Bacteriocins and their application

Bacteriocins are proteinaceous compounds produced by certain bacteria, and they have antimicrobial properties. These compounds are part of a bacterium's defense mechanism against other bacteria, often serving to inhibit the growth or kill competing microorganisms. Bacteriocins can be thought of as natural antibiotics produced by bacteria.

Bacteriocins are antimicrobial peptides or proteins produced by certain bacteria as a defense mechanism against competing microorganisms.

Here's an overview of bacteriocins and their production:

1. **Nature of Bacteriocins:** Bacteriocins are typically small, heat-stable proteins or peptides that can kill or inhibit the growth of closely related or even unrelated bacterial strains. They are usually effective against bacteria closely related to the producer strain, making them an important tool in bacterial competition and niche protection.
2. **Production:** Bacteriocins are produced by various bacterial species, including lactic acid bacteria (LAB) such as Lactobacillus and Streptococcus. The production of bacteriocins follows a complex process:

   a. **Gene Expression:** Bacteriocin production is regulated by specific genes in the bacterium's genome. When conditions favor bacteriocin production, these genes are expressed.
   b. **Peptide Synthesis:** The bacterium synthesizes the precursor bacteriocin peptide. This peptide is typically inactive until it is post-translationally modified.
   c. **Post-Translational Modifications:** The precursor bacteriocin peptide undergoes various post-translational modifications, including cleavage by specific enzymes. These modifications are essential for activating the bacteriocin and making it antimicrobially active.
   d. **Secretion:** Once activated, the bacteriocin is secreted into the extracellular environment. It can then interact with and target other bacteria.
   e. **Mode of Action:** Bacteriocins can act through various mechanisms, such as pore formation in the target cell membrane, disruption of cellular functions, or interference with DNA replication.
3. **Applications:** Bacteriocins have several potential applications:
   - **Food Preservation:** Bacteriocins produced by LAB are used in the food industry as natural preservatives to inhibit the growth of spoilage and pathogenic bacteria.

- **Probiotics:** Some probiotic strains of bacteria produce bacteriocins, which can contribute to their ability to compete with harmful bacteria in the gut and maintain gut health.
- **Biotechnology:** Bacteriocins have been explored for their potential in biotechnology and medicine as alternatives to traditional antibiotics.

4. **Safety:** Bacteriocins are generally considered safe for consumption because they are produced by bacteria that are part of the human microbiota and have a long history of safe use in fermented foods.
5. **Engineering Bacteriocin Production:** Researchers are also working on engineering bacteria to produce specific bacteriocins or to enhance their production for various applications, including medical treatments and biotechnology.

In summary, bacteriocins are antimicrobial peptides or proteins produced by certain bacteria, primarily to compete with other microorganisms in their environment. They have various applications, particularly in food preservation and gut health, and their production can be modulated and engineered for specific purposes.

The extraction and purification of bacteriocins from bacterial cultures involve several steps to isolate these antimicrobial peptides or proteins. Here's an overview of the production steps for extracting bacteriocins:

1. **Bacterial Culture:** The first step is to cultivate the bacterium that produces the bacteriocin. This typically involves growing the bacterium in a suitable nutrient medium under controlled conditions. The choice of medium and culture conditions can influence bacteriocin production.
2. **Harvesting the Culture:** Once the bacterial culture reaches the desired growth phase and bacteriocin production has occurred, the culture is harvested. This involves separating the bacterial biomass from the culture broth, usually by centrifugation or filtration.
3. **Cell Disruption:** To release the intracellular components, including bacteriocins, from the bacterial cells, cell disruption methods are employed. Common techniques include mechanical disruption (e.g., using a homogenizer or sonicator), enzymatic digestion, or chemical disruption (e.g., using detergents).
4. **Centrifugation:** After cell disruption, the mixture is centrifuged to separate the cell debris and other insoluble components from the supernatant, which contains the bacteriocin.

5. **Concentration:** The supernatant, which contains the bacteriocin, is often quite dilute. It may be concentrated using techniques like ultrafiltration or diafiltration to reduce the volume and increase the concentration of the bacteriocin.
6. **Purification:** Purification steps are crucial to separate the bacteriocin from other proteins, peptides, and contaminants present in the culture supernatant. Common purification techniques include:
    - **Chromatography:** Various chromatographic methods, such as ion-exchange chromatography, size-exclusion chromatography, and affinity chromatography, can be employed to isolate and purify the bacteriocin based on its properties (charge, size, binding affinity, etc.).
    - **Precipitation:** Salting out or adding organic solvents can be used to selectively precipitate the bacteriocin, which can then be separated from the precipitated contaminants.
    - **Electrophoresis:** Techniques like gel electrophoresis can be used for further separation and characterization of the bacteriocin.
7. **Characterization:** Once the bacteriocin is purified, it is characterized to confirm its identity, purity, and activity. This may involve techniques such as mass spectrometry, nuclear magnetic resonance (NMR) spectroscopy, and antimicrobial assays.
8. **Storage:** The purified bacteriocin is usually stored at low temperatures (e.g., -20°C or -80°C) to maintain its stability and activity over an extended period.

Mode of action

1. **Disruption of Cell Membranes:** Many bacteriocins act by disrupting the integrity of the target bacterial cell's membrane. They can create pores or holes in the cell membrane, which leads to the leakage of ions, small molecules, and eventually cell death. This disruptive action is often rapid and effective.
2. **Inhibition of Cell Wall Synthesis:** Some bacteriocins interfere with the synthesis of the peptidoglycan cell wall, an essential component of bacterial cell walls. By disrupting cell wall formation, they weaken the target bacteria's structural integrity, leading to cell lysis and death.
3. **Enzyme Inhibition:** Certain bacteriocins inhibit specific enzymes crucial for bacterial growth and metabolism. For example, they may target enzymes involved in DNA replication, RNA synthesis, protein synthesis, or energy production. Inhibiting these enzymes disrupts bacterial metabolism and growth.

4. **DNA or RNA Binding:** Some bacteriocins can bind to bacterial DNA or RNA, preventing replication or transcription processes. This interference with genetic material disrupts the bacteria's ability to reproduce and function properly.
5. **Competition for Nutrients:** In addition to direct killing or inhibition, some bacteriocins may compete with target bacteria for essential nutrients, such as iron or other micronutrients, making it difficult for the target bacteria to thrive.
6. **Quorum Sensing Interference:** Quorum sensing is a bacterial communication mechanism that regulates gene expression in response to cell population density. Some bacteriocins interfere with quorum sensing systems, disrupting the ability of bacteria to coordinate their behaviors and virulence factors.
7. **Induction of Programmed Cell Death:** Some bacteriocins induce programmed cell death, or apoptosis, in the target bacteria. This process leads to controlled and organized cell death, preventing the release of inflammatory molecules that can harm the host.
8. **Specificity:** Bacteriocins often exhibit a high degree of specificity, targeting particular bacterial species or strains. This specificity is advantageous as it allows them to selectively inhibit harmful bacteria while sparing beneficial ones, such as probiotics.

Application of Bacteriocins

1. **Food Preservation**:
    - Bacteriocins are used in the food industry as natural preservatives to extend the shelf life of perishable foods. They can inhibit the growth of pathogenic bacteria and spoilage organisms without the need for synthetic chemical preservatives.
2. **Food Safety**:
    - Bacteriocins can enhance food safety by preventing the growth of foodborne pathogens such as Listeria monocytogenes, Escherichia coli, and Salmonella. This application is particularly important in ready-to-eat and processed foods.
3. **Dairy Products**:
    - Bacteriocins are used in the production of dairy products like cheese and yogurt. Lactic acid bacteria, such as Lactococcus and Streptococcus species, produce bacteriocins that help control undesirable bacteria and molds during fermentation and storage.
4. **Biopreservation**:
    - Bacteriocins are employed as biopreservatives in various food products. They can be added directly to foods or used as part of protective cultures to

inhibit spoilage microorganisms and pathogens, improving food quality and safety.

5. **Veterinary Medicine**:
   - Bacteriocins are explored as potential alternatives to antibiotics in veterinary medicine. They can be used to treat bacterial infections in animals, potentially reducing the use of antibiotics and the development of antibiotic-resistant strains.
6. **Medical and Clinical Applications**:
   - Bacteriocins are being researched for their potential use in medical settings. Some bacteriocins show promise in the treatment of bacterial infections, including multidrug-resistant strains. They may also be used in wound care products and as alternatives to traditional antibiotics.
7. **Agriculture and Crop Protection**:
   - Bacteriocins can be used in agriculture to combat plant diseases caused by pathogenic bacteria. They may serve as biocontrol agents to protect crops from bacterial infections, reducing the need for chemical pesticides.
8. **Aquaculture**:
   - Bacteriocins have applications in aquaculture to control bacterial diseases in fish and shellfish farming. They can help maintain the health of aquatic organisms and improve the sustainability of aquaculture practices.
9. **Probiotics and Gut Health**:
   - Some probiotic bacteria produce bacteriocins, which can help maintain a healthy balance of gut microflora by inhibiting the growth of harmful bacteria in the gastrointestinal tract. This can contribute to overall gut health and digestive well-being.

Probiotics

Probiotic bacteria are live microorganisms that, when consumed in adequate amounts, confer health benefits on the host. These beneficial bacteria, often referred to as "friendly" or "good" bacteria, primarily reside in the gastrointestinal tract and play a crucial role in maintaining a healthy balance of gut microbiota.

Here are some key characteristics and functions of probiotic bacteria:

1. **Live Microorganisms:** Probiotic bacteria are living microorganisms, typically belonging to the Lactobacillus and Bifidobacterium genera, among others. They can also include certain strains of yeast, such as Saccharomyces boulardii.

2. Health Benefits: Probiotic bacteria offer a range of health benefits, including

- **Digestive Health:** They support digestion and help maintain a healthy gut microbiota. Probiotics can alleviate symptoms of irritable bowel syndrome (IBS), diarrhea, and constipation.
- **Immune System Support:** Probiotics can enhance the immune system's function by promoting a balanced immune response and improving the body's defense against infections.
- **Nutrient Absorption:** They aid in the absorption of nutrients, such as vitamins and minerals, in the gut.
- **Prevention of Pathogens:** Probiotics can inhibit the growth of harmful pathogens (pathogenic bacteria) by competing for nutrients and attachment sites in the gut.

