1500–500 BC) and is described in the ancient Indian scripture Atharvaveda. Rabies in India is present throughout the country, except in the islands of Lakshadweep and, Andaman and Nicobar.

The disease causes heavy losses in human and livestock populations in our country. The disease is caused by virus belonging to Genus *Lyssavirus* in the family Rhabdoviridae. Transmission between animals of different species and between animals and humans is usually by bite contaminated with infectious saliva, licks and occasionally by aerosol route. It can also be transmitted by corneal transplant, sexual contact, infected tissues of an animal or fresh wound that comes in contact with salivas of an infected animal.

Dogs play an important role in the maintenance and spread of rabies in India. However, transmission from wild animals is rare in the country. The disease is characterized by profound dysfunction of the Central Nervous System and ends usually in death. In animals, the clinical features are similar in most of the species. The incubation period varies between 90 and 147 days. Incubation period upto one year has been reported. Clinically, the disease occurs in two forms (1) Furious or aggressive mad-dog form and (2) dumb or paralytic form.

Furious formis characterized by restlessness, nervousness and aggressiveness. There may be loss of appetite. The animal loses fear of humans. It becomes sensitive to noise and light. Rabid animal bites anything that comes its way or attempts to eat wood, soil, plants, stones or other foreign objects. A hoarse throaty howl replaces the normal bark and snarl in dog which is considered to be an important diagnostic criterion. Excessive salivation and holding of head downward angle results in drooling of saliva. Dilatation of pupil occurs. Frothing at the mouth and holding of the tail between the rear legs are characteristic of canine rabies

Paralytic form, on the other hand, leaves the animal paralyzed. There is dropping of jaws, drooling and frothing of saliva and difficulty in swallowing food or water. Finally, the animal becomes comatosed and dies due to respiratory failure.

Humans are affected by the bite of a rabid animal or sometimes by the scratch of the rabid animal. Infected saliva in contact with an open wound or freshly abraded skin or mucous membrane can also transmit the infection. Incubation period, in humans, ranges between 3 and 8 weeks, generally shorter in children than in adults. Severity of infection depends on the site of bite. Richly ennerved areas like face, neck, hands, and fingertips lead to infection with a shorter incubation period.

Initially, the patients suffer from a low- grade fever, anorexia, headache, bodyache, weakness and fatigue followed by symptoms like soar-throat, cough, gastritis, vomiting. Clinical rabies is characterized by hyperexcitability marked by increasing activity to tactile, visual and auditory stimuli. Increased muscular tone, accelerated pulse, dilatation of pupil, lacrimation and excessive perspiration and salivation are some of the additional prominent features. Dramatic onset of painful spasmodic contraction of muscles leading to difficulty in swallowing and ejection of fluid. Patient may remain lucid. Delirium and coma finally leads to death.

The suspected dog should be observed for 10 days. However, the treatment of exposed (bitten) person should be started immediately. The bite wounds, scratches and abrasions should be thoroughly cleaned and washed with plenty of soap solution and water. Tetanus toxoid must be administered followed by post exposure prophylactic antirabies vaccination. Administration of part of antirabies vaccine and part of antirabies immunoglobulin at the bite site is most effective.

II. Japanese encephalitis

Japanese encephalitis (JE) is a mosquito borne viral disease of public health importance. Disease can occur in outbreak form with high mortality rate. Japanese encephalitis virus (JEV) is classified within the Genus - *Flavivirus* of the family Flaviviridae and is the most common cause of childhood viral encephalitis in the world. The disease was first recognized in Japan as the JE virus was first isolated in 1935 in Japan. JE is primarily a disease of rural, semi urban, agricultural areas where vector mosquitoes (mainly *Culex tritaeniorhynchus* and less frequently other species of *Culex* and *Anopheles*) proliferate in close association with pigs and other animal reservoirs.

It is a seasonal disease in temperate areas. Epidemics coincide with the heavy rainfall and or floods during monsoon and post monsoon period (August to December), agricultural practices, due to high density of the mosquito vector (because of stagnant water), and presence of reservoir host (pigs). Pigs and birds are the most important reservoirs. They develop very high titres and infect mosquitoes without manifesting the disease. JE virus is maintained between pig - mosquito - pig cycles in nature. Thus, pig acts as amplifier host. The virus enters in the brain and neurological cells through hematogenous route where it causes extensive damage to the brain cells by mechanical means and inflammatory reactions. Later, the virus causes complement mediated cytolysis of the infected brains cells. Humans suffer from inapparent to acute fatal encephalitis. The incubation period ranges between 7 and 10 days. The infected person exhibit high fever, severe headache, prosration, neuchal rigidity and altered sensorium. In some cases, incoordication, paralysis and death can be occur due to extensive damage of the neurons. Man is an incidental and dead-end host. Man-to-man transmission does not occur in nature. Other animals like cattle, sheep and goat are also affected but these animals do not seem to play a significant role in the maintenance and transmission of JE virus in nature. Disease can be prevented by vaccination. Vector control is important to break the transmission cycle to control the disease. Prevention of mosquito bites and vector control by killing the larvae by insecticide spraying are the best ways to achieve the desirable decrease in the vector mosquito population.

III. Chikungunya virus

This is also a mosquito borne viral infection characterized by severe, sometimes persistent joint pain (arthritis) with fever and rashes. Monkeys, and possibly other wild animals, may serve as reservoirs of the virus. It is mainly caused by the bite of infected *Aedes aegypti* mosquitoes. The incubation period can be 2-12 days. Incubation period is followed by fever, debility, joint pain, swelling of joints, stiffness of joints, muscular pain, headache, fatigue (weakness), nausea, vomiting and rash. It is rarely life-threatening.

IV. Kyasanur forest disease

Kyasanur forest disease (KFD) was first discovered in 1957 by Telford Work and Harold Trapido in a small forest region in the Kyasanur forest area of Sorab taluka in Shimoga district of Karnataka. The disease causes heavy mortality in monkeys. KFD virus belongs to Russian Spring Summer Encephalitis group, a member of family *Flaviviridae*. The disease is transmitted to man through the bite of a tick *Haemaphysalis spinigera* (*H.spinigera*) which is the predominant species of ticks infesting man. Incubation period is of 2-7 days. The clinical symptoms start with the onset of fever (about 40°C) which continue for about 12 days or more, headache, vomition, muscle pain, sleeplessness, increase in heart rate, encephalitis, neck stiffness, tremor, mental disorders and hemorrhages on mucous membranes. Recovered persons develop life-long immunity. KFD is mainly seasonal and most cases occur during the intermonsoon period i.e., from December to June as larval and nymphal stages of *H. spinigera* and *H. turturis* are very active during this period. Adults humans are more susceptible than the children and males more than the females. Man invariably enters the forest during this period for collecting wood and plants for the fuel purposes and in the process is bitten by the infected ticks. Man is a dead end host. The diagnosis of KFD can be done by isolation of the virus, serological tests mainly by haemagglutination inhibition test. Disease can be prevented by vaccination.

V. Yellow fever

Yellow fever (YF) is a mosquito borne infection of humans and simians characterized by jaundice, fever, headache, backache, nausea and epistaxis in humans. The virus belongs to Genus-Flavivirus. The vector that transmits the disease is mosquito *Aedes aegypti* and few more mosquitoes belonging to *Aedes* genus. The virus shares an antigenic relationship with other flaviviruses. All primates are susceptible to YF virus infection. Humans exhibit fever, lack of correlation between pulse and body temperature, jaundice and epistaxis. The disease runs a clinical course of 2-3 days followed by uneventful recovery. Diagnosisis b**y**isolation of YF virus from acute blood sample or autopsy specimens, by increase in antibody titre which provides confirmatory result. Prevention of the disease is by protection of humans from exposure to mosquito bite and vaccination.

VI. Dengue fever

Dengue fever is a mosquito borne viral infection. This virus causes disease in humans with varying degree of severity. The mild form is called Dengue Fever and the severe forms are called Dengue Hemorrhagic Fever (DHF). The viruses are maintained by man-mosquito-man cycle. *Aedes aegypti* is the principle vector besides some other species of Aedes mosquitoes. In humans, the disease is characterized by fever, muscle pain, rash and lymphadenopathy. DHF exhibits as abnormalities of haemostatis and in severe cases causing shock syndrome called Dengue Shock Syndrome. In animals (macaques, cyanomoglus, cercopithicus monkeys), infection is essentially asymptomatic. On the other hand, infant mice are highly susceptible to dengue viruses. Virus isolation and serological techniques for diagnosis are essentially identical to those for humans. For prevention and control, avoid mosquito bite using mosquitos' repellents and protective clothing, proper storage of water and environmental spraying of insecticides to destroy adult mosquito population.

VII. Influenza

Influenza viruses belong to the family *Orthomyxoviridae* which includes three important species. Influenza-A which infects pig, horse, bird, and humans, Influenza B –which affects human only and Influenza C virus which is also a human pathogen but rarely causes serious disease. The characteristic feature of influenza A virus is the antigenic variability of the envelope glycoproteins viz. hemagglutinin and neuraminidase antigens (HA and NA) which undergo antigenic drift (minor antigenic changes occurring due to point mutation(s) and antigenic shift (major changes resulting in emergence of new sub type with a completely different surface proteins). Several subtypes of influenza viruses exist in nature depending on the HA and NA antigens.

Swine influenza

Swine influenza is an acute infectious respiratory disease of pigs characterized by fever, coughing and dyspnoea. Infection with this virus does not necessarily result in disease probably due to the presence of maternal antibody. The disease occurs more frequently in winter. The incubation period is usually 1-3 days. Clinical signs of the disease in pigs are fever, anorexia rhinitis, nasal discharge, sneezing and rapid breathing. The animals do not move freely but tend to huddle together. Herd infection spreads by way of introduction of infected animal to the herd or when a new breeding stock is added to the herd. Recovery usually takes place after 3 to 6 days. Humans get infected with H1N1 virus through direct aerosol contact from pig, through the nasal secretions containing the virus or through indirect contact with families affected by the disease and excreting infectious nasal discharge. Common manifestations include fever, chill, headache, muscle pain, pharyngitis and cough. Diagnosis is through isolation and identification of the virus. Serodiagnosis is not specific and hence unreliable.

Avian influenza

Avian influenza refers to the disease caused by infection with avian (bird) influenza (flu) Type A viruses. These viruses occur naturally among wild aquatic birds worldwide and can infect domestic poultry and other bird and animal species.Aquatic birds including gulls, terns, and shorebirds, and waterfowl such as ducks, geese and swans are considered reservoirs (hosts) for avian influenza A viruses. Avian influenza A virus could spread from humans to birds and vice versa. The virus was isolated in 1959 from the blood of a man suffering from clinically diagnosed infectious hepatitis. These avian influenza viruses generally do not infect humans but as both avian and human influenza viruses share the haemagglutinin and neuraminidase antigens, and it is likely that some of these viruses may have resulted by way of recombination during infection of mammals by avian viruses and birds by mammalian viruses. Preventive measures include avoidance of wild birds and observing them only from a distance; avoid contact with ill birds or those which have died; avoiding contact with surfaces contaminated with feces from wild or domestic birds.