3. Sources: Probiotic bacteria can be found in various food sources and dietary supplements. Common sources include yogurt, kefir, fermented foods (e.g., sauerkraut, kimchi), and certain dietary supplements (probiotic capsules, powders, or liquids).

4. Strain-Specific Benefits: Different strains of probiotic bacteria may have unique properties and health benefits. For example, specific strains may be more effective in alleviating certain digestive conditions, while others may be more beneficial for immune support.

5. Survival and Viability: For probiotics to be effective, they must survive the acidic environment of the stomach and reach the intestines alive, where they exert their health-promoting effects. The ability to survive and thrive in the gut is strain-dependent.

6. Prebiotics: Prebiotics are non-digestible fibers and compounds that serve as food for probiotic bacteria, helping them grow and thrive in the gut. Combining probiotics with prebiotics is known as synbiotics and can enhance their effectiveness.

7. Research and Clinical Applications: Probiotic research continues to grow, with studies examining their role in various health conditions, including gastrointestinal disorders, immune function, allergies, and more. Probiotics are also being explored for their potential impact on mental health and overall well-being.

8. Safety: Probiotic supplements are generally considered safe for most individuals when consumed in recommended amounts. However, individuals with weakened immune systems or certain medical conditions should consult with a healthcare

Production of probiotics

Probiotic bacteria have gained popularity due to their potential to support digestive health and overall well-being. When considering probiotic supplements, it's essential to choose products with well-documented strains and follow recommended dosages for specific health goals. Additionally, incorporating probiotic-rich foods into your diet can be a natural and tasty way to promote gut health.

The production of probiotics involves several key steps to ensure the growth, maintenance, and viability of beneficial microorganisms. Probiotics are live microorganisms, typically bacteria or yeast, that provide health benefits when consumed in adequate amounts.

Here's an overview of the production process:

1. **Selection of Strains**: The first step is to select the specific strains of probiotic microorganisms that will be used in the product. These strains should be well-researched, safe, and capable of surviving the digestive system to reach the gut.
2. **Culture Medium**: Probiotic microorganisms need a suitable culture medium to grow and multiply. The medium usually contains nutrients like sugars, amino acids, vitamins, and minerals. The composition of the medium depends on the specific requirements of the chosen strains.
3. **Inoculation**: The selected probiotic strains are inoculated into the culture medium. This involves adding a small amount of the pure culture to the medium to initiate the growth process.
4. **Fermentation**: The culture is then allowed to ferment. During fermentation, the microorganisms consume nutrients and reproduce, increasing in number. The duration of fermentation can vary depending on the strains used and the desired properties of the final product.
5. **Harvesting**: After fermentation, the probiotic culture is harvested. This can involve separating the live microorganisms from the culture medium, typically through processes like centrifugation or filtration.
6. **Viability Testing**: It's crucial to assess the viability (live cell count) of the probiotics to ensure they meet the desired potency and are capable of providing health benefits.

7. **Formulation**: The harvested probiotics may be mixed with other ingredients to create the final product. For example, they can be added to a yogurt base, encapsulated in pills, or included in a powdered supplement.
8. **Packaging**: The final product is packaged in a way that protects the probiotics from environmental factors like moisture, light, and oxygen, which can degrade their viability.
9. **Quality Control**: Quality control measures are implemented throughout the production process to ensure the product meets safety and quality standards. This includes regular testing for microbial contamination and potency.
10. **Storage**: Probiotic products should be stored under conditions that maintain the viability of the microorganisms. This often means refrigeration or other controlled storage conditions.
11. **Labeling and Marketing**: Probiotic products must be accurately labeled with information about the strains used, recommended dosage, and any health claims supported by scientific evidence.

Probiotics as preservatives

Probiotics are not typically used as preservatives in the same way that chemical preservatives are employed to extend the shelf life of food products. Instead, probiotics are used to ferment and preserve certain foods through a natural fermentation process.

Here's how probiotics can be involved in food preservation:

1. **Fermentation**: Probiotics play a crucial role in the fermentation of various foods and beverages. During fermentation, beneficial bacteria, such as Lactobacillus and Bifidobacterium, convert sugars and other compounds into lactic acid and other organic acids. This acidification of the food creates an environment that is unfavorable for the growth of harmful microorganisms like pathogenic bacteria, molds, and yeast. As a result, the food becomes preserved and safe to eat for an extended period.
2. **Preservation of Vegetables**: Probiotic fermentation is commonly used to preserve vegetables like cucumbers (pickles), cabbage (sauerkraut), and various other vegetables. The probiotic bacteria help acidify the environment, preventing the growth of spoilage organisms and pathogens. The result is a tangy, preserved vegetable product.
3. **Preservation of Dairy Products**: Probiotic bacteria are used to ferment dairy products like yogurt and kefir. These bacteria consume lactose (milk sugar) and

produce lactic acid, which acidifies the milk and prevents the growth of harmful bacteria. This acidification not only preserves the dairy product but also enhances its flavor and texture.
4. **Preservation of Beverages**: Probiotics can also be used in the fermentation of certain beverages like kombucha and water kefir. In these cases, probiotic cultures ferment sugars to produce organic acids and carbonation, which helps preserve the beverage while also giving it a unique flavor profile.

It's important to note that while probiotics can help preserve certain foods, they may not provide the same level of preservation as chemical preservatives. The shelf life of foods preserved with probiotics may be shorter than that of foods preserved with chemical additives. Additionally, the temperature, acidity, and other environmental factors during fermentation can influence the effectiveness of probiotic preservation.

Advantages of Probiotics

1. **Improved Gut Health**: Probiotics can help maintain a balanced gut microbiome, which is essential for digestion and overall well-being. Example: Lactobacillus and Bifidobacterium strains are commonly used probiotics that support gut health.
2. **Treatment of Diarrhea**: Probiotics can be beneficial in treating various forms of diarrhea, including antibiotic-associated diarrhea and infectious diarrhea. Example: Saccharomyces boulardii is a probiotic yeast often used to manage diarrhea.
3. **Immune System Support**: Probiotics may enhance immune function by promoting the growth of beneficial gut bacteria. Example: Lactobacillus rhamnosus GG (LGG) has been studied for its immune-boosting properties.
4. **Management of Irritable Bowel Syndrome (IBS)**: Probiotics may help alleviate symptoms of IBS, such as abdominal pain and irregular bowel movements. Example: Bifidobacterium infantis 35624 is a probiotic strain used for IBS management.
5. **Prevention of Vaginal Infections**: Probiotics can help maintain vaginal health by preventing and treating infections like bacterial vaginosis and yeast infections. Example: Lactobacillus acidophilus is used to support vaginal health.
6. **Mental Health Benefits**: Some research suggests that probiotics may have a positive impact on mental health by modulating the gut-brain axis. Example: Psychobiotics, which include certain strains like Lactobacillus and Bifidobacterium, are studied for their potential to influence mood.

7. **Reduction in Allergy Risk**: Early probiotic supplementation may reduce the risk of allergies, particularly in infants. Example: Certain formulas and infant foods are fortified with probiotics to support immune development.

Disadvantages of Probiotics

1. **Individual Variation**: Response to probiotics varies among individuals. Example: While a specific strain may help one person with diarrhea, it may not be effective for another.
2. **Potential Side Effects**: Probiotics can sometimes cause gas, bloating, or an upset stomach. Example: Some people may experience digestive discomfort when taking high-dose probiotic supplements.
3. **Lack of Scientific Consensus**: Not all probiotic benefits are universally accepted due to variations in study results. Example: While some studies show probiotics may help with IBS, others do not.
4. **Quality Control Issues**: The probiotic market is not uniformly regulated, leading to variations in product quality. Example: Some probiotic supplements may not contain the number of live organisms claimed on the label.
5. **Safety Concerns for Vulnerable Populations**: Probiotics may pose risks for individuals with compromised immune systems. Example: People with weakened immune systems, such as those with HIV/AIDS, should consult a healthcare professional before using probiotics.
6. **Cost**: High-quality probiotic supplements can be relatively expensive, especially when taken regularly. Example: Premium probiotic brands can be costly, making long-term use a financial consideration.
7. **Overuse and Inappropriate Use**: Inappropriate or excessive use of probiotics may lead to imbalances in the gut microbiome. Example: Taking high-dose probiotics without a medical reason may disrupt the natural gut flora.

Prebiotic

Prebiotics are non-digestible fibers or compounds that serve as a food source for beneficial gut bacteria, such as probiotics. They promote the growth and activity of these beneficial microorganisms in the digestive system. Prebiotics offer several advantages, but there are also some potential disadvantages to consider.

Advantages of Prebiotics:

1. **Supports Gut Health**: Prebiotics help nourish the beneficial bacteria in the gut, which can lead to a more balanced and healthy gut microbiome.
2. **Improved Digestion**: A healthy gut microbiome can enhance digestion and the absorption of essential nutrients from the foods you eat.
3. **Enhanced Immune Function**: A well-balanced gut microbiome can boost the immune system's effectiveness, helping the body defend against infections and illnesses.
4. **Potential Weight Management**: Some studies suggest that prebiotics may help with weight management by promoting a feeling of fullness and reducing calorie absorption.
5. **Mood and Mental Health**: Emerging research indicates a connection between gut health and mental health. Prebiotics may play a role in promoting positive mental well-being.
6. **Balanced Blood Sugar**: Prebiotics can help stabilize blood sugar levels by influencing how the body processes carbohydrates.
7. **Improved Bone Health**: Prebiotics may contribute to better calcium absorption and, consequently, improved bone health.

Disadvantages of Prebiotics:

1. **Gastrointestinal Symptoms**: In some individuals, high doses of prebiotics can lead to gastrointestinal symptoms such as gas, bloating, and diarrhea. This is especially true if someone has an imbalanced gut microbiome.
2. **Individual Variation**: The response to prebiotics can vary from person to person. Some individuals may benefit greatly, while others may not experience significant improvements in gut health.
3. **Overconsumption**: Consuming excessive amounts of prebiotics may lead to an overgrowth of certain gut bacteria, which can potentially have negative health consequences.
4. **Potential for Fermentation**: Prebiotics are fermented by gut bacteria, which can lead to the production of gases and short-chain fatty acids. While short-chain fatty acids are generally beneficial, excessive gas production can be uncomfortable.
5. **Limited Dietary Sources**: Prebiotics are found in certain foods, such as chicory root, garlic, onions, and some whole grains. A limited dietary intake of prebiotic-rich foods can make it challenging to incorporate them into one's diet.
6. **Allergies or Sensitivities**: Some individuals may have allergies or sensitivities to foods that are rich in prebiotics, such as onions or garlic.

7. **Digestive Disorders**: People with certain digestive disorders, like irritable bowel syndrome (IBS), may be more sensitive to prebiotics and experience increased gastrointestinal symptoms.

Food poisoning

Food poisoning, also known as foodborne illness, is a common and potentially serious health issue caused by consuming contaminated food or beverages. It occurs when harmful microorganisms, such as bacteria, viruses, parasites, or toxins produced by them, contaminate the food or drink and are ingested. Food poisoning can lead to a range of symptoms, which can vary in severity, from mild gastrointestinal discomfort to severe illness.

Common causes and sources of food poisoning include:

1. **Bacteria**: Bacteria like Salmonella, Escherichia coli (E. coli), Campylobacter, and Listeria are among the most common culprits. These bacteria can multiply rapidly in food if it is not stored, cooked, or handled properly.
2. **Viruses**: Viruses such as Norovirus and Hepatitis A can cause food poisoning. Contamination can occur through contact with infected food handlers or contaminated water.
3. **Parasites**: Parasites like Giardia and Cryptosporidium can contaminate food or water and cause illness when ingested.
4. **Toxins**: Some bacteria produce toxins that can cause food poisoning even if the bacteria themselves are not present in high numbers. Examples include Staphylococcus aureus and Clostridium perfringens.

Symptoms of food poisoning can vary depending on the specific pathogen involved, but common symptoms include:

- Nausea
- Vomiting
- Diarrhea
- Abdominal pain or cramps
- Fever
- Headache
- Muscle aches

In more severe cases or with certain pathogens, food poisoning can lead to complications, such as dehydration, electrolyte imbalances, kidney problems, and, in rare instances, life-threatening conditions.

Reason for food poisoning

Food poisoning can occur for various reasons, but it typically happens when food becomes contaminated with harmful microorganisms or toxins. Here are some common reasons for food poisoning:

1. **Bacterial Contamination**: Bacteria are a leading cause of food poisoning. They can multiply rapidly in certain conditions. Common bacterial culprits include Salmonella, Escherichia coli (E. coli), Campylobacter, Listeria, and Staphylococcus aureus.
2. **Cross-Contamination**: This occurs when harmful microorganisms from one food item are transferred to another, often through shared utensils, cutting boards, or hands. For example, cutting raw chicken on a cutting board and then using the same board to chop vegetables can lead to cross-contamination.
3. **Improper Food Handling**: Poor food handling practices, such as not washing hands before food preparation, not storing food at proper temperatures, and undercooking meat and poultry, can introduce or promote the growth of harmful bacteria.
4. **Raw or Undercooked Foods**: Consuming raw or undercooked animal products, such as eggs, poultry, seafood, and ground beef, can expose individuals to bacteria like Salmonella, Campylobacter, and E. coli.
5. **Contaminated Water**: Water contaminated with bacteria, viruses, or parasites can be a source of food poisoning, particularly when used for washing produce or diluting beverages.
6. **Cross-Contamination in the Kitchen**: Inadequate cleaning and sanitation of kitchen equipment, countertops, and utensils can lead to cross-contamination.
7. **Improper Food Storage**: Storing perishable foods, such as meat, poultry, and dairy products, at temperatures that are too high can allow bacteria to multiply. Similarly, storing food for extended periods can lead to bacterial growth and spoilage.
8. **Consuming Raw or Unpasteurized Products**: Unpasteurized milk, cheese, and other dairy products, as well as raw seafood and shellfish, can harbor harmful microorganisms.
9. **Contaminated Produce**: Fresh produce can become contaminated with bacteria from soil, water, or handling during processing or at the grocery store.

10. **Ready-to-Eat Foods**: Ready-to-eat foods that are not properly refrigerated or stored can become contaminated with bacteria like Listeria and Staphylococcus aureus.
11. **Toxic Substances**: Some foods can contain natural toxins or chemical contaminants that can cause food poisoning. For example, certain types of fish can contain high levels of mercury or histamine.
12. **Inadequate Food Preservation**: Inadequate preservation methods, such as home canning errors or insufficiently pasteurized products, can allow bacteria like Clostridium botulinum to thrive.
13. **Restaurant and Food Service Hygiene**: Poor hygiene practices among food handlers, improper storage of ingredients, and inadequate cooking or reheating can lead to outbreaks of food poisoning in restaurants and foodservice establishments.

Mechanisms of action

The mechanisms through which these microorganisms or toxins cause food poisoning can vary depending on the specific pathogen or toxin involved. Here are some common mechanisms of food poisoning:

1. **Infection**:
    - **Bacterial Infection**: Some bacteria, such as Salmonella, Campylobacter, and Listeria, can invade the lining of the gastrointestinal tract and multiply, leading to infection. This invasion can cause inflammation, damage to the gut lining, and a host of symptoms, including diarrhea, abdominal pain, and fever.
    - **Viral Infection**: Certain viruses, like Norovirus and Hepatitis A, infect the cells of the gastrointestinal tract, leading to inflammation and symptoms such as diarrhea, vomiting, and abdominal pain.
2. **Toxin Production**:
    - **Bacterial Toxins**: Some bacteria produce toxins that, when ingested, cause illness. For example, Staphylococcus aureus produces toxins that can lead to symptoms like nausea, vomiting, and diarrhea within a few hours of consuming contaminated food.
    - **Bacterial Growth and Toxin Production**: In other cases, bacteria multiply in food and produce toxins before it is consumed. For instance, Clostridium botulinum produces a potent neurotoxin when it multiplies in improperly canned foods, leading to botulism.
    - **Toxic Plants and Seafood**: Certain plants, mushrooms, and seafood can contain natural toxins that cause food poisoning when ingested. For

example, the consumption of poisonous mushrooms or certain species of fish can lead to toxic reactions.

3. **Invasion of Cells**:
    - Some bacteria, such as E. coli O157:H7, possess mechanisms to attach to and invade the cells lining the gastrointestinal tract, where they can cause damage and inflammation.
4. **Disruption of Normal Gut Function**:
    - Certain pathogens, like Vibrio cholerae (which causes cholera), produce toxins that disrupt normal water and electrolyte balance in the intestines. This can lead to profuse diarrhea and dehydration.
5. **Inflammatory Response**:
    - The presence of harmful microorganisms in the gastrointestinal tract triggers an immune response, leading to inflammation. This inflammation can cause the characteristic symptoms of food poisoning, such as abdominal pain, diarrhea, and fever.
6. **Gastrointestinal Irritation**:
    - Some pathogens or toxins directly irritate the gastrointestinal lining, leading to symptoms like nausea, vomiting, and abdominal cramps.
7. **Neurological Effects**:
    - Certain toxins, such as those produced by Clostridium botulinum or Bacillus cereus, can have neurological effects, causing symptoms like muscle weakness, blurred vision, and difficulty swallowing or breathing.

Food poisoning is caused by

Food poisoning can be caused by various microorganisms, including bacteria, viruses, and parasites. These organisms can contaminate different types of food products, leading to a range of symptoms when consumed. Here's a list of common foodborne pathogens, their associated symptoms, and the types of products in which they can occur:

1. **Salmonella:**
    - Symptoms: Nausea, vomiting, diarrhea, abdominal cramps, fever.
    - Occurs in: Raw poultry, eggs, unpasteurized milk, raw meat, and contaminated produce.
2. **Escherichia coli (E. coli):**
    - Symptoms: Diarrhea (sometimes bloody), abdominal pain, fever.
    - Occurs in: Undercooked ground beef, raw vegetables, unpasteurized dairy products.

3. **Campylobacter:**
    - Symptoms: Diarrhea (often bloody), abdominal pain, fever.
    - Occurs in: Undercooked poultry, contaminated water, and unpasteurized milk.
4. **Listeria monocytogenes (Listeriosis):**
    - Symptoms: Fever, muscle aches, diarrhea, nausea.
    - Occurs in: Ready-to-eat foods like deli meats, soft cheeses, and unpasteurized milk.
5. **Norovirus:**
    - Symptoms: Sudden vomiting, diarrhea, nausea, stomach cramps.
    - Occurs in: Contaminated food or water, often associated with food handling by infected individuals.
6. **Staphylococcus aureus (Staph Infection):**
    - Symptoms: Nausea, vomiting, abdominal cramps, diarrhea.
    - Occurs in: Foods that are handled and stored improperly, such as dairy products, salads, and sandwiches.
7. **Clostridium perfringens:**
    - Symptoms: Abdominal cramps, diarrhea.
    - Occurs in: Foods that are kept warm for extended periods, like buffets and large casseroles.
8. **Vibrio species:**
    - Symptoms: Diarrhea, abdominal pain, vomiting.
    - Occurs in: Raw or undercooked seafood, especially shellfish.
9. **Shigella:**
    - Symptoms: Diarrhea (often bloody), abdominal cramps, fever.
    - Occurs in: Contaminated water and foods like salads and vegetables.
10. **Giardia and Cryptosporidium (Parasites):**
    - Symptoms: Prolonged diarrhea, stomach cramps, and other gastrointestinal symptoms.
    - Occurs in: Contaminated water and can sometimes be associated with contaminated food.
11. **Clostridium botulinum (Botulism):**
    - Symptoms: Muscle weakness, paralysis, difficulty breathing.
    - Occurs in: Home-canned and preserved foods, particularly low-acid vegetables.
12. **Toxoplasma (Toxoplasmosis):**
    - Symptoms: Flu-like symptoms, muscle aches, headache.
    - Occurs in: Undercooked or raw meat, unwashed fruits and vegetables, and contaminated water.