VIII. Buffalopox

Buffalo pox is a zoonotic and contagious viral disease, which mostly affects buffaloes, but rarely cows and human beings. It is caused by buffalopox virus (BPV), classified in *Orthopoxvirus* genus of *Poxviridae* family. The disease appears to be endemic in certain parts of India among milch buffaloes. The pox lesions in buffalo may be localized or generalized. Local lesions are usually noticed on teats, udder, medial aspects of thighs, lips and muzzle followed by thickening of teats and treat canals leading to stenosis. Occasionally the infection leads to mastitis. The disease causes a considerable economic loss to dairy industry. Infected animals usually recover. The disease is not reported to be fatal. The virus is transmitted to humans by direct contact with infected animals. The clinical signs in humans are fever followed by local lesions in the form of multiple pocks on hands, fingers, forearms and wrists as well as on interdigital webs. Occasionally lymphadenopathy is also seen. No vaccine is available for prophylaxis among buffaloes. Control can be achieved by restricting the movement of the infected/sick animals.

IX. Rift valley fever

Rift Valley Fever (RVF) is a mosquito-borne zoonotic viral disease of ruminants and humans. A number of species of mosquitoes belonging to *Aedes* and *Culux* genera are involved in the transmission of virus. RVF virus belongs to the family *Bunyaviridae* and Genus *Phlebovirus*. In humans, the disease is characterized by fever, chill, headache, backache, muscular pain and hepatitis. The disease runs an influenza-like course. In animals, the incubation period is short i.e. about 1-2 days. Infected sheep develop fever, anorexia, vomiting, mucopurulent nasal discharge and diarrhea followed by death in a day or two. Pregnant ewes usually abort. The disease is more severe in young lambs (mortality around 90-100%) compared to adult sheep (20-60% mortality). Similar clinical features appear in goats. In cattle, abortion is an indication of infection and sub-clinical infection is also common. The mortality rate is relatively less (10-30%) in cows and calves. In humans, infection usually results from inhalation of infectious aerosols and contact with infected animals or animal products. The incubation period in humans varies from 3-7 days, usually 4 days. In humans, the disease is characterized by sudden onset of fever, chill, severe backache, vomiting, muscular pain, soft and fragile liver, meningoencephalitis and in some cases visual impairment due to retinitis. Diagnosis is based on isolation and identification of the virus from acute blood samples in mice or tissue culture. Serological diagnosis can be done by Hemagglutination inhibition test, Complement Fixation test and ELISA. The disease is an important occupational hazard as it affects farmers, dairy farm workers, veterinarians and abattoir workers. Prevention and controlmeasures includevaccination of animal and human population at risk and vector control.

X. Ganjam Virus Disease

Ganjum virus is a tick borne infection which causes an acute febrile disease of sheep and goat. The virus belongs to the genus *Nairovirus* in the family *Bunyaviridae*. In India, the isolation of Ganjam virus in India was done in 1969 from *Haemaphysalis intermedia* ticks from sheep in the Ganjam district of Orissa. The disease has a short incubation period. Disease in animals is characterized by high fever, anorexia, listlessness, haemorrhagic enteritis, lumbar paralysis and may cause high morbidity. In man the disease is characterized by fever for 2-3 days, headache, listlessness, nausea, vomiting, joint pain and backache. No vaccine is available for prophylaxis.

3.7.3 Miscellaneous Zoonotic Diseases

I. Toxoplasmosis

Toxoplasmosis is a disease caused by a protozoan parasite,*Toxoplasma gondii* that infects most species of warm blooded animals like cattle, buffalo, sheep, goat, pig, horse, camel, dog, cat, monkey, rodent including humans. The disease is more important in immunocompromised persons. The definitive hosts are members of family Felidae (domestic cats and related species) in which the organism reproduces sexually and the cysts are shed in feces of cat and spread the disease to other animals and man. Humans can become infected by eating undercooked meat of animals harboring tissue cysts, consuming food or water contaminated with cat feces or by contaminated environmental samples (such as fecal-contaminated soil or changing the litter box of a pet cat), blood transfusion or organ transplantation or transplacentally from mother to fetus.

The tissue cysts are commonly found in skeletal muscle, myocardium, brain and eyes of the infected individuals which may remain throughout the life of the host. The infected humans suffer from pyrexia, lymphadenopathy, headache, stiff neck, pain in joints and maculopapular rash. Pregnant women may report abortions and premature births. Upon congenital infection, the new born may exhibit symptoms like hydrocephaly, microcephaly, hepatomegaly, spleenomegaly, fever, icterus, blindness, epileptic convulsion, cerebral calcification and mental retardation. Prevention can be done by adopting hygienic measures.

II. Dermatophytosis

Commonly known as "ringworm", dermatophytosis is a superficial mycotic saprozoonotic disease that affects skin, hair or nails. The disease is caused mainly by species of *Trichophyton* and *Microsporum* species and is characterized by redness of the skin, small popular vesicles, fissures and scaling. It is a true zoonotic disease as the disease spreads mainly through direct contact. The transmission may also take place through indirect contact and also spreads by aerosols, especially from contaminated bedding materials and dust. Symptoms in man are generally mild and self limiting. Clinical signs in man are scaling, redness and occasionally vesicles or fissures, thickening and discolouring of nails. Skin lesions show circular pattern of development, which is clear in the centre forming a ring.

The lesions in humans are categorized according to the area affected:

Tinea capitis – infection on scalp and hair

T**inea corporis** – infection on body (extremities, arm and hand)

Tinea pedis – infection on foot / Athlete's foot

Tinea unguium – infection on nails

Tinea barbae - infection of beard / Barber's itch

Tinea interdigitale - infection of inter digital space

Prophylaxis and control of the disease involves hygienic measures.

III. Scrub Typhus

Scrub typhus is a rickettsial infection caused by *Orientia tsutsugamushi and* transmitted by the bite of larval mites or 'chiggers' ***(Leptotrombidium deliense*)** belonging to the family *Trombiculidae*. Small rodents particularly wild rats of subgenus *Rattus* are natural hosts for scrub typhus. The infection perpetuates in nature between rodents and the vector mites which are present in ecological patches called 'mite islands'. The mites feed usually on rodents and accidentally on humans and transmit the infection during the prolonged feeding which can last for 1-3 days. The common symptoms in humans include breathlessness, cough, nausea, vomiting, muscular pain and headache. The presence of a single or multiple eschars (painless, punched out ulcers with a black necrotic centre surrounded by an erythematous margin) found at the site of chigger bite is a characteristic sign of scrub typhus.

IV. Q fever

The disease is also known asQ or Querry fever, Balkan influenza, Balkan grippe, Pneumorickettsiosis, Abattoir fever, Burnet's Rickettsiosis, Australian Q fever, Nine mile fever, Coxiellosis and Queensland fever. The disease is caused by rickettsial pathogen, *Coxiella burnetii.* Cattle, sheep, and goats are the main reservoir of infection for humans. The organism is found in the birth products (i.e. placenta, amniotic fluid), urine, feces and milk of infected animals.They can survive for long periods of time in the environment and may be carried to long distances by wind. People can get infected by breathing in dust that has been contaminated by infected animal feces, urine, milk, and birth products. Veterinarians and farmers who are in contact with animals during parturition are at higher risk. Prominent symptoms manifested by humans include fever, chills or sweats, fatigue, headache, muscular pain, nausea, vomiting or diarrhoea, chest pain, stomach pain, weight loss and non-productive cough. In severe cases, people develop pneumonia or hepatitis. Pregnant women are at risk of miscarriage, stillbirth, premature delivery or low infant birth weight. Chronic Q fever is serious and can be fatal if not treated. Chronic condition is more likely to occur in humans with heart valve disease, blood vessel abnormalities or with immunosuppression. Prevention includes avoiding contact with animals and consumption of unpasteurized milk.

Check Your Progress 3

Note: a) Write your answer in about 50 words.

b) Check your answer with those given at the end of the unit.

1. Write briefly about avian influenza.

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2. Describe different forms of Anthrax in man. How anthrax is an occupational disease and how to prevent and control anthrax in an endemic area.

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3. Describe various transmission cycles of plague and the various forms .. occurring in infected humans.

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3.8 LET US SUM UP

Zoonotic diseases are the diseases that are transmitted between lower vertebrates and humans. These diseases have reservoir mostly in animals and humans. Based on reservoir host and transmission, the diseases can be anthropozoonotic, zooanthropozoonoses or amphixenoses. Zoonotic diseases primarily transmitted from the lower vertebrate animals to human beings are called anthropozoonotic diseases while those diseases transmitted from human beings to the lower vertebrate animals are called zooanthroponotic diseases. Amphixenoses is the term given to diseases that are transmitted in both directions that is, from animals to humans and humans to animals. E.g. Streptococcosis, non-host specific salmonellosis, staphylococcosis.

Till today, more than 250 diseases have been reported to be zoonotic and the list is still increasing. With the increase in diagnostic techniques, better surveillance and monitoring systems, advanced trade and travel policies and means, ecological changes and increase human-animal interference have led to newer, emerging and re-emerging diseases.

Most of the diseases that are zoonotic falls into the category of anthropozoonoses but few diseases such as human type tuberculosis, diphtheria and amoebiasis are categorized as being zooanthroponoses. As these diseases are of great public health concern, prevention and control steps are to be taken to protect the human and as well as animal health.

3.9 KEY WORDS

Yellow fever: Yellow fever (YF) is a mosquito borne infection of humans and simians characterized by jaundice, fever, headache, backache, nausea and epistaxis in humans. The virus belongs to Genus-Flavivirus. The vector that transmits the disease is mosquito *Aedes aegypti* and few more mosquitoes belonging to *Aedes* genus.

Dengue fever: Dengue fever is a mosquito borne viral infection. This virus causes disease in humans with varying degree of severity. The mild form is called Dengue Fever and the severe forms are called Dengue Hemorrhagic Fever (DHF).

3.10 REFERENCES AND SUGGESTED FURTHER READINGS

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3.11 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress 1

Your answers should include the following points:

I. Explain Metazoonosis. Describe with suitable example.

In this, both vertebrate and invertebrate species are involved in the completion of the life cycle. In the invertebrate hosts (biological vectors), infectious agent may multiply (propagative), develop (developmental) or both (cyclopropagative). Depending on the number of vertebrates or invertebrates involved in the perpetuation of the cycle, metazoonoses have been further divided into four subgroups. eg Yellow fever, plague, Paragonimiasis, Clonorchiasis, Tick-borne encephalitis.

II. Write in brief the major routes of transmission.

Answer:

A) Direct transmission.

1. *By direct contact.* e.g. Leptospirosis, dermatophytosis, vibriosis, anthrax, foot and mouth diseases, cow pox, orf.

2. *Droplets or Droplet nuclei.* e.g. Tuberculosis, common cold, diphtheria.

3. *Contact with soil.*. E.g. anthrax, hookworm infection, tetanus.

4. *Bite of an animal.*.e.g. Rabies.

5. *Transplacental / vertical transmission:* E.g. Toxoplasmosis, Hepatitis-B virus.

(B) ***Indirect transmission.***

1. ***Vector-borne transmision.***

(a) ***Mechanical transmission.*** e.g. Amoebiasis, serum hepatitis, cholera.

(b) ***Biological transmission***. Biological transmission is of four types-

(i) **Propagative type.** e.g. Plague bacilli in rat fleas.

(ii) **Cyclo-propagative type.** e.g. Malaria parasites in mosquitoes.

(iii) **Developmental type.** e.g. Microfilaria in mosquitoes.

(iv). **Transovarian type.** e.g. Tick borne encephalitis.

2. ***Vehicle-borne transmission.*** e.g. Water - Hepatitis A virus, Meat - Salmonellosis, *Trichinella spiralis,* Milk -Tuberculosis, brucellosis, Fish - *Diphyllobothrium latum, Vibrio parahaemolyticus,* Blood - Hepatitis B virus, Organ - Cytomegalo virus in kidney transplants

3. ***Air borne transmission.*** e.g. Tuberculosis, Q-fever. Dusts are larger droplets expelled during talking, coughing or sneezing but settle down along with dust. e.g. Streptococcal infection, fungal spores.

4. ***Fomite-borne infections.*** e.g. Diphtheria, typhoid fever, skin infections.

III. Describe briefly the maintenance of a zoonotic agent perpetuating in sylvatic animals.

Sylvatic cycle is the cycle in which the pathogen is confined to wild vertebrates in forests and propagates among wild animals. The agent gets transmitted to humans when he enters the forest ecosystem as hunters / forest rangers or to domestic animals that stray in the forest. Eg. Kyasanoor forest disease, monkey pox etc.

Answers to Check Your Progress 2

Your answers should include the following points:

I. Explain emerging and re-emerging zoonotic diseases giving suitable examples? What are the possible reasons for the occurrence of such diseases?

Emerging zoonoses are defined as “diseases that are caused either by an apparently new agent or by a previously known organism that appears in places or in species in which it was previously unknown”. A re-emerging disease is considered a known or endemic disease that either shifts its geographical setting or expands its host range, or significantly increases its prevalence. The factors responsible for its emergence can be

- Microbial adaptation and change
- Change in immunological status of population
- Ecological changes and agricultural growth Movement of human population and changes in human behavior
- Rapid industrialization and urbanization
- Increasing international trade in live animals and food
- Economic development and land use
- Breakdown of public health measures and deficiencies in public health infrastructure

I. What strategies can be adopted in general to prevent and control a disease in a population?

The following strategies can be adopted for efficient prevention of zoonotic diseases

(i) Detection of zoonotic disease in human and animal populations, identification of vectors, estimating the extent of infection and recognizing the influencing environmental factors.

(ii) Elimination of reservoirs.

(iii) Elimination/control of vectors.

(iv) Reducing contact potential

(v) Increasing host resistance

(vi) Health education and public awareness

Answers to Check Your Progress 3

I. Write briefly about avian influenza.

Avian influenza refers to the disease caused by infection with avian (bird) influenza (flu) Type A viruses. These viruses occur naturally among wild aquatic birds worldwide and can infect domestic poultry and other bird and animal species.Aquatic birds including gulls, terns, and shorebirds, and waterfowl such as ducks, geese and swans are considered reservoirs (hosts) for avian influenza A viruses. Avian influenza A virus could spread from humans to birds and vice versa. The virus was isolated in 1959 from the blood of a man suffering from clinically diagnosed infectious hepatitis. These avian influenza viruses generally do not infect humans but as both avian and human influenza viruses share the haemagglutinin and neuraminidase antigens, and it is likely that some of these viruses may have resulted by way of recombination during infection of mammals by avian viruses and birds by mammalian viruses. Preventive measures include avoidance of wild birds and observing them only from a distance; avoid contact with ill birds or those which have died; avoiding contact with surfaces contaminated with feces from wild or domestic birds.

II. Describe different forms of Anthrax in man. How anthrax is an occupational

disease and how to prevent and control anthrax in an endemic area.

Clinically, the disease has three forms.

i. *Cutaneous form (malignant pustule/eschar)* caused by spores entering the skin through cuts and abrasions. The form is often self limiting and exhibited by the papule that becomes increasingly necrotic and later ruptures to painless, black scar or carbuncle surrounded by an oedematous zone.

ii. *Pulmonary form (wool sorter's disease)*caused by inhalation of airborne spores while handling raw wool, hides, bones, blood meal and meat meal. The form is characterized by fever, dyspnoea, pneumonia, emphysema and cardiac failure. Septicaemia is highly fatal causing death in few hours.

iii. *Intestinal form* caused by ingestion of spores present in infected meat, milk or other foodstuffs. The characteristic scab or malignant carbuncle mostly occurs in the oropharynx, stomach, duodenum and upper ileum. The most common symptoms are nausea, vomiting, anorexia, fever, abdominal pain, watery to bloody diarrhoea and tenderness in right upper and lower quadrants.

In man, it is occupational as it can be transmitted to humans through:

a. Direct contact of skin with infected animal (during animal husbandry and agricultural operations leading to close contact) or carcass (during post-mortem examination, rendering, slaughtering, dressing and removal and handling of hides and wool).

b. Inhalation of spores in dust clouds created from handling of dry hides, skins, bone, blood meal, meat meal etc. (leads to pulmonary anthrax).

c. Ingestion of meat from animals that have died of anthrax (leads to intestinal anthrax). Man to man transmission is rare

Prevention can be achieved by vaccinations of people at high risk. Proper disposal of carcass should be done.

III. Describe various transmission cycles of plague and the various forms occurring in infected humans.

Various transmission cycles may be:

(i) Domestic rodent— rat flea — man

(ii) Wild rodents — rat flea/direct contact — man

(iii) Wild rodents — rat flea — domestic rodent — rat flea — man

(iv) Man — human flea (*Pulex irritans*) — man

(v) Man — man by droplet infection

(vi) Through infected animals, particularly the rats during skinning and trapping.

(vii) Use of unlaundered, dirty clothings infested with fleas.

(viii) Bites of ticks, lice and bed bugs

(ix) Bites and scratches of infected cats.

In humans, the disease manifests itself in three forms:

v) Bubonic plague - most prevalent form and characterized by intense haemorrhagic inflammation (*bubo) usually occurring in the groin(s) as flea-bites are common on the lower extremities.

vi) Pneumonic plague which is now rare but highly fatal disease involving the lungs.

vii) Septicemic plague characterized by rapidly progressive fever, hypotension and high mortality that is the terminal stage of both bubonic and pneumonic plague.

viii) Unusual forms are the *meningeal form* predominantly exhibited by fever and neck rigidity and the *cutaneous form* manifested by pustule, eschar, carbuncle or ecthyma gangrenosum accompanies a buboes.

UNIT 4 FOOD LOSSES AND WASTE

Structure

4.0 INTRODUCTION

Food waste and loss is defined as the decrease of food in different stages of the food chain intended for consumption by the humans. The issue of global food losses and waste (FLW) has recently received much attention and has been given high visibility. According to FAO (2011a), almost one-third of food produced for human consumption – approximately 1.3 billion tonnes per year – is either lost or wasted globally. The reduction of FLW is now presented as essential to improve food security (HLPE, 2011; FAO, 2012a,b) and to reduce the environmental footprint of food systems (HLPE, 2012; FAO, 2012a,b; UNEP, 2012a,b). A lot of food is wasted or lostfrom the supply chain, from initial stage that is producing till the last stage of consumption in household. Current issues are the substantial proportion of food produce for us is lost through decrease in its quality, quantity. But it is discarded when it still fits for consumption.Food losses have bad and negative impacts on the environment, natural resources and nutrition's. The way of reducing food loss is through the Processing and preservation of food and reducing its negative effects. Coordination by FAO, activities and projects and various initiatives on food losses waste reduction at global level by collaborating with UN agencies, international organizations, and worldwide stakeholders, which includes the civil society as well as economic sector. Now a day the challenges in developing countries are by limited values of small and medium Argo industries, which is lack of infrastructure, logistics and cold chain system which are important to make products.

4.1 OBJECTIVES

After reading this unit you will be able to:

- define food waste and food loss;
- explain the causes and types of food waste and food loss;
- describe the various impacts of food loss and waste and its effects; and
- explain the strategies for reducing food loss and food waste.

4.2 DEFINITION

What are FLW? Trying to define FLW and their scope, one is immediately confronted with two competing approaches, reflecting fundamentally different perspectives, underlying objectives and policy concerns. One approach focuses on waste, and for it FLW are *the part of waste that is food or related to food, including non-edible parts*. The other approach, retained in this report, focuses on food, and for it FLW are *the edible part of food that is lost or wasted*.

Food loss and waste (FLW) alludes to a diminishing, at all phases of the natural way of life from gather to utilization in mass, of sustenance that was initially expected for human utilization, paying little heed to the reason**.**

Food losses (FL) alludes to a decline, at all phases of the evolved way of life preceding the buyer level, in mass, of nourishment that was initially expected for human utilization, paying little mind to the reason.

Food waste (FW) alludes to sustenance proper for human utilization being disposed of or left to ruin at buyer level – paying little mind to the reason.

Food quality loss or waste (FQLW) alludes to the reduction of a quality characteristic of nourishment (sustenance, perspective, and so forth.), connected to the corruption of the item, at all phases of the natural way of life from collect to utilization**.**

Eatable parts harvested or produced by plants and animals are consumed by humans but not ultimately consumed by people is called as food loss. A first distinction is therefore whether the approach to FLW is focused on waste or focused on food:

The *waste-focused* approach derives from the concern of diminishing waste of all kinds, and reducing negative impacts and costs of the treatment of waste, mainly non-food but including food – and including non-edible parts of produce. It often reflects local environmental impact considerations, calling to consider "what happens with the waste", either as feed, recycled, for energy production, as compost to return nutrients to the soil, incineration or landfill.