Preventing food poisoning involves good food safety practices, including:

1. **Proper Food Handling**: Wash hands, utensils, and surfaces regularly, especially when handling raw meat, poultry, seafood, and eggs. Avoid cross-contamination by keeping these items separate from other foods.
2. **Cooking Thoroughly**: Cook meat, poultry, and seafood to safe internal temperatures to kill harmful microorganisms. Use a food thermometer to ensure accuracy.
3. **Refrigeration**: Refrigerate perishable foods promptly, and keep the refrigerator at a temperature below 40°F (4°C).
4. **Avoiding Raw or Undercooked Foods**: Avoid consuming raw or undercooked eggs, meat, seafood, and unpasteurized dairy products.
5. **Hand Hygiene**: Proper handwashing is critical, especially for food handlers, to prevent the spread of harmful microorganisms.
6. **Safe Water and Produce**: Use clean, safe water for drinking and food preparation. Wash fruits and vegetables thoroughly.
7. **Avoiding Cross-Contamination**: Keep raw and cooked foods separate during storage and preparation. Use separate cutting boards and utensils for different food items.
8. **Food Storage**: Store leftovers promptly and properly, and consume them within a reasonable time frame

Food born pathogenic bacteria

Foodborne pathogenic bacteria are microorganisms that can cause illness or infection when ingested through contaminated food. These bacteria can multiply rapidly if food is not handled, stored, or cooked properly.:

Foodborne pathogenic bacteria can cause illness through various mechanisms when ingested through contaminated food. These mechanisms often involve the bacteria's ability to colonize and infect the human gastrointestinal tract, produce toxins, or induce inflammatory responses

1. **Salmonella (Salmonella spp.):**
    - Common Sources: Raw poultry, eggs, unpasteurized milk, raw meat, and contaminated produce.
    - Associated Illness: Salmonellosis.
    - Symptoms: Nausea, vomiting, diarrhea, abdominal cramps, fever.
2. **Escherichia coli (E. coli)**

- Common Sources: Undercooked ground beef, raw vegetables, unpasteurized dairy products.
- Associated Illness: Escherichia coli infection.
- Symptoms: Diarrhea (sometimes bloody), abdominal pain, fever.

3. **Campylobacter (Campylobacter jejuni):**
   - Common Sources: Undercooked poultry, contaminated water, and unpasteurized milk.
   - Associated Illness: Campylobacteriosis.
   - Symptoms: Diarrhea (often bloody), abdominal pain, fever.
4. **Listeria (Listeria monocytogenes):**
   - Common Sources: Ready-to-eat foods like deli meats, soft cheeses, and unpasteurized milk.
   - Associated Illness: Listeriosis.
   - Symptoms: Fever, muscle aches, diarrhea, nausea.
5. **Clostridium perfringens:**
   - Common Sources: Foods that are kept warm for extended periods, such as buffets and large casseroles.
   - Associated Illness: Clostridium perfringens infection.
   - Symptoms: Abdominal cramps, diarrhea.
6. **Staphylococcus aureus (Staph Infection):**
   - Common Sources: Foods that are handled and stored improperly, such as dairy products, salads, and sandwiches.
   - Associated Illness: Staphylococcal food poisoning.
   - Symptoms: Nausea, vomiting, abdominal cramps, diarrhea.
7. **Vibrio (Various Vibrio species):**
   - Common Sources: Raw or undercooked seafood, especially shellfish.
   - Associated Illness: Vibrio infections.
   - Symptoms: Diarrhea, abdominal pain, vomiting.
8. **Shigella (Shigella spp.):**
   - Common Sources: Contaminated water and foods like salads and vegetables.
   - Associated Illness: Shigellosis.
   - Symptoms: Diarrhea (often bloody), abdominal cramps, fever.
9. **Clostridium botulinum (Botulism):**
   - Common Sources: Home-canned and preserved foods, particularly low-acid vegetables.
   - Associated Illness: Botulism.
   - Symptoms: Muscle weakness, paralysis, difficulty breathing.
10. **Yersinia (Yersinia enterocolitica and Yersinia pseudotuberculosis):**
    - Common Sources: Contaminated pork products and untreated water.

- Associated Illness: Yersiniosis.
- Symptoms: Diarrhea, abdominal pain, fever, joint pain (in some cases).

Indicator Organisms

- Indicator microorganisms are used to suggest the presence of pathogens in water.
- The direct detection of pathogenic bacteria and viruses , and cysts of protozoan parasites requires costly and time consuming procedures, and a well trained labor.
- These requirements led to the concept of indicator organisms of fecal contamination.

The criteria of an ideal Indicator organisms are

1. One of the intestinal microflora of warm blooded animal.
2. It should be present when pathogens are present and absent in uncontaminated samples.
3. Present in greater numbers than the pathogen.
4. At least equally resistant as the pathogen to environmental factors and to disinfection in water and waste water treatment plants.

5. It should not multiply in the environment.

6. It should be detectable by means of easy, rapid and inexpensive methods.

7. Nonpathogenic

8. Useful for water types.

- Various microrganisms have been proposed and used for indicating the occurrence of fecal contamination, treatment efficiency in water and waste water treatment plants.

- The main indicator groups are
- Coliforms
- Fecal streptococci
- Sulphite reducing clostridia

• Faecal indicator

- A group of organisms that indicates the Presence of faecal contamination, such as the thermo tolerant coliforms (E.coli) or fecal streptococci .

- Their presence denotes that pathogens may be present.

1. Coliforms

- The total coliform groups belong to the family Enterobacteriaceae.
- These are aerobic and facultative anaerobic, gram negative, non spore forming, oxidase negative, rod shaped bacteria that ferment lactose(betagalactosidase positive) with gas and acid production within 24-48 hours at 35 degree Celsius. Not specific indicators of faecal pollution.

- Eg : *Escherichia coli, Enterobacteria,klebsiella and Citrobacter.*
- Coliforms are discharged in high numbers in human and animal faeces , but not all of them are of faecal origin.
- These indicators are useful for determining the quality of potable water.
- They are less sensitive than viruses or protozoan cysts to environmental factors and to disinfection.
- Some members of this group (klebsiella) may sometimes grow under environmental conditions in industrial and agricultural wastes.

• Fecal coliforms

- Fecal coliforms are thermotolerant coliforms include all coliforms that can ferment lactose with gas and acid production at 44.5 degree Celsius within 24-48 hours in addition to 35 degree Celsius.
- The fecal coliform group comprises bacteria such as *Escherichia coli* .
- Thermophilic coliforms produce Indole from tryptophan

cannot utilize citrate as sole source of carbon and produce beta gluconidase.

- They are the specific indicators of recent fecal pollution from warm blooded animals.
- However human and animal sources of contamination cannot be differentiated.
- They are much less resistant to disinfection than viruses or protozoan cysts.

2. Fecal streptococci

- Gram positive, catalase negative cocci.
- This group comprises *streptococcus faecalis, S.bovis, S. equinus and S.avium.*
- *S.faecalis ,S.faecium,S.durans* are commonly isolated from animal sources, cattle,horse and birds respectively.
- Because they commonly inhabit the intestinal tract of humans and warm blooded animals, they are used to detect recent fecal contamination in water.

- All fecal streptococci that grow at pH 9.6 , 10 degree and 45 degree Celsius and in 6.5 % Nacl are designated as Enterococci.
- They show resistance to 60 degree Celsius for 30 min and ability to reduce 0.1% methylene blue.
- Faecal streptococci can also grow in presence of 40% bile , sodium azide and potassium tellurite concentrations which normally inhibit other organisms including coliforms.

3. Sulphite reducing clostridia

Clostridium perfringens : Clostridia are mostly opportunistic pathogens , but are also implicated in human diseases such as gas gangrene (C.perfringens).

- Clostridium perfringens are gram positive, strictly anaerobic rods which are endospore forming, non motile and can reduce sulphite to H2S.
- Clostridium perfringens can ferment lactose, sucrose and inositol with the production of gas, produce a stormy clot

fermentation with milk, reduce Nitrate,hydrolyse gelatin and produce lecithinase and acid phosphatase.

- These sulphite reducing Bacterium found in the colon form approximately 0.5 % of the fecal microflora.
- The spores are quite resistant to environmental stresses, and to disinfection by oxidizing agents and UV than bacterial and phage indicators.
- It is commonly found in human and animal faeces and in waste water contaminated aquatic environments.

- The Hardy spores make this Bacterium too resistant to be useful as an indicator organism.
- It is an indicator of past pollution.

4. Bacteriophages

- To evaluate the virological quantity of water, the use of bacteriophages as indicators has been proposed.
- Three groups of phages have been suggested : somatic coliphages (infect mostly E.coli) , F specific RNA bacteriophages and phages infecting *Bacteroides fragilis*

- The occurrence of specific pathogens is seasonal.
- Also viruses and other pathogens not part of the normal faecal microbiota and are excreted by infected individuals.
- So the idea of indicators of microbial water quality help in alerting and managing waterborne microbial risks, where the pathogens may escape chances of detection.

Microbiology of canned foods- Spoilage of canned foods

Canning is the process of sealing food stuffs or products hermetically in containers and sterilizing them by heat for long storages.

Causes of spoilage Spoilage of heated foods may have a chemical cause or a biological cause or both. The most important kind of chemical spoilage of canned foods is hydrogen swell.

Hydrogen Swell results from the pressure of hydrogen gas released by the action of the acid of a food on the iron of the can.

Hydrogen swells are favored by

(1) Increasing acidities of foods.

(2) Increasing temperatures of storage.

(3) Imperfections in the tinnning and lacquering of the interior of the can.

(4) A poor exhaust.

(5) The presence of soluble sulfur and phosphorus compounds.

Other defects, caused by interaction between the steel base of the can and the contained food include

(1) Discoloration of the inside of the can.

(2) Discoloration of the food.

(3) Production of off-flavors in the food.

(4) Cloudiness of liquors' or syrups.

(5) Corrosion or perforation of the metal.

(6) Loss in nutritive value.

Biological spoilage of canned foods by microorganisms may result from either or both of two causes:

(1) survival of organisms after the administration of the heat treatment and

(2) leakage of the container after the heat process, permitting the entrance of organisms.

Mild heat treatments permit the successful storage of the foods for limited periods with the help of refrigeration. Examples are processing of meat loaves and pasteurization of milk are examples of such mild heat processes. Acid foods, such as fruits, are processed at temperatures approaching 100o C, treatments which result in killing all vegetative cells of bacteria, yeasts, and molds and their spores and some bacterial spores. The only survivors ordinarily are spores of bacteria, which cannot grow in a 174 very acid food. Any survivors of heat treatments by steam under pressure are very heat resistant bacterial spores, usually only one or two kinds.

Microorganisms entering through leaks in containers may be of various kinds and are not necessarily heat-resistant. Leakage and subsequent spoilage of canned food may be a result of mechanical damage of the empty cans so that side and end seams are defective; rough handling offilled cans may also result in damage.

Appearance of the unopened container

1. Flat: Normally the ends of a can of food are termed flat, which means that they are actually slightly concave; and a partial vacuum exists in the container. If pressure develops inside, the can goes through a series of distortions as a result of increasing pressures and is called successively a flipper, springer, soft swell, or hard swell.

2. Flipper: A flipper has flat ends, one of which will become convex when the side of the can is struck sharply or the temperature of the contents is increased.

3. A springer: A springer has both ends of the can bulged, but one or both ends will stay concave if pushed in; or if a swollen end is pushed in, an opposite flat end will pop out. The terms "flipper" and "springer" are used by some to designate slight pressures in the can not caused by gas production but by such things as a poor exhaust, overfilling, denting of the can, changes in temperature, etc., but the

can may have the same outward characteristics at the start of gas production from either a microbial or a chemical cause or both.

4. A Soft swell: A soft swell has both ends of the can bulged, but the gas pressure is low enough to permit the ends to be dented by manual pressure.

5. A hard swell: A hard swell has such high gas pressure from within that the ends are too hard to dent by hand. Often the high gas pressures distort or buckle the ends or side seam of the cans. The final step is the bursting of the can, usually through the side seam, but sometimes through the seals at the ends.

6. A breather: A breather is a can with a minute leak that permits air to move in or out but does not necessarily allow microorganisms to enter.

Other defects in the general appearance of the can are noted before and after it are opened.

- Dents are responsible for a flipper.
- Other defects are rust perforations, defective side seam or end seals and corrosion.
- The glass container of food under gas pressure may have its cover bulged or popped off or may show leakage of food through the broken seal.

Of course, it is possible to see evidence of microbial growth through the glass sides, such as gas bubbles, cloudiness, and films of growth. 175 Grouping of canned foods on the basis of acidity. The acidity of canned foods is important in determining the heat process necessary for their sterilization and the type of spoilage to be expected if the process is inadequate or leakage takes place.

Various groupings of canned foods have been made by the National Food Processors Association, always with a division into

the low-acid foods with the pH above 4.5, and

a highacid group, with the pH below 4.5.

Types of Biological spoilage of canned foods

Types of spoilage of canned foods by microorganism usually are divided into those caused by the thermophilic bacteria and those caused by mesophilic microorganisms.

Other methods of classification of kinds of spoilage are based on the kinds of changes produced in the food, e.g., putrefaction, acid production, gas formation, and blackening. Types of spoilage also may be grouped on the basis of the kinds of foods involved.

The three most important kinds of biological spoilage of commercially canned foods are

- flat sour spoilage,
- TA spoilage, and
- putrefaction.
- Hydrogen Swell: A fourth important kind of spoilage, caused by action of food acid on the iron of the can, results in hydrogen swell.

Types of Spoilage by Thermophilic Spore-forming Bacteria

Most spoilage of commercially heat processed canned foods results from under processing and caused by thermophilic bacteria because their spores are more heat resistant than those of most mesophilic bacteria. The three chief types of spoilage by thermophiles are Flat sour spoilage, TA spoilage, and Sulfide spoilage, or "Sulfide stinker."

Flat Sour Spoilage:

This kind of spoilage derives its name from the fact that the ends of the can of food remain flat during souring, or the development of lactic acid in the food by the flat sour bacteria. Because the can retains a normal outward appearance. This type of spoilage cannot be detected by examination of the unopened can but must be detected by cultural methods. The spoilage occurs chiefly in low-acid foods, such as peas and corn, and is caused by species of Bacillus.

Flat sour spoilage of acid foods, e.g., tomatoes or tomato juice, is caused by a special facultatively thermophilic species, B. coagulans. The various species

of Bacillus that are able to form acid without gas in food may be mesophiles, facultative thermophiles, or obligate thermophiles.

The spores of the mesophiles are the least heat-resistant and are usually 176 killed by the heat processing and hence are rarely concerned with flat sour spoilage of low-acid foods. The spores of the thermophiles are more heat-resistant and may survive the heat process to cause flat sour spoilage. Thermophiles, such as B. stearothermophilus, would not cause spoilage unless the food were held hot for a while, as in slow cooling or storage in the tropics, but facultative thermophiles could grow at ordinary temperatures. The immediate source of the flat sour bacteria is usually the plant equipment, e.g., the blanchers, but they may come originally from sugar, starch, or soil. The ability of B. coagulans to grow in tomato juice depends on the number of spores present, the availability of oxygen, and the pH of the juice. The organism, which is homo fermentative under almost anaerobic conditions and hetero fermentative under aerobic conditions, can grow in low concentrations of oxygen.

TA Spoilage (Thermophilic anaerobe)

The bacterium causing this type of spoilage has been nick named T A, which is short for "thermophilic anaerobe not producing hydrogen sulfide," or for the species Clostridium thermosaccharolyticum. This is a thermophilic spore-forming anaerobe that forms acid and gas in foods.

The gas, a mixture of carbon dioxide and hydrogen, swells the can if it is held long enough at a high temperature and may eventually cause bursting. he spoiled food usually has a sour or "cheesy" odor. Sources are the same as for flat sour bacteria.

Sulfide, or "Sulfur Stinker," Spoilage

This spoilage, caused by Desulfotomacculum nigrificans. This bacterium is found uncommonly in low-acid foods such as peas and corn. The spores of this bacterium have considerably less heat resistance than those of flat sour and T A bacteria; hence their appearance in canned foods is indicative of gross under processing.

The organism is an obligate thermophile and therefore also requires poor cooling of the heat-processed foods or hot storage for its development. It is

detected by means of the black (FeS) colonies it forms in an iron sulfite agar at 55o C. Hydrogen sulfide, formed in the canned peas or corn, is evident by odor when the can is opened.

In corn, a bluish-gray liquid is evident in which blackened germs and gray kernels of corn float. Peas usually give the H2S odor but without any marked discoloration. Sources of the spores are similar to those for flat sour and T A bacteria, but manure can also be an original source.

Spoilage by Non-Spore-Forming Bacteria:

If viable non-spore-forming bacteria are found in canned foods, a very mild heat treatment was used. Vegetative cells of some kinds of bacteria are fairly heat resistant in that they can with stand pasteurization.

Among these thermoduric bacteria are the enterococci, Streptococcus thermophilus, some species of Micrococcus and Lactobacillus, and Microbacterium. Acid-forming Lactobacillus and Leuconostoc species have been found growing in under processed tomato products, pears, and other fruits. The hetero fermentative species may release enough CO2 gas to swell the can. Microococci have been reported in meat pastes and S. faecalis or S. faecium is often present in canned hams that are only partially sterilized and may be responsible for spoilage on storage.

The presence of viable non-spore-forming bacteria in heat processed canned foods indicates leakage of the container by cooling water through tiny orifices e.g., the coliform bacteria, produce gas which swells the cans. It should be noted that spore forming bacteria also can enter the can through a leak, so that the aerobacilli (B. macerans and B. polymyxa) or the clostridia could be responsible for the gas formation.

Non-gas-forming bacteria are found growing in the food in leaky cans, along with the gas former or by themselves. Ex; Pseudomonas, Alcaligenes, Micrococcus, Flavobacterium, Proteus, and others.

Spoilage by Yeasts: Since yeasts and their spores are killed readily by most pasteurization treatments, their presence in canned foods is the result of either gross under processing or leakage. Canned 179 fruits, jams, jellies, fruit juices, syrups, and sweetened condensed milk have been spoiled by fermentative yeasts, with swelling of the cans by the CO2 produced. Film yeasts may grow on the surface of jellied pickled pork, repacked pickles or olives, and similar products, but their presence indicates recontamination or lack of heat processing, plus poor evacuation.

Spoilage by Molds: Molds are the most common cause of the spoilage of home-canned foods, which they enter through a leak in the seal of the container. Jams, jellies, marmalades, and fruit butters will permit mold growth when sugar concentrations are as high as 70 percent and in the acidity usually present in these products. It has been claimed that adjustment of the soluble extract of jam to 70 to 72 percent sugar in the presence of a normal 0.8 to 1.0 percent acid will practically remove the risk of mold spoilage.

Strains of Aspergillus, Penicillium, and Citromyces, found growing in jellies and candied fruits, are able to grow in sugar concentrations up to 67.5 percent. Some molds are fairly resistant to heat, especially those forming the tightly packed masses of mycelium called sclerotia. Byssochlamys fulva, a pectin-fermenting mold, has ascospores that have resisted the heat processing of bottled and canned fruits and have caused spoilage.

Spoilage of Canned Foods of Different Acidities:

1. The low-acid foods with a pH above 5.3 are especially subject to flat sour spoilage and putrefaction.

2. Foods with a pH between 5.3 and 4.5 are likely to undergo TA spoilage.

3. High-acid foods with a pH between 4.5 and 3.7 usually are spoiled by a special flat sour bacterium or by a saccharolytic anaerobe.