The *food-focused* approach considers as a starting point food1 and parts of food *that are edible and intended for human consumption*, but lost or discarded at some point in the food chain. This leads to introduce, at the beginning of the chain, the cultural dimension of "*edibility*" (as parts of food that are originally considered "not edible" will not be accounted as lost or wasted) and, at the end of the chain, the food safety dimension of "*edibility*" (as food that was originally edible but *becomes* non-edible for food-safety reasons needs to be discarded, leading to food loss and waste). It invites considering improvement of the functioning of the food system, with a food chain perspective.

Eatable food mass available for the human consumption throughout the supply chain is called as food waste. Food products can also face a failure quality and leading to economic loss and nutritional value loss. Food waste is most often depends with retailers behaviour's and consumers mistake. But food waste and losses take place all along food supply chains. The moment when a product is ready to be harvested, and the moment when it is consumed or removed from the food chain, FLW occurs. FLW are never considered as removal of fractions of uneatable from the food supply chain (e.g. side streams). Yield gaps are also not considered as FLW. Conversion of products from plants into bio products, and extra nutrition is considered as FLW, as efficiency of food systems are related to broader considerations.

Due to inexpert to produce, harvest, process and transport the food there is huge loss in the developing countries. Traders, collectors, agro processors and marketing cooperatives activities are carried out by smallholder farmers or other people who are stay close to the farm. **Supply chain resources and deficient national infrastructure results in inefficient it is negatively impacted on food security.**

Check Your Progress 1

Note: a) Write your answer in about 50 words.

b) Check your answer with those given at the end of the unit.

1. Define Food loss?

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2. Define Food waste?

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4.3 CAUSES AND TYPES OF FOOD LOSS AND WASTE

Food chain has many stages of food loss and waste. All stages are as follows:

1. Produce
2. Storage and handle.
3. Packing and processing.
4. Distribute and sending it to market.
5. Consuming.

- Poor harvesting equipment leads to wastage of some grains. They fail to meet the quality and standards. These are the wastes taking place during production.
- The food can be affected by pests, fungus and disease during storage. Many foods will be loosed during handling.
- The food is damaged or spilled during packing. Due to poor forecasting and factory processes foods may be lost or wasted.
- Food should be used before the expiry date or else it will be wasted during distributing or marketing.
- Food is purchased by consumers, restaurants but it is not eaten by them, this cause food loss during consumption.

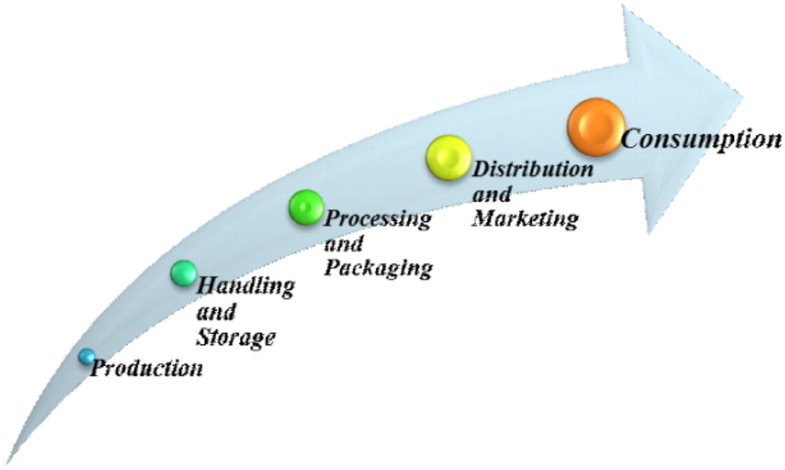

Figure 4.1: Pictorial Representation of stages

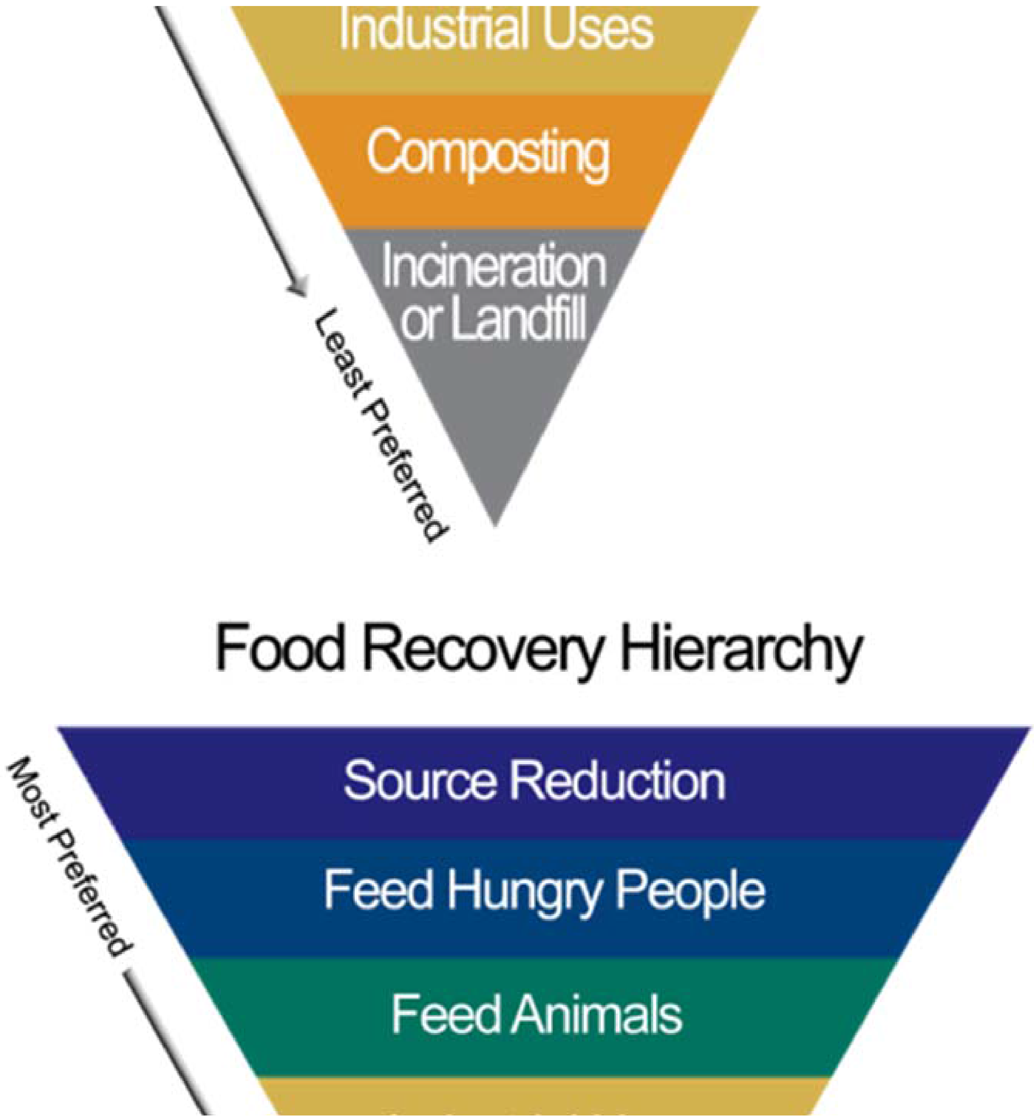

Figure 4.2: Food Waste Recovery Hierarchy

Food loss and waste and be reduced by many ways. A subset of approaches is profiled that is suggested by the experts which are both practically implementable as well as cheap, which is relatively quick to implement, and which could achieve quick results. These methods also include to facilitate redistribution of the food or to donate, where refrigeration is not available use evaporative coolers ,hermetically fixed plastic stockpiling sacks for harvests ought to be presented, utilizing little metal storehouses, utilizing plastic boxes rather than packs for yields, changing sustenance date names to diminish customer perplexity about when nourishment is perilous, leading shopper mindfulness battles about how to decrease family nourishment waste, and lessening segment sizes at eateries and cafeterias. These non-thorough rundown clues at the range of methodologies accessible crosswise over chose phases of the nourishment esteem chain. Every one of these methodologies—and others like them—can help diminish nourishment misfortune and waste. To additionally stir pledge to decreasing nourishment misfortune and waste, a few cross-cutting procedures are required. These methodologies will require activity from multilateral and respective contributors, intergovernmental organizations, national governments, and the private area, among others. We recommend five strategies:

- Develop a food loss and waste measurement protocol.
- Set food loss and waste reduction targets.
- Increase investment in reducing postharvest losses in developing countries.
- Create entities devoted to reducing food waste in developed countries.
- Accelerate and support collaborative initiatives.

Various studies and projects are conducted due to post-harvest losses, by making use of agronomic or engineering knowledge, showing the various causes at every stage of production. One such example is the African Postharvest Losses Information System which estimated the postharvest weight loss data for seven cereal crops in Sub-Saharan Africa (APHLIS, 2014), at national as well as local scale. APHLIS assembled together a network of local experts who supplied relevant data and verified the loss estimate; a central database; and for calculating losses from different states of the countries in that region, a loss calculator was used. From the best known estimates of the loss, loss estimates are derived for every link in the postharvest chain which includes crop type, the scale of farming and climate. For other factors, corrections are made. According to APHLIS, total post-harvest loss for the cereals to harvest, dry, operations to be handled, storing in farm, transportation and storing in market in that region varied between 14.3 percent and 15.8 percent of the production during the year 2003-2013.6

The FAO (2011a) study is however the only global study currently available with FLW data at all levels from production to consumption and encompassing all sectors of food production, including fisheries. Despite shortcomings in terms of data available, the global results of the study, and the order of magnitude found of one-third of FLW (and its declination in developed and developing countries) is coherent with existing studies at regional/national level, as well as with sectoral studies.

Finally, it is important to note that all the studies of global relevance providing estimates of global FLW, published subsequently to the FAO (2011a) study, rely on the same raw data from FAO (2011a). These studies, such as Kummu*et al*. (2012), the WRI study (Lipinski *et al.*, 2013), the FAO, 2013 Toolkit (FAO, 2013a), or the 2013 Report from the Institution of Mechanical Engineers (IMechE, 2013), etc. therefore do not provide independent estimates of the extent of FLW.

Check Your Progress 2

Note: a) Write your answer in about 50 words.

b) Check your answer with those given at the end of the unit.

1. What are the stages of Food loss or Waste?

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4.4 EXTENT AND IMPACTS OF FOOD LOSS AND WASTE

To produce food we need lot of natural resource. It also affect environment. It produces GHG and release excessive nutrients. Rise of this leads to the climatic change which causes many biosphere problems. Freshwater resources scarcity are increasing and creating pollution as well. Due to agriculture and irrigation huge amounts of water is being consumed mainly around the world. Main problem caused by irrigation is water depletion and salinization. Food losses have many negative impacts and it reduces economic value of food chain.

The production of food, which is ultimately not eaten, whether it is lost during the production and transformation processes or wasted at the consumption stage, entails a “waste” of economic or natural resources. It also brings social impacts. In this section, we review impacts of FLW on the three dimensions of the sustainability of food systems – economic, social and environmental. These impacts could be described at three levels (Table 1), namely: at the level of the households and individual enterprises (micro-level), at the level of the production chain (meso level), and at the more general level of society (macro level).

Impacts are presented as:

- ✓ Value of resources is visible form in the waste
- ✓ Value of output is:
- ✓ Should feed people
- ✓ Save money and use it for something else
- ✓ It has been avoided emissions.

Qualitative literature:

- ➢ Incomes are likely to get lowered and Food Loss and Wastage leads to increase in food prices and the security of food is negatively affected by it.

- Combating FLW would benefit food security:
- For household consumption of food, it will be available plenty.
- It will increase the sales in income and will help in reducing the cost of production and therefore sales (and incomes) will be increased for producers.
- Food security is a big concern in developing countries, but impacts like food consumption, food prices and incomes, are also felt and of concerns

Table 4.1 Sustainability of food systems

Impact of FLW on the of food systems sustainability	***Economic***	***Social***	***Environmental***
Micro food system	▪ Consumers spend more money on food that is not sold or consumed.	▪ Lower wages and lack of products for the consumers.	▪ Generates lot of waste and garbage that pollutes the environment in rural and urban areas.
Meso food system	▪ Reduction in profit. ▪ Supply chain in inefficient.	▪ Labour productivity is low ▪ Companies Planning is difficult.	▪ Landfills start increasing.
Macro food system	▪ Economic effort is not created. ▪ Financial resources for investment in other areas are reduced.	▪ Below the Poverty lines there are many people lying. ▪ There are Higher demand to get food now a day.	▪ Water and Soil is the pressure of environment. ▪ Greenhouse Gases are emitted. Conservative areas and woodlands are occupied. Aquatic resources are getting depleted. ▪ Pressure on Animals and birds. ▪ Non-Renewable energy is in great demand.

Check Your Progress 3

Note: a) Write your answer in about 50 words.

b) Check your answer with those given at the end of the unit.

1. What are the impacts of Food losses?

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2. Explain the environmental impact of Macro food system?

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4.5 STRATEGIES FOR REDUCING FOOD LOSS AND WASTE

As mentioned above, studies on FLW can be traced back to two major work streams: studies on *food losses* or *post-harvest losses* for a particular product, generally with the aim of improving the economic efficiency of a particular food chain, and studies *on waste* or *food-related waste* (including packaging), often at local or national level, aiming to reduce it and improve its management.

Some studies give perspectives on FLW in specific parts of food supply chains: production, processing, wholesale, logistics, retail, markets, redistribution, catering and other food services or households (e.g. Hanssen and Møller, 2013). These studies, being adapted to their specific object, are often difficult to compare and amalgamate.

Post-harvest losses have given way to various studies and projects, mainly using agronomic or engineering knowledge, addressing their various causes at each stage of production. One example is for instance the African Postharvest Losses Information System providing postharvest weight loss estimates for seven cereal crops in Sub-Saharan Africa (APHLIS, 2014), at national and provincial scale. APHLIS gathers a network of local experts supplying relevant data and verifying loss estimates; a central database; and a loss calculator to calculate losses from all provinces of the countries in the region. Loss estimates are derived from the best known estimates of the loss for each link in the postharvest chain allowing for crop type, climate and scale of farming. Further corrections are applied for a range of other factors. According to APHLIS, total post-harvest losses for cereals during harvesting, drying, handling operations, farm storage, transport and market storage in the region oscillated between 14.3 percent and 15.8 percent of the production during the period 2003-2013.

On the basis of different levels of the food system using different instruments we can find the solutions to reduce FLW. To encourage decision makers to take appropriate actions the HLPE panel summarized a palette of possible instruments for FLW reduction depending on the type of solution and the stakeholder's scope of responsibility. Community interest in food waste prevention is growing in BC as more community organizations are beginning to educate both businesses and the public on the many benefits to food waste prevention/reduction. Food waste prevention has become a topic of interest as it represents a significant opportunity to reduce environmental impacts that are caused by western civilization's food consumption habits. Food waste prevention has social, environmental, and economic benefits for citizens and municipalities.

Table 4.2: Solutions to reduce FLW

Categories of solutions to reduce FLW	**Levels**		
	Macro	***Macro***	***Macro***
Investment	❖ Exclusive Investment to produce, postharvest, businesses and food services	❖ Financial mechanisms ❖ Collective private investments ❖ Public investments	❖ Infrastructure ❖ Environment is enabled and incentives are proper.
Good practice	❖ Good practices in production and postharvest	❖ Capacity building Training	❖ Support to capacity building ❖ Multi stakeholder initiatives
Behaviour change	❖ Change in Businesses and consumer's behaviour.	❖ Corporate social responsibility ❖ Community and local engagement	❖ Raising awareness ❖ Multi stakeholder initiatives
Coordination inside food chains		❖ Approach in food chain ❖ Relationships with actors in the food chain	❖ Enabling environment (contractual rules and incentives) ❖ Policies
Valorisation of food and by-products		❖ Food processing	❖ Support or implementation of uses of hierarchy.
Coordination of policies and actions			❖ Policies ❖ Multi stakeholder initiative.

The suggested solutions involve all relevant actors in the food supply chain as well as policy makers and stakeholders who impact the supply chain. Solutions at the micro level refer to solutions from individual actors of the supply chain, such as technical solutions in transport, processing and packaging, better food preparation techniques at home. The meso level requires changes along the whole supply chain, involving the collaboration of two or more actors, such as investing in adapted cold chain developments, promoting corporate social responsibility, ensuring proper building of capacity, educating, training, and service extension. The suggested solutions on the macro level catalyse actions on both the micro and meso level, such as addressing cost and benefits to overcome "winners and losers" constraints in the food system and integrating FLW concern in policies.

The solution to reduce food loss is directly related in developing countries. Farming methods, structural infrastructure and the operating environment are the three components of food supply chain. Improved farming methods, including increased mechanization and the use of fertilisers and improved seeds, result in increased efficiency during the early stages of the supply chain and minimise losses.

At last country's environment needs to be strong enough to make easy markets. It is effective including import and export systems, stable environment and minimal corruption. By analysing these issues, many developing countries will be able to prevent food loss and increase food security. In developed countries most of the problems are because of the consumer behaviour and which is addressed to both cultural and political levels. Throughout the rich world, wasting food is socially acceptable.

The only globally available current study with FLW data at all level is from the process of producing to consuming and enclosing all sectors of food production, which include fisheries. Inspite of having so many limitations in the availability of data, it was found out that one-third of FLW (and its declination in developed and developing countries) is coherent with existing studies at regional and national level, as well as with sectoral studies by the global results of the study, and the order of magnitude.

At long last, take note of that crude information from FAO (2011a) and every one of the investigations of worldwide importance which give the evaluations of worldwide FLW, distributed in this way to the FAO (2011a) think about, depend on same information. Along these lines the beneath studies don't give autonomous assessments of the degree of FLW. Case of concentrates, for example, Kummu et al. (2012), the WRI think about (Lipinski et al., 2013), the FAO, 2013 Toolkit (FAO, 2013a), or the 2013 Report from the Institution of Mechanical Engineers (IMechE, 2013), and so forth.

Check Your Progress 4

Note: a) Write your answer in about 50 words.

b) Check your answer with those given at the end of the unit.

1. What are the Categories to reduce Food Loss and food waste?

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2. What are the Categories to reduce Food Loss and food waste?

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4.6 LET US SUM UP

This report confirms that reducing food losses and waste is one concrete way to improve the sustainability of food systems, towards food and nutrition security. As such, reducing FLW goes much further than just optimizing the functioning of the food system: it can be part of broader systemic changes towards more sustainable food systems and global food security. To contribute to this enterprise, the present report clarifies the question of definitions of FLW, including by introducing the notion of food quality losses and waste (FQLW), and it highlights the importance of sound methodologies for data collection, as currently available estimates are often still fragile. The HLPE defines sustainable food systems in relation to food security and nutrition. There are many causes to FLW. The report shows that for a diagnosis leading to solutions, it is crucial to identify causal links to FLW, as well as constraints to implement solutions. To enable this exercise, one of the report's main innovations is to propose a "hierarchy" of causes to FLW, which is important to guide action and understand the different levels of solutions. There are proven solutions, at different levels, to reduce FLW and the report presents some of them. The report shows that solutions need to take into account that there are different levels of causes, and that the causal links have to be considered and addressed. This calls often for coordinated action. This is why the report proposes three levels of solutions. However it is not so simple to implement them. Context-specific causes of FLW mean that solutions to reduce FLW are also very context-specific. The specificities of the food systems, local conditions of agriculture, fisheries, and animal husbandry, infrastructure, transport and retail, as well as "cultural" habits and modes of consumption make any package of solutions very much context-dependent. There is no one-size-fits-all package to fight food losses and waste. Deciding what strategy to adopt, at individual and collective level, adapted to specific contexts, which can be very diverse between countries, necessitates a thorough analysis of causes and the consideration of winners and losers, and of costs and benefits for all involved. It also necessitates the promotion of individual and collective action of many actors along the food chain, and in support of them. Addressing FLW goes with a stronger emphasis on the value of food and on the need to preserve it. It goes with changes towards more efficiency and sustainability, and to reconcile economics with the real value of resource use. Key to it would be to recognize an economic value to food that can still have a use in spite of having lost some of the expected qualities, as food, feed or for energy. In addition co-products and food-related waste can also be better valorized.

4.7 KEY WORDS

Food losses (FL) alludes to a decline, at all phases of the evolved way of life preceding the buyer level, in mass, of nourishment that was initially expected for human utilization, paying little mind to the reason.

Food waste (FW) alludes to sustenance proper for human utilization being disposed of or left to ruin at buyer level – paying little mind to the reason.

Food quality loss or waste (FQLW) alludes to the reduction of a quality characteristic of nourishment (sustenance, perspective, and so forth.), connected to the corruption of the item, at all phases of the natural way of life from collect to utilization**.**

4.8 REFERENCES AND SUGGESTED FURTHER READINGS

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4.9 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress 1

Your answers should include the following points:

1. Eatable parts harvested or produced by plants and animals are consumed by humans but not ultimately consumed by people is called as food loss.

2. Eatable food mass available for the human consumption throughout the supply chain is called as food waste. Food products can also face a failure quality and leading to economic loss and nutritional value loss.