4. High-acid foods with a pH below 3.7 ordinarily do not undergo spoilage by microorganisms, but in cans may become hydrogen swell

UNIT 10 FOOD BORNE, WATER BORNE AND VECTOR BORNE DISEASES

Structure

10.0 INTRODUCTION

Food is a potential source of infection, and is vulnerable to contamination by microorganisms during production, storage, and consumption that is, during all stages of pre as well as post cooking. In bulk cooking, as in community kitchens in post disaster phase, food hygiene is very important. Condition at cooking areas, and temporary kitchens should be regularly supervised. Food handlers must maintain good hygiene. Proper handling of food, utensils and dishes are essential.

"Water is life" – What said in layman's term is also scientifically true. Water is a vital environmental factor for all living beings. There cannot be any life without it. In India, a large percentage of diseases and ill health are due to consumption of polluted water. Water should be free from contamination and should be safe and easily available in adequate quantity. Water is essential for survival, and is therefore, important when it

comes to any disaster. Water intended for human consumption should be safe and wholesome.

Overcrowding, poor hygiene, insufficient water, and poor sanitation and sewage disposal, favour the proliferation of communicable disease vectors. Common vectors that cause concern are flies, mosquitoes, lice, fleas, and rats.Maintaining a clean and hygienic environment can help in intercepting the spread of communicable diseases. Garbage control, vector control, proper and adequate disposal system for wastes-solid and liquid, and use of insecticides will lessen the intensity and spread of such diseases. In this unit we will discuss all how if not kept hygrine and sanitation how contaminated food, polluted water and insects can be the potential source of disease transmission.

10.1 OBJECTIVES

After studying this Unit, you should be able to: ,

- explain various food borne diseases, their classification, pathogenesis, prevention and control
- explain and discuss various water borne diseases, their pathogenesis, diagnosis, prevention and control
- describe common vectors, vectors borne diseases, their pathogenesis, prevention and control of vectors
- understand the need to maintain proper sanitation and hygiene
- keep note of prevention and control of these disease

10.2 FOOD BORNE DISEASES

Food-borne diseases or illness are acquired through consumption of contaminated food. They are also commonly known as **food poisoning**. It includes both foodborne intoxications and food-borne infections. Food-borne diseases are one of the major health concern worldwide leading to high morbidity and mortality. Globally 3-5 billion cases of diarrhoea infection and nearly 1.8 million deaths, mainly in young children, are reported annually by contaminated food and water.

The food borne disease can be classified as given below. A difference between these two types of food borne disease is given in table 3.1.

10.2.1 CLASSIFICATION

A) Food-borne infections - caused by consuming foods or liquids contaminated with bacteria, viruses, or parasites. These pathogens cause infection by:

   1) Invading and multiplying in the lining of the intestines and/or other tissues

   2) Invading and multiplying in the intestinal tract and releasing a toxin (bacteria only)

B) Food-borne intoxications - caused by consuming foods or beverages already contaminated with a toxin. Sources of toxins are as follows:

1) Certain bacteria (pre-formed toxins)

2) Poisonous chemicals

3) Natural toxins found in animals, plants, and fungi.

Table 10.1: Difference between infection and intoxication

	Infection	**Intoxication**
Cause	Bacteria/Virus/parasites	Toxin
Mechanism	Invade and/or multiply within the lining of the intestines	No invasion or multiplication
Incubation period	Hours to days	Minutes to hours
Symptoms	Diarrhoea, Nausea, Vomiting Abdominal cramps, Fever	Vomiting, Nausea, Double vision, Weakness, Respiratory failure, Numbness Sensory and motor dysfunction
Transmission	Can spread from person-to-person via the faeco-oral route	Not communicable
Factors related to food contamination	Inadequate cooking, Cross-contamination, Poor personal hygiene, Bare hand contact	Inadequate cooking, Improper holding temperatures

10.2.2 PATHOGENESIS OF FOOD BORNE DISEASES

By now you must have understood that food-borne illness is typically caused by microorganisms or their toxins. These diseases are most often manifests with gastro-intestinal symptoms, which can vary in severity and duration. In addition to food-borne pathogens (bacteria, viruses and parasites), food-borne disease may also be caused by contaminants like heavy metals, chemicals, pesticides and toxic substances present naturally in food like toxic mushrooms, plants, fish or shellfish. The severity of the infection depends on the number of the pathogens infecting a person. This may be as small as 10 to 100 bacteria or cysts for *Shigella*, EnteroHaemorrhagic *E. coli* (EHEC), *Giardia lamblia* and *Entamoebahistolytica*. That is why only minor unhygienic condition can cause infection with these pathogens. The infective dose for *Vibrio cholerae* on the other hand is usually 105 – 108, and may be variable for *Salmonella sp.* A list of food borne diseases, their causative agent and symptoms is given in table 3.2

Table 10.2: Common food borne illness.
(Adapted from CDC Gov. Reports, 2004)

Etiology	**Incubation Period**	**Signs and symptoms**	**Associated Foods**
Bacterial food borne illness			
Bacillus anthracis	2 days to weeks	Nausea, vomiting, malaise, bloody diarrhoea, acute abdominal pain	Insufficiently cooked contaminated meat

Bacillus cereus (preformed toxin)	1-6 hrs	Sudden onset of severe nausea and vomiting. Diarrhoea may be present	Improperly cooked or fried rice, meat.
Clostridium botulism (preformed toxin)	12-72 hrs	Diarrhoea, Vomiting, blurred vision, diplopia, dysphagia and descending muscle weakness	Home canned food with low acid content, baked potatoes in aluminium foil, food held warm for extended periods of time.
E.coli	1-8 days	Severe diarrhoea, abdominal pain and vomiting	Undercooked beef, unpasteurized milk, raw fruits and vegetables
Salmonella sp.	1-3 days	Diarrhoea, vomiting, fever, abdominal cramps	Contaminated egg, poultry, unpasteurized milk, contaminated raw fruits and vegetables
Shigella sp.	24-48 hrs	Diarrhoea, fever, abdominal cramps Stools may contain blood	Food contaminated with human faecal matter, ready to eat food. Faecal-oral transmission
Staphylococcus aureus	1-6 hrs	Sudden onset of vomiting, abdominal cramps, diarrhoea.	Unrefrigerated food, meat, potatoes, eggs, salads, pastries, cutaneous infection of human and animal
Viral food borne illness			
Hepatitis A	15-50 days	Diarrhoea, dark urine, jaundice and flu like symptoms fever, headache, nausea and abdominal pain	Raw, uncooked food, or food which is not reheated after contact with infected food handler
Norovirus	12-48 hrs	Diarrhoea, fever, abdominal cramps, vomiting, myalgia	Fecal contaminated, ready to eat foods
Rotavirus	1-3 days	Vomiting, watery diarrhoea, fever, temporary lactose intolerance,	Fecal contaminated, ready to eat foods touched by infected food handlers (salads, fruits)
Parasitic food borne illness			
Trichinellaspiralis	1-2 days initially or 2-8 weeks after infection	Diarrhoea, fever, fatigue, abdominal cramps followed by muscle soreness, weakness, occasional cardiac and neurologic complication	Raw or undercooked contaminated meat
Toxoplasma gondii	5-23 days	Generally asymptomatic, 20% may develop cervical lymphadenopathy and flu like illness	accidental illness of contaminated substances (soil, fruits, vegetables), raw or partially cooked meat

Non-infectious food borne illness			
Mushroom toxins (short/ long acting)	<2hrs/4-8 hrs	Vomiting diarrhoea, confusion, visual disturbance/ may leads to hepatic or renal failure,	Mushrooms (cooking may not destroy the short acting toxins)
Pesticides (organophosphates or carbamates)	Few minutes to few hrs	Vomiting, diarrhoea, headache, nausea, twitching, convulsions, salivation	Unwashed foods, heavy pesticide treated foods
Mercury	one week or longer	Numbness, weakness of legs, spastic paralysis, impaired vision,	Fish exposed to organic mercury, grains treated with mercury fungicides

10.2.3 FOOD-BORNE TRANSMISSION OF PATHOGENS AND TOXINS

Food may become contaminated during production and processing or during food preparation and handling. A common pathway of pathogen transmission from a food handler to a consumer is outlined in figure 3.1.

1) Food contamination during its production and processing

   There are two ways in which food are contaminated by pathogens. Most often plant foods, such as fruits and vegetables, may be contaminated if washed or irrigated with water that is contaminated with pathogens from animal or human faeces. You must be knowing that all animals naturally harbour many food-borne bacteria in their intestines that can cause illness in humans, but often do not cause illness in the animals. Therefore, the poultry meat are generally contaminatedduring slaughter if they are exposed to small amounts of their intestinal bacteria.

2) Food contamination during its preparation and handling

   a) Faeco-oral transmission–You know that most food-borne pathogens are shed in the faeces of infected persons and these pathogens may be transferred to others through food via the faecal-oral route. Additionally, bacteria present in infected lesions and normal nasal flora may also be transmitted from an infected food-handler to ready-to-eat foods.

   b) Transmission between food products - Pathogens naturally present in one food may be transferred to other foods during food preparation if same cooking equipment and utensils are used without washing and disinfecting in between, especially in case of ready-to-eat foods.

   c) Insufficient cooking of food–Most of the bacteria are heat sensitive that is they die on heating. Therefore it is very important to properly cook the food. With insufficient cooking bacteria can stay alive and multiply to produce toxins within the food. Many bacterial toxins are heat stable and may not be destroyed by cooking.

   d) Improper storage- Food held or stored at warm (10-50ºC) temperature allows multiplication of pathogens and is an important cause of foodborne outbreaks.

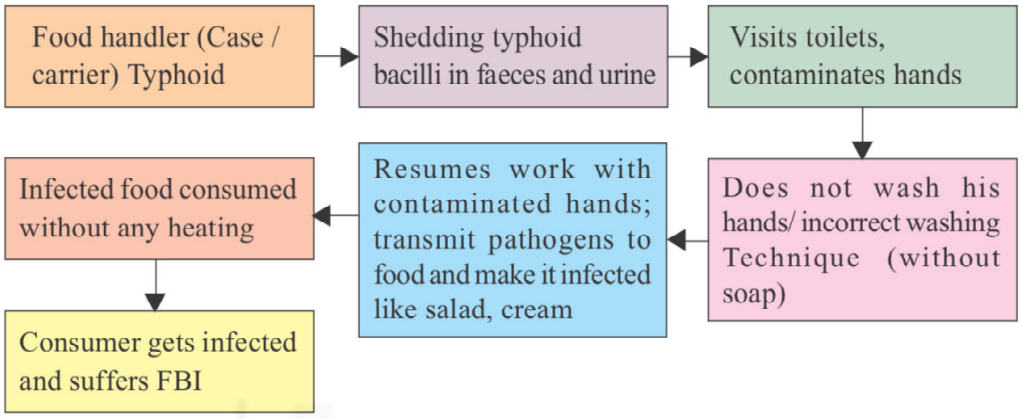

Figure 3.1: Pathogen transmission pathway from a food handler to a consumer.

10.2.4 LABORATORY AND CLINICAL DIAGNOSIS OF FOODBORNE ILLNESSES

Clinically the patient is examined for the vital signs of infection like degree of dehydration and abdominal discomforts. The severity of the food borne diseases has been observed in the patients with moderate or severe dehydration or those suffering from Shigellosis, even leading to death in children. When pathogen invade any internal organ of the patient the symptoms becomes more fatal like feverand bloody diarrhoea.

The main objectives of laboratory analysis during food-borne disease infection are to

1) Confirm the clinical diagnosis by isolation of causative agent from human specimens
2) Ensure proper identification of the disease, and
3) In case of food –borne disease outbreaks to determine if the same causative agent is present in implicated food sources, using relevant epidemiological markers like biotyping, serotyping, antimicrobial susceptibility profile, phage typing, plasmid profile, pulsed field gel electrophoresis, PCR, etc.

Most food-borne infections are diagnosed through the identification of the pathogen in stool collected from infected persons. Vomitus has also been used to detect certain organisms and confirm the aetiology. Serologic testingare recommended for cases with systemic invasion of the pathogen.

Initial treatment of patients with food poisoning should focus on assessment and reversal of dehydration, either through oral rehydration therapy (ORT) especially in children, or through IV fluids in seriously dehydrated cases.Specific treatment in case of pesticide poisoning with chelating agents may be done based on epidemiological and clinical features, under medical supervision.

10.2.5 PREVENTION OF FOOD BORNE DISEASES

Hazard Analysis and Critical Control Point (HACCP) is a systematic preventive approach to food safety that addresses physical, chemical, and biological hazards as a means of prevention rather than finished product inspection. HACCP is used in the food industry to identify potential food safety hazards, so that key actions can be taken at these Critical Control Points (CCPs). The system is used in the food industry at all stages of food production and preparation processes including packaging, distribution, etc. HACCP is an effective approach to food safety and protecting public health.

Apart from food contamination, transmission of infection occurs by direct contact, favoured by the habits and customs of people, improper storage and handling of cooked food is equally responsible for food-borne illnesses, as during storage, especially at ambient temperatures (28- 38 degree C) there is higher risk of multiplication of pathogenic organisms. Food safety education is a critical pre-requisite to prevent food-borne outbreaks by education of food-handlers and the community about proper practices in cooking and storage of food, and personal hygiene. Handwashing is one of the key interventions, not just by food handlers, but also by the community at large. Environmental measures include discouraging sewage farming for growing vegetables and fruits. The five key points to avoid food borne illness are enlisted in table 3.3

Table 10.3: Preventive methods to avoid food borne illness.

FIVE KEYS TO SAFER FOOD

1. Keep Clean
   - Wash your hands before handling food and often during food preparation
   - Wash your hands after going to the toilet
   - Wash and sanitize all surfaces and equipment used for food preparation
   - Protect kitchen areas and food from insects, pests and other animals
2. Separate raw and cooked food
   - Separate raw meat, poultry and seafood from other foods
   - Use separate utensils such as knives and cutting boards for handling raw foods
   - Store food in containers to avoid contact between raw and prepared foods
3. Cook thoroughly
   - Cook food thoroughly, especially meat, poultry, eggs and seafood
   - Bring foods like soups and stews to boiling to make sure that they have reached 70°
   - Reheat cooked food thoroughly
4. Keep food at safe temperatures
   - Do not leave cooked food at room temperature for more than 2 hours
   - Refrigerate promptly all cooked and perishable food (preferably below 5°C)
   - Keep cooked food piping hot (more than 60°C) prior to serving
   - Do not store food too long even in the refrigerator
   - Do not thaw frozen food at room temperature
5. Use safe water and raw materials
   - Use safe water or treat it to make it safe
   - Select fresh and wholesome foods
   - Choose foods processed for safety, such as pasteurized milk
   - Wash fruits and vegetables, especially if eaten raw
   - Do not use food beyond its expiry date

* Foodborne disease outbreaks: Guidelines for investigation and control. WHO, 2008

Check Your Progress Exercise 1

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

b) Check your progress with possible answers given at the end of the unit.

Q1 Canned food is mostly associated with which bacterial food poisoning?

a) Salmonella

b) Staphylococcal

c) Botulism

d) Bacillus

Q2 Cooked food should not be left at room temperature for more than

a) 1hrs

b) 2hrs

c) 3hrs

d) 4hrs

Q3 The toxin which causes intestinal discomforts are called

a) Enterotoxins

b) Haemotoxins

c) Endotoxins

d) Exotoxins

Q4 Which of the following food consumption may lead to non-pathogenic food poisoning

a) Cabbage

b) Mushrooms

c) Carrots

d) Tomato

10.3 WATER BORNE DISEASES

Water borne disease includes those diseases that are caused by pathogenic microorganism that most commonly are transmitted through contaminated fresh water. Microorganisms causing diseases that characteristically are water borne prominently include protozoa and bacteria, many of which are intestinal parasites or invade the tissues or circulatory system through walls of the digestive tract. Other important classes of water borne diseases are caused by metazoan parasites like nematode (round worms). One important water borne nematodal diseases is Dracunculiasis and it is acquired by swallowing water in which certain copepod occurs that act as vectors for the nematode. Another class of water borne metazoan pathogens are certain members of the Schistosomiasis, a family of blood flukes that cause Schistosomiasis. Some of the common water diseases are enlisted in **table 3.4**

Table 10.4 : Common water borne diseases, their infectious agents and symptoms

Disease	Infectious Agent	Symptoms
Water borne diseases caused by bacteria		
Cholera	*Vibrio cholera*	Severe diarrhoea, vomiting; fluid loss of as much as 20 quarts per day causes cramps and collapse
Dysentery	*Shigelladysenteriae*	Infection of the colon causes painful diarrhea with mucus and blood in the stools; abdominal pain
Enteritis	*Clostridium perfringens,* other bacteria	Inflammation of the small intestine causes general discomfort, loss of appetite, abdominal cramps, and diarrhea
Typhoid	*Salmonella typhi*	Early symptoms include headache, loss of energy, fever; later, a pink rash appears along with (sometimes) hemorrhaging in the intestines
Water borne diseases caused by Virus		
Infectious hepatitis	Hepatitis virus A	Inflammation of liver causes jaundice, fever, headache, nausea, vomiting, severe loss of appetite; aching in the muscles occurs
Poliomyelitis	Poliovirus	Early symptoms include sore throat, fever, diarrhoea, and aching in limbs and back; when infection spreads to spinal cord, paralysis and atrophy of muscles
Cryptosporid-iosis	*Cryptosporidium* sp.	Diarrhoea and cramps that last up to 22 days
Water borne diseases caused by Protozoa		
Amoebic dysentery	*Entamoebahistolytica*	Infection of the colon causes painful diarrhoea with mucus and blood in the stools; abdominal pain
Schistosom-iasis	*Schistosoma*sp.	Tropical disorder of the liver and bladder causes blood in urine, diarrhoea, weakness, lack of energy, repeated attacks of abdominal pain
Ancylostom-iasis	*Ancylostoma*sp.	Severe anaemia, sometimes symptoms of bronchitis

10.3.1 WATER BORNE TRANSMISSION OF DISEASES

Water-borne diseases are transmitted by water that has been contaminated with human waste (excreta) containing the different types of pathogenic organisms. Knowledge of the route of transmission of waterborne diseases is essential to providing preventive and control measures. The job of Environmental Health Technicians is to design ways

to break the chain of water-borne diseases transmission. The faeco-oral chain of transmission of water borne diseases is illustrated by figure 3.2.

10.3.2 PATHOGENESIS OF WATER BORNE DISEASES

The infection withbacteria *vibrio cholera* results in watery diarrhoea due to the production of bacterial toxin (enterotoxin) which acts upon the upper small intestine. In rare cases the pathogen invades the colon to cause inflammatory diarrhoea.However in typhoid fever, the pathogen*Salmonella typhi*, enters the gastro intestinal tract and invades the mucosa of colon and ileum. It multiplyintracellularly. After certain period of time the cells bursts to release bacteria (bacteraemia) which then circulate and invade different organs of the body like spleen, liver and bone marrow. Tissue invasion causes inflammation in the intestine and gall bladder. Shigellosis Organisms reach the large intestine and invade the tissue causing mucosal ulceration. *Shigella*dysenteriae produces shiga toxin that increases the ability of *Shigella* to invade tissues.

The virus infects the cells of the small intestine leading to decreased absorption and diarrhoea.For example, the polio virus infects epithelial cells of gastrointestinal tract and then spreads to lymphoid tissue, blood stream and the central nervous system. Another example is the Hepatitis A virus which replicates in the liver causing degenerative and regenerative changes of the cells.

In Amoebiasis, one of the larval stage called trophozoiteattaches to colonic mucosa and epithelial cells and cause ulceration of the mucosa of cecum, colon and rectum. Rarely, intestinal infection results in the formation of mass lesion or ameboma. Sometimes trophozoites invade veins to reach the liver and cause liver abscess

Giardiasis infection may be transient, recurrent or chronic. The mechanism by which Giardia causes alteration in small bowel function is largely unknown. Infection is limited to small intestine and biliary tract.

10.3.3 DIAGNOSIS

Laboratory diagnosis of water borne diseases is done in several ways since their methods of detection are different. Macroscopic and microscopic examination and culture and serological tests are the main techniques used.

1) Macroscopic Examination-Direct identification of the adult pathogenic parasite as well as the physical characteristics of the specimen (stool) are used in the diagnosis.