Answers to Check Your Progress 2

Your answers should include the following points:

1. Production, Handling and storage, Processing and packing, Distribution and marketing, Consumption.

Answers to Check Your Progress 3

Your answers should include the following points:

1. The impacts are as follows:
   - Value of resources is visible form in the waste
   - Value of output is:
   - Should feed people
   - Save money and use it for something else
   - It has been avoided emissions.
2. The environmental impacts of macro system are:
   - Water and soil are the pressure of environment.
   - Greenhouse gases are emitted. Forests and conservation areas are occupied. Fishery resources are depleted.
   - Pressure on animals and birds.
   - Non- renewable energy is in great demand

Answers to Check Your Progress 4

Your answers should include the following points:

1. The categories to reduce food loss are:
   - Coordination inside food chains
   - Behavior change
   - Good practice
   - Investments
   - Valorization of food and by-products
   - Coordination of policies and actions
2. Farming methods, structural infrastructure and the operating environment are the three components of food supply chain. Improved farming methods, including increased mechanization and the use of fertilizers and improved seeds, reinimize losses.

UNIT 5 GENETICALLY MODIFIED ORGANISMS

Structure

5.0 INTRODUCTION

People have been altering the genomes of plants and animals for many years using traditional breeding techniques. Artificial selection for specific, desired traits has resulted in a variety of different organisms, ranging from sweet corn to hairless cats. But this artificial selection, in which organisms that exhibit specific traits are chosen to breed subsequent generations, has been limited to naturally occurring variations. In recent decades, however, advances in the field of genetic engineering have allowed for precise control over the genetic changes introduced into an organism. Today, we can incorporate new genes from one species into a completely unrelated species through genetic engineering, optimizing agricultural performance or facilitating the production of valuable pharmaceutical substances. Crop plants, farm animals, and soil bacteria are some of the more prominent examples of organisms that have been subject to genetic engineering.

5.1 OBJECTIVES

After reading this unit, you should be able to:

- define the concept and principle behind the production of GM crops;
- have a brief historical background of the GM crops;
- describe various methods used in the production of GM crops;
- comprehend the safety and ethical issues related to the production and utilisation of GM crops; and
- explain the competent authorities dealing with the regulation of GMO's in India.

5.2 WHAT ARE GENETICALLY MODIFIED CROPS?

Genetically modified organisms are those (plant, animal or microorganism) in which desired DNA from different organism has been inserted for improvement of certain traits. "Golden rice" is an example of GM crop. GMOs have novel combination of genetic material created for human consumption by using the molecular biology techniques. This technology is often known 'recombinant DNA technology' or 'genetic engineering' and the resulting organism is said to be 'genetically modified'. These plants have been modified in the laboratory to introduce noble and desired traits such as increased resistance to herbicides or improved nutritional content.

Traditionally, the enhancement of desired traits has been undertaken through breeding, but conventional breeding methods are very time consuming and are not very accurate. However, on the other hand, Genetic engineering can create organisms with the exact desired trait very rapidly and with great accuracy. GMOs are created by splicing genes of interest obtained from different species and them combining through genetic engineering.

5.3 BRIEF HISTORY OF GENETICALLY MODIFIED (GM) CROPS

Genetically modified organisms have attracted a large amount of media attention in recent years. First genetically modified organism (GMO) was made by two scientists named, Herbert Boyer and Stanley Cohen in 1973. They took a gene from a bacterium which provided resistance to the antibiotic, inserted it into a vector organism and then induced another bacterium to uptake the plasmid. The transformed or genetically modified bacterium was then able to survive in the presence of antibiotic. In 1974, a transgenic mouse was created by introducing foreign DNA into its embryo, making it the world's first GM animal. Then in 1976, the first genetic engineering company was founded and they produced a human protein in the bacterium. The production of genetically engineered human insulin was announced in the year 1978. However, the insulin produced by bacteria, called Humulin, was approved for release in 1982. The first GM crop produced in 1982was a tobacco plant genetically modified with an antibiotic-resistant gene. It was developed through tissue culture techniques by infecting tobacco with *Agrobacterium* with an antibiotic resistance gene. The GM tobacco plant thus obtained was able to grow a new plant containing the resistance gene.The first genetically engineered (GE) tobacco plant was found to be resistant to direct application of herbicides and to resist insects. Further, a range of field trials were performed to develop plants resistant to viral and fungal diseases. Also, modification of traits like delaying ripening, enhancement of starch content and so on was also done. In 1985, the first transgenic livestock was produced.With the invention of gene gun method in 1987, it became possible to transform the plants having low or no susceptibility to *Agrobacterium* infection.

China became the first country to commercialize transgenic plants, by introducing a virus-resistant tobacco in 1992. In 1992, the first genetically modified corn was approved for use by the U.S. Food and Drug Administration (FDA). A Tomato called Flavrsavr was the first commercially grown GMO and was modified to ripen without softening. It was developed by Calgene Inc., USA in 1994. Currently, a number of food crops such as soybean, corn, cotton, tomatoes, Hawaiian papaya, potatoes, canola, sugarcane, sugar beet, field corn as well as sweet corn and rice have been genetically modified to enhance their yield, grain size, durability, etc. The first biotechnologically produced food ingredient was Chymosin, an agent that helps in clotting of milk clot during production of cheese. Also in 1994, the European Union approved GM tobacco making it the first genetically engineered crop commercialized in Europe. An insect resistant Potato was approved for release in the USA in 1995, and by 1996 approval had been granted to commercially grow 8 transgenic crops and one flower crop in 6 countries plus the European Union. Therefore, the commercialization of GM food started in 1996 by 6 countries. Major producers of transgenic crops include USA, Argentina, Brazil, India, Canada, China, Paraguay, South Africa, among others. Therefore, it is clear that since genetically modified food has been introduced, it has become a huge part of the crop industry. Therefore, it is very important that we understand the effects genetically modified crops have on our environment.

In 2010, scientists announced that they had created the first synthetic bacterial genome. It was the world's first synthetic life form. The first commercialized genetically modified animal was the Zebra fish with a fluorescent gene added that allows it to glow in the dark under UV light. The first genetically modified animal to be approved for food use was a salmon in 2015. The salmon were transformed with a growth hormone regulating gene enabling it to grow year-round instead of only during spring and summer. Most of the research on GM crops has been carried out in developed countries. However, many developing countries have also established the capacity for genetic engineering.

5.4 CONCEPT

Genetically modified organisms are organisms whose genetic makeup has been directly altered by humans. Living organism's biochemical, anatomical, physiological and behavioural traits are determined by genetic information encoded in deoxyribonucleic acid (DNA). The process of genetic modification involves identifying the portions of DNA that are responsible for a particular trait in one organism, copying these DNA sequences, and then introducing them into a different organism (either directly, or using "vectors," such as bacteria or viruses). Traditionally, many of the characteristics of domestic animals and agricultural crops have been modified developed through such selective breeding. For example, two different species of the grass family, wheat and rye, were bred to form a hybrid offspring that have the ruggedness of rye and the high yield of wheat. However, the GMOs are produced by using modern genetics with the help of recombinant DNA technology, which helps in improving plants, animals and microorganisms for production of food. Genes are cut from plants or animals that have a desired trait, and then pasted into plants or animals at precise locations to create a desired beneficial effect. The organism produced by these methods are said to be genetically modified or genetically engineered or transgenic.

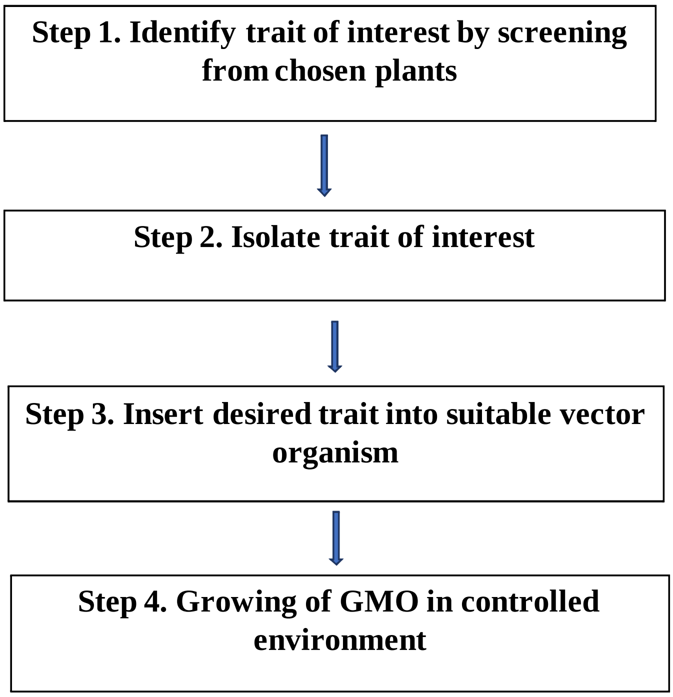

Figure 5.1: Schematic chart of the steps involved in the laboratory production of a Genetically Modified Organism

Human DNA sequences have been transplanted into mice, causing the mice to produce components for human blood needed in medicine. Similarly, crop plant have been developed that carry genetic information from bacteria making plants resistant to herbicides. Almost 150 million hectares of world crop acreage is planted with GM crops. The America constitutes the largest growing region, but GM cotton area is substantial in Asia. A variety of GM crops having novel traits have been developed and released for commercial agriculture production. These include, inter alia, herbicide glyphosate resistant soybean; cotton and viral disease, pest resistant cotton, maize, canola; resistant potatoes, papaya and squash. In addition, various transgenic crops are under development with traits for phytoremediation, bioforti?cation, and production of pharmaceuticals such as bananas with vaccines. Commercial cultivation of transgenic crops started in the early 1990s. GM crops are now commercially planted on about 100 million hectares in some 22 developed and developing countries. Argentina, Brazil, China and India are the largest developing-countries producing transgenic crops.

5.5 VARIOUS METHODS INVOLVED IN GM ORGANISM (GMO) PRODUCTION

The methods involved in the production include physical, chemical and biological methods. These methods include:

- Gene Gun method or biolistics
- Microinjection
- Electroporation
- *Agro-bacterium* mediated transformation
- **Gene guns (also known as biolistics)** shoot target genes into plant cells. It is the most common method. DNA is bound to tiny particles of gold or tungsten which are shot into plant tissue or single plant cells under high pressure. The accelerated particles penetrate into cell wall and membranes. The DNA separates from the metal and is integrated into plant DNA inside the nucleus. This method has been applied successfully for many cultivated crops, like wheat or maize. The major disadvantage of this procedure is that serious damage can be done to the cellular tissue.
- ***Agrobacterium tumefaciens*-mediated transformation** is another common technique. It is a natural plant parasite that has the ability to transfer genes.
- **Electroporation** is used when the plant tissue does not contain cell walls. In this technique, electric pulses are used to create miniature pores in the plant cell through which the DNA enters.
- **Microinjection** is used to directly inject foreign DNA into cells.

5.6 SAFETY AND ETHICAL ISSUES ASSOCIATED WITH GM CROPS

Till date no negative effects of GM crops on animals have been reported. It is rare that genes may transfer from plants to disease-causing bacteria through the food chain. The vast majority of the research based on GM organisms suggests that they are safe to eat and that they have the potential to feed millions of starving people worldwide.Nevertheless, scientists advise that genes which determine resistance to antibiotics that are critical for treating humans should not be used in genetically modified plants.

There are very few genetically-modified whole fruits and vegetables available on produce stand and no genetically modified animals were used in commercial agriculture anywhere in the world, but several livestock and aquatic organisms were being studied. Some genetic modifications could lead to more intensive livestock production and thus increased pollution. Food items made of genetically modified crops that are currently available (mainly maize, soybean, and oilseed rape) have been judged safe to eat. However, the lack of evidence of negative effects does not mean that new genetically modified foods are without risk.Scientists recommend that food safety assessment should take place on a case-by-case basis before genetically modified food is brought in to the market. Agriculture of any type has an impact on the environment and therefore growing genetically modified or conventional plants in the field has raised concern for the potential transfer of genes from cultivated species to their wild relatives. In the future, genetically modified plants may be equipped with mechanisms designed to prevent gene flow to other plants. A controversy has arisen about whether certain genetically modified plants which are insect resistant because they carry the*Bt* gene could harm not only insect pests but also other species such as the monarch butterfly. Therefore, continued monitoring for such effects is needed.

Genetically modified crops may also have indirect environmental effects due to changing agricultural or environmental practices. However, it remains controversial whether the net effect of these changes will be positive or negative for the environment. Many environmental organizations and public interest groups have been actively protesting against GM foods for years. The overall goal of genetically modifying food is to create a better yield for farmers by supplying these crops with resistance to factors that would generally harm organic food. However, the broad consensus is that the environmental effects of genetically modified plants should be evaluated using science-based assessment procedures, considering each crop individually in comparison to its conventional counterparts.

The Convention on Biological Diversity (CBD) is mainly concerned with the conservation and sustainable use of ecosystem but also with environmental effects of GMOs. A part of this convention is the Cartagena Protocol on Biosafety, which regulates the export and import of genetically modified crops. The Cartagena Protocol on Biosafety came into force in 2003, and by October 2011 has been rati?ed by 161 countries. The objective of the Protocol, as stated "is to contribute to ensure an adequate level of protection in the ?eld of the safe transfer, handling and use of living modi?ed organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking into account risks to human health, and speci?cally focusing on trans-boundary movements". For the host of countries, it is also mandatory to label products that use GM ingredients. Many environmental activists, religious organizations, public interest groups, and other scientists and government officials have all raised concerns about GM foods, and criticized government for pursuing profit without concern for potential hazards. The starting point for the safety assessment of genetically modified crops is to assess if the food is 'substantially equivalent' to its natural counterpart or not. The product is tested by the manufacturer for unexpected changes in components such as toxins, nutrients or allergens that are present in the unmodified food. The data is then assessed by an independent regulatory body. If these tests show no significant difference between the modified and the unmodified products, then no further food safety testing is required.

The status of GM crops is controversial and the subject of protests and scientific disputes. The controversies involve governmental regulators, consumers, biotechnology NGOs and scientists. The key areas include effect of GM crops on human health and environment, impact on farmers, labelling of GM food, and role of government regulators. According to current scientific consensus use of GM crops poses no great risk to human health but GM goods need to be tested before introduction. The legal and regulatory status of GM foods varies by country, with some nations restricting them, and others permitting them.

No reports of ill effects have been documented in the human population from GM food. Still, GM crop labelling is required in many countries. The ethical issues concern with the use of GM crops includes violation of natural organism's intrinsic values and tampering with nature by mixing genes among species.

Check Your Progress 1

Note: a) Write your answer in about 50 words.

b) Check your answer with those given at the end of the unit.

1. What are genetically modified (GM) organisms and GM foods?

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2. Why are GM foods produced? How is a safety assessment of GM food conducted?

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5.7 STATUS OF GMO's IN INDIA

India's government has not yet announced a policy on GM foods because no edible GM crops are grown in India and no products are commercially available in markets yet. India is, however, very supportive of transgenic plant research *Bt*Cotton is an important fire crop of India. After China, India is the largest producer and consumer of cotton. However, it suffers great crop losses due to its susceptibility to insect pests. Therefore, the cotton plant was genetically modified with a pest resistant gene from bacterium *Bacillus thringenesis* (*Bt*). *Bt* cotton is therefore a genetically modified cotton variety with very high resistivity to bollworm, a major pest of cotton. In 2011, India celebrated a decade of successful cultivation of *Bt* cotton, which has achieved phenomenal success in transforming the cotton crop into the most productive and profitable crop in the country.Use of *Bt* cotton increases yield of cotton due to effective control of bollworms andreduction in insecticide use in the cultivation. Further, it causes potential reduction in the cost of cultivation and decrease in environmental pollution by the use of insecticides.However, it possess certain limitations like high cost of *Bt* cotton seeds as compared to non *Bt* cotton seeds, effectiveness up to 120 days after whichthe toxin producing efficiency drastically reduces. However, excessive use of *Bt* cotton lead to loss of genetic diversity, sheep death, farmer suicides, developing resistance among the pests, illegal *Bt* cotton seed marketing and low yield compared to USA and China.

Bt Brinjal (*Solanum melongena* L.) is the fourth most important vegetable grown after potato, onion and tomato in India. It is an indigenous vegetableplant to India and home to a vast number of varieties. Today, Brinjal contributes to almost 8% of vegetable production in India and is a widely consumed vegetable. It is beneficial for human health because it is high in fibre and water, rich in anti-oxidants, and a good source of vitamins and minerals. Eggplant farmers suffer significant yield losses at 51-73% annually due to the Eggplant Fruit and Shoot Borer (FSB).Farmers rely mainly on the application of chemical pesticides to control FSB. The chemical control involves excessive and indiscriminate use of pesticides, causing multiple side-effects.Due to the above constraints, the use of*Bt*Brinjal will provide insect resistance that gives a selective advantage to the plant and increases its ability to survive and reproduce. It will also reduce the use of insecticides, thus making the growing environment less harmful for fauna and flora.It is the first Genetically Modified food crop in India that has reached the approval stage for commercialization.

Dhara Mustard Hybrid-11 or DMH-11 is a genetically modified variety of mustard If approved by the Centre, this will be the second GM crop, after *Bt* Cotton, and the first transgenic food crop to be allowed for cultivation in the country. *Bt*mustard is a hybrid variety developed by Delhi University's Centre for Genetic Manipulation of crop plants. GM mustard hybrid, it is claimed, gives 25-30% more yield than the best varieties currently grown in the country. Regulatory agencies are making final review regarding the biosafety data related to GM mustard.

Major companies interested in Genetically Modified crops in India include Monsanto India, Mahyco and BASF. The industry body, Association of Biotech Led Enterprises- Agriculture Group (ABLE-AG) wants a progressive push to the march of GM technology in India. The only genetically modified cash crop under commercial cultivation in India is cotton.As per the Indian GMO Research Information System (IGMORIS), the GM crops, apart from Brinjal and Mustard that are being currently tested are:

Table 5.1: List of Genetically Modified crop plants being currently tested in India

\Sr. No.	GM Crop	Trait modified
1.	Cabbage and Cauliflower	Insect resistance
2.	Potato	Transgenic dwarf potato Disease resistance, Reduction in cold induced sweetening and chip colour improvement
3.	Groundnut	Virus Resistance
4.	RRF cotton	Insect resistance and Herbicide Tolerance
5.	Corn	Insect resistance and Herbicide Tolerance
6.	Rice	Insect resistance
7.	Cotton	Insect resistance
8.	Sorghum	Insect resistance

Source: Secretariat, R.S. (2009)

ACTIVITIES

Organize students into groups, based on whether they took notes for or against the use of genetically modified foods. Give each group a copy of the "Are Genetically Modified Foods Safe?"

Hold a class discussion about whether students would be willing to eat genetically modified foods and why or why not. To conclude the lesson, have students discuss how the decision whether to allow these foods to be grown should be made and who should be part of the decision-making process.

Make a list, how many and what kind of GE crops have been approved?

5.8 COMPETENT AUTHORITIES DEALING WITH THE REGULATION OF GMO's IN INDIA

- **Genetic Engineering Approval Committee (GEAC)**

  GEAC under the Ministry of Environment and Forests, to look into approval for large scale releases and commercialization of the GMOs.

- **Recombinant DNA Advisory Committee (RDAC)**

  RDAC under the Department of Biotechnology, Ministry of Science and Technology, to recommend appropriate safety regulations in recombinant research, use and applications.

- **Review Committee on Genetic Manipulation (RCGM)**

  RCGM under the Department of Biotechnology, to monitor safety related aspects in respect of ongoing research projects and activities involving genetically engineered organisms. It lays down procedures/regulations regarding research, production, sale, import and use of genetically engineered organisms with a view to ensure environment safety.

- **Institutional Biosafety Committees (IBSC)**

  IBSC under the Department of Biotechnology, Ministry of Science and Technology, to prepare site-specific plans for use of genetically engineered microorganisms.

- **State Biotechnology Coordination Committee (SBCC)**

  SBCC in the States wherever necessary to inspect, investigate and take punitive action in case of violations of safety and control measures in the handling of genetically engineered organisms.

- **District Level Committee (DLC)**

  DLC in the districts wherever necessary under the District Collectors to monitor safety regulations in installations engaged in the use of genetically modified organisms and their applications in the environment.

5.9 PROSPECTS AND PROBLEMS

Dear learners let us now read about prospects and problems in the following lines:

5.9.1 Possible Benefits of GM crops

- **Increased nutritional value**

  Genetically modified crops are better to taste and have greater nutrients. Farmers can also grow more plants or food on less land with genetically modified crops. Genetically modified crops contain additional nutrients that are lacking in commonly grown varieties. An important example of the potential of this technology is the 'Golden Rice Project'. Vitamin A deficiency is widespread in the developing world. Golden Rice was developed to have enhanced levels of ß-carotene, in order to prevent vitamin A deficiency. The overpopulation causes a major stress on our environment because we are expecting it to provide us with all the resources we need. GM crops will reduce world hunger because they increase the yield.