The adult form of D.medinensis can be easily identified by observing the emergence of the worm from the wound.

2) Microscopic Examination-Bacterial Gram stains of presumed sterile fluids.

3) Culture- A selective medium is used to isolate the bacterial pathogen. The sample source may be stool, urine or blood according to the distribution of the bacteria in the body. There is a recommended optimum period of time for the specific collection to isolate the pathogen successfully.

4) Biochemical Reactions-This test is done to separate/identify the specific pathogenic bacteria based on their response for different biochemical reactions.

5) Serology-Serological diagnosis is used to classify the specific pathogen into its sub groups(serotypes).

10.3.4 PREVENTION AND CONTROL

Water-borne diseases are one of the major public health threats especially in developing countries, where unsafe water, sanitation problems and poor hygienic practices exit. The public health approach to the prevention and control of water-borne diseases should consist of three basic components.

Provision of an adequate and safe water supply will positively contribute to the health and welfare of individuals, families, and communities. The safeness of the water supply can be ensured through different activities as

Pre-treatment of water

The water, which is in lakes and reservoirs, gets exposed to the ultra violet rays of the sun. Also, it gets clean with sedimentation owing to storage. As a result, quality of water improves, and harmful bacteria and pathogens get destroyed. The level of ammonia in the water also gets reduced.

Sedimentation aided with coagulation

Chemicals like aluminiumsulphate, ferric or ferrous sulphate, and ferric chloride can be used to remove suspended impurities in the water. The mud particles increase in size with the ejection of these chemicals and become flocculated particles. These particles on thorough mixing turn to a gelatinous precipitate called floc. Floc confines the mud particles and other colloidal matter, and helps in getting water rid of the turbidity and pathogens to a greater extent. The coagulated water is then passed through the sedimentation tanks that helps to remove the flocculated particles after proper settlement.

Filtration

Water is filtered through layers of granular material, like sand, to get rid of impurities such as colour, odour, turbidity, and some pathogens.

Disinfection

When water is added with a disinfectant, such as, chlorine, it is known as the disinfection. Rather, a small amount of such a chemical should be in the water always to eliminate later contaminations. Besides chlorine, boiling of water, treatment with lime, ozone, iodine and bromine, ultra violet rays, and potassium permanganate, also can be used to disinfect water.

The local administration should ensure purification of water. Civic authorities should get water samples tested. Surveillance of drinking water quality in disaster situations should be done by undertaking sanitary surveys, and quality checks in laboratories. The guidelines for determining drinking water quality, as laid down by World Health Organisation (WHO) are:

a) Water should be clear, have no colour or odour. Taste and odour may develop during storage, but it, should be checked for contaminations. Water should be tested for inorganic constituents like ammonia, hydrogen sulphide, sulphates, etc.

b) Microbiological indicators to check the presence of bacteria, viruses and other organisms like protozoa, helminthes, etc.

c) Chemical constitution of water is very important, as there can be a risk from toxic chemical caused due to massive accidental contamination. Pesticides value should be tested.

d) Radiological aspects of drinking water should not be ignored, and risk of ionising radiations should be kept in mind. Radioactivity in drinking water should be kept within safety limits.

Local administration should also be responsible for proper upkeep of storage and distribution of water. Water can be stored on an emergency basis in canvas bags, rubber coated nylon, and plastic containers. Water tanks can also be used to store water. Tanks and other storage items should be kept clean, and protected. The people should be provided with water containers. When water is distributed through water tankers, safety of the water should be ensured by the local administration.

Check Your Progress Exercise 2

Note: a) Fill in the blanks .

b) Check your progress with possible answers given at the end of the unit.

Q1. Commonest chemical agent used for purification of water is available in the form of……

Q2. Best method for rendering drinking water safe……

Q3. The infectious larval stage of amoeba is called …….

Q4. Which of the following is a protozoan water borne disease

a) Cholera

b) Giardiasis

c) Cryptosporidiosis

d) Enteritis

10.4 VECTOR BORNE DISEASES

Vectors are living organisms that can transmit infectious diseases between humans or from animals to humans. The special feature of a vector organism is its capability for passing the disease causative agent from one organism to the second organism without contracting the disease. It acts as a medium for the disease agent to spread and survive in a new organism. Many of these vectors are bloodsucking insects, which ingest disease-producing microorganisms during a blood meal from an infected host (human or animal) and later inject it into a new host during their subsequent blood meal. Mosquitoes are the best known disease vector. Others include ticks, flies, sandflies, fleas, triatomine bugs and some freshwater aquatic snails. Some of the vectors are discussed below and the diseases they spread are enlisted in table 3.5 and figure 3.3

10.4.1 Important vectors

Mosquitoes

They are the most important vectors of all the insects. They are small insects found all overthe world. They have round head with prominent eyes, two antennae and a proboscis whichcontains all the mouth parts. The life cycle consists of 10 to 14 days. Male mosquitoes live on vegetable matter while females can pierce the human skin, suck blood and transmit the disease. Male mosquitoes have short bushy antennae with numerous long bristles while females have long slender antennae with only a few bristles. The male lives for 1 to 3 weeks. There are three important genera of mosquito viz. *Anopheles, Culex*and *Aedes*. The life cycle in all the three is almost similar.

Anopheles: Adult is grey or black in colour and in resting position keeps the proboscis and body in straight line, the length of the body and proboscis is almost equal. *Anopheles* sits at an angle in the resting position. Copulation takes place while the male and female are on the wings. The life cycle consists of eggs, larvae and pupae stages which develop in water. Female *Anopheles* spreads malaria disease. (Fig. 4.13)

Culex: Adult *Culex*is grey or brown in colour and in resting position keeps the proboscis and body at an angle and not in straight line. The body is humped and shorter in length than the proboscis. Female *Culex*lays cigar shaped 200 to 500 eggs in clusters in dirty water collection such as drains around houses. *Culex*transmits filarial and viral encephalitis in man.

Aedes: *Aedesaegyptii*is commonly known as tiger mosquito. It has black and white stripes with scales over head and abdomen. Adult *Aedes*is brown in colour and like *Culex*in resting position keeps the proboscis and body at an angle and not in straight line. The body as in *Culex*is hunch backed. *Aedes*sits curved with head and tail touching the wall. Female lays singly oval shaped eggs in water collected in artificial receptacles like flower pots, bottles, utensils etc. *Aedes*transmits dengue fever, yellow fever and haemorrhagic fever.

Housefly

Like mosquito housefly is also two winged insect. The mouth parts (proboscis) in housefly are suited only for sucking the liquid and not for piercing the tissues.The flies generally come to the earth for copulation and female lays oval pearly white eggs 6 to 8 days after the copulation. Eggs are laid in groups of about 100 to 150 at a time on horse manure, cow dung, faeces or any decaying vegetable or animal matter. The life cycle includes egg, larva and pupa stages. The larva of flies is called maggot. The accidental invasion of maggot cause a disease called myiasis.

Apart from the annoying habits, fly when flies over cup of tea or walks over any other food material, it leaves behind a mark of filth, bacteria or protozoa which can cause serious disease. Typhoid germs are distributed in this way. Houseflies feed on garbage, manure, faeces and also visit all such places for laying eggs. They pick up disease germs on their legs and leave them on our uncovered food in kitchen, restaurants etc. At times, these flies also deposit eggs on decaying and cut fruits, exposed sweets and when such fruits or sweets are eaten by man the young larvae enter the alimentary canal, cause intestinal disorders such as typhoid, para typhoid, diarrhoea, both bacillary

and amoebic dysentery, gastroenteritis, cholera and can even cause food poisoning. They also carry eggs of intestinal worms such as *Taeniasolium*(pork tapeworm), *Ascarislumbricodes*(roundworm), *Ancylostomaduodenale*(hookworm), *Trichuristrichura*(whipworm). Some of the other diseases transmitted by houseflies are trachoma, opthalmia, leprosy, anthrax, gangrene, poliomyelitis, infective hepatitis, tuberculosis.

***Sand Fly* (*Phlebotomus*)**

It is a small yellowish brown hairy delicate insect a bit smaller than mosquito. It has two wings and legs are longer than the body. The proboscis is fairly long and it is not bent during feeding. Sand fly does not fly but jumps from one place to another.

Fleas

They are small wingless laterally compressed insects. The adults are small dark brown coloured blood sucking ectoparasites mostly on mammals like rat, squirrel, dog and only one species viz. *Xenopsyllacheopis*, in the absence of rat when starved bites man. They have piercing and sucking type of mouth parts. They transmit the disease plague from rat to rat or from rat to man. They also transmit typhus fever.

Lice

These are small wingless flat dark pale coloured insects found on the body of animal and man and they live on host throughout their life. *Pediculushumanuscapitis*is found on the head clinging to the hairs of the host and *Pediculushumanuscorporis*is found on the clothes next to the skin. They have piercing and sucking type of mouth parts. They have dark markings on the sides and each of the six legs has a large curved claw adapted for clinging to the hair of the host. Female lays eggs on hair or clothes and adult lives for about 30 to 40 days. Infestation is by direct contact through combs, brushes and clothes. They transmit disease such as louse borne typhus fever, louse borne relapsing fever, trench fever and staphylococcal infections.

Bed Bugs

These are small oval flat reddish brown wingless insects. During the day, they hide in cervices, cracks in the bed, furniture, carpets etc. but at night they move about and suck human blood. The larger part of the body including legs is covered by a large number of bristles. They live for about a year. Normally they do not cause any disease but are mechanical vectors of human pathogens.

10.4.3 Mode of transmission

There are two mode of pathogen transmission by vectors which are discussed below:

Mechanical transmission

- Mechanical transmission occurs when arthropods *physically* carry pathogens from one place or host to another, usually on body parts. No biological relationship with vectors. For example -house flies, blow flies, cockroaches.

  In case of certain insects transmission may be by regurgitation or by defecation. Biting flies may transmit pathogens by biting with contaminated mouthparts.

Nearly all mechanically transmitted diseases can also be transmitted in other ways (e.g. contaminated food and water)

Biological transmission

- Biological transmission