- **Increased crop yields**

  There is an expectation widely held by those in agriculture that GM seeds will increase. There is a statistically significant relationship between increased crop yields and increased adoption of herbicide- and pesticide-tolerant crop seeds. It is found that crop yields significantly increased when farmers adopted herbicide-tolerant cotton and Bt cotton. Bt crops out-yielded non Bt crops.

- **Protection from Biotic and Abiotic Environmental Stresses**

  New genetically modified crops can withstand environmental stresses such as drought, salinity, or the presence of aluminum in the environment. They may permit cultivation of soils that are presently of low productivity for agriculture. There are many viruses, fungi and bacteria that cause plant diseases. Plant biologists are working to create plants with genetically-engineered resistance to these diseases. Unexpected frost can destroy sensitive seedlings. An antifreeze gene from cold water fish has been introduced into plants such as tobacco and potato. With this antifreeze gene, these plants are able to tolerate cold temperatures that normally. It will reduce strain on non-renewable resources.

- **Application in pharmaceuticals**

Genetically modified plants produce vaccines or other medicines. Potatoes have been modified to produce edible vaccines against *Escherichia coli*bacteria which cause diarrhea. This would allow cheap and easy distribution of the vaccine.

- **Reduction in Herbicide and Pesticide Use**

  GMOs reduced pesticide spraying and as a result, decreased the environmental impact associated with herbicide and insecticide use on these crops. Farmers typically use many tons of chemical pesticides annually. Growing GM foods such as *Bt* corn can help eliminate the application of chemical pesticides and reduce the cost of bringing a crop to market. Crop plants genetically-engineered to be resistant to powerful herbicide could help prevent environmental damage by reducing the number of herbicides needed.

- **Help in combating climate change impacts**

  In addition, the GMO technology has reduced greenhouse gas emission, originally caused by conventional ways of farming. Emission of greenhouse gasses causes a huge detriment to the environment. If we can lessen greenhouse gases, then we can help our current climate change situation. Climate change is a major controversy right now and from this statistic, GMOs will positively affect this issue.

5.9.2 Possible Risks Associated with the Use of GM Crops

- As the use of GMOs has become more frequent, weeds have developed a resistance to the herbicides. Therefore, we have to increase the use of herbicides in order to control the weeds. This can cause a negative effect on our environment because herbicides are not good for human intake.
- The use of GM crops may cause leakage of GM proteins into the soil that will affect the useful bacteria, microbes and beneficial interactions in soil. It will also lead to inadvertent toxicity to benign flora and fauna.
- Non-GM crops could be contaminated by the spread of genetically modified traits by wind and insect cross-pollination. Once those traits are in the agricultural gene pool, they say, there's no way to remove them. A second negative impact is that genetically modified organisms have the potential of disturbing the natural ecosystem. The use of herbicide-resistant corn and soybeans raises the possibility of out-crossing, which could lead to the development of more aggressive weeds or herbicide-resistant wild relatives of these cultivated plants.
- This use of herbicides also has an indirect effect on animal development. For example, certain amphibians, including tadpoles, live in aquatic habitats in the first stages of their life and are directly affected by GM crops because they are blown into the water. When they ingest these crops their growth and development is greatly affected.
- These GM crops may cause threat to other species of insects for example, *Bt* 176, the transgenic component in *Bt* corn, produces pollen that is highly toxic to Monarch larvae and other butterfly species.
- Since it's a very costly technology, one has to depend on the multinationals which disrupt the traditional practices in developing countries.

5.9.3 Human Health Risks Associated with GMOs

Allergenicity

Many children worldwide have developed life-threatening allergies to peanuts and other foods. There is a possibility that introducing a gene into a plant may create an allergic reaction in susceptible individuals. Extensive testing of GM foods may be required to avoid the possibility of harm to consumers with food allergies.

5.9.4 Unknown Effects on Human Health

There is a growing concern that introducing foreign genes into food plants may have an unexpected and negative impact on human health. A recent article published examined the effects of GM potatoes on the digestive tract in rats. This study claimed that there were differences in the intestines of rats fed GM potatoes and rats fed unmodified potatoes.

GM crops are a profitable farming endeavour. GM crops are used in agriculture to improve crop yields and reduce farming costs, however the use of GM crops is a contentious issue, as economic benefits must be weighed against environmental risks. It is important to develop the technical capacity and expertise to regulate the use of GM crops in developing countries.Agreements between policy makers and the seed industry should be established, to facilitate compensation of small scale farmers. Scientists cannot declare any technology completely risk free. GM crops can reduce some environmental risks associated with traditional agriculture, but will also imposes new challenges that must be addressed. Genetically-modified foods have the potential to solve the world's hunger and malnutrition problems, and to help and preserve the environment by increasing yield and reducing reliance upon chemical pesticides and herbicides. GM foods have the potential to solve many of the world's hunger and malnutrition problems, and to help protect and preserve the environment by increasing yield and reducing reliance upon chemical pesticides. There are many challenges ahead for governments, especially in the areas of safety testing, regulation, industrial policy and food labelling.

Check Your Progress 2

Note: a) Write your answer in about 50 words.

b) Check your answer with those given at the end of the unit.

1. What are the main issues of concern for human health? What are the .... issues of concern for the environment?

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   ....

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2. How are GM foods regulated nationally? Why has there been concern about GM foods among some politicians, public interest groups and consumers?

   ....

   ....

   ....

   ....

5.10 LET US SUM UP

- Genetically modified organisms (GMOs) can be defined as organisms (i.e. plants, animals or microorganisms) in which the genetic material (DNA) has been altered in a way that does not occur naturally. The technology is called genetic engineering. Foods produced from or using GM organisms are often referred to as GM foods.

- One of the objectives for developing plants based on GM organisms is to improve crop protection. Resistance against insects is achieved by incorporating into the food plant the gene for toxin production from the bacterium *Bacillus thuringiensis* (*Bt*). This toxin is currently used as a conventional insecticide in agriculture and is safe for human consumption. Susceptible to diseases caused by such viruses, resulting in higher crop yields.

- Most of national authorities consider that specific assessments are necessary for GM foods. Specific systems have been set up for the rigorous evaluation of GM organisms and GM foods relative to both human health and the environment.

- The safety assessment of GM foods generally focuses on: (a) direct health effects (toxicity), (b) potential to provoke allergic reaction (allergenicity); (c) specific components thought to have nutritional or toxic properties; (d) the stability of the inserted gene; (e) nutritional effects associated with genetic modification; and (f) any unintended effects which could result from the gene insertion.

- The three main issues debated are the potentials to provoke allergic reaction (allergenicity), gene transfer and outcrossing.

- The issues of concern for the environment include: the capability of the GMO to escape and potentially introduce the engineered genes into wild populations; the persistence of the gene after the GMO has been harvested; the susceptibility of non-target organisms (e.g. insects which are not pests) to the gene product; the stability of the gene; the reduction in the spectrum of other plants including loss of biodiversity; and increased use of chemicals in agriculture.

- Individual GM foods and their safety should be assessed on a case-by-case basis and that it is not possible to make general statements on the safety of all GM foods.

- The way governments have regulated GM foods varies. In some countries GM foods are not yet regulated. Countries which have legislation in place focus primarily on assessment of risks for consumer health.

- The Cartagena Protocol on Biosafety, an environmental treaty legally binding for its Parties which took effect in 2003, regulates transboundary movements of Living Modified Organisms (LMOs).

- The release of GMOs into the environment and the marketing of GM foods have resulted in a public debate in many parts of the world. This debate is likely to continue, probably in the broader context of other uses of biotechnology (e.g. in human medicine) and their consequences for human societies.

- Intellectual property rights are likely to be an element in the debate on GM foods, with an impact on the rights of farmers.

5.11 KEY WORDS

Genetically modified organisms are those (plant, animal or microorganism) in which desired DNA from different organism has been inserted for improvement of certain traits.

Electroporation is used when the plant tissue does not contain cell walls. In this technique, electric pulses are used to create miniature pores in the plant cell through which the DNA enters.

5.12 REFERENCES AND SUGGESTED FURTHER READINGS

'Protocols for Food and Feed Safety Assessment of GE crops', Department of Biotechnology, Ministry of Science and Technology, Government of India, 2008

Amarnath K. Menon, 'GM Food: How Safe is it?', India Today, 2 November 2009

Cartagena Protocol on Biosafety (bch.cbd.int/protocol)

Genetically modified crops issues and challenges in the context of India, Research unit (LARRDIS) Rajya Sabha secretariat, New Delhi, December, 2009

National Biotechnology Development Strategy: Key Elements', Department of Biotechnology, Ministry of Science and Technology.

5.13 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress 1

Your answers should include following points:

1. Genetically modified organisms (GMOs) can be defined as organisms (i.e. plants, animals or microorganisms) in which the genetic material (DNA) has been altered in a way that does not occur naturally. The technology is called genetic engineering. Foods produced from or using GM organisms are often referred to as GM foods.

2. Genetically modified foods, GM foods or genetically engineered foods, are foods produced from organisms that have had changes introduced into their DNA using the methods of genetic engineering as opposed to traditional cross breeding.

3. One of the objectives for developing plants based on GM organisms is to improve crop protection.

4. Resistance against insects is achieved by incorporating into the food plant the gene for toxin production from the bacterium *Bacillus thuringiensis* (*Bt*).

5. Specific systems have been set up for the rigorous evaluation of GM organisms and GM foods relative to both human health and the environment.

6. Safety assessment generally focuses on:

   a) toxicity;

   b) allergenicity;

   c) specific components thought to have nutritional or toxic properties;

   d) the stability of the inserted gene;

   (e) nutritional effects associated with genetic modification; and

   (f) any unintended effects which could result from the gene insertion.

Answers to Check Your Progress 2

Your answer should include the following points:

1. The three main issues debated are:

   a) allergenicity;

   b) gene transfer; and

   c) outcrossing.

2. The issues of concern for the environment include:

   a) entry of the engineered genes into wild populations;

   b) the persistence of the gene after harvesting if GM crop;

   c) the susceptibility of non-target organisms to the gene product;

   d) the stability of the gene;

   e) the reduction in the spectrum of other plants including loss of biodiversity; and

   f) increased use of chemicals in agriculture.

3. The way governments have regulated GM foods varies. In some countries GM foods are not yet regulated. Countries which have legislation in place focus primarily on assessment of risks for consumer health.

4. The Cartagena Protocol on Biosafety, an environmental treaty legally binding for its Parties which took effect in 2003, regulates transboundary movements of Living Modified Organisms (LMOs).

5. The release of GMOs into the environment and the marketing of GM foods have resulted in a public debate in many parts of the world. This debate is likely to continue, probably in the broader context of other uses of biotechnology (e.g. in human medicine) and their consequences for human societies.

6. Intellectual property rights are likely to be an element in the debate on GM foods, with an impact on the rights of farmers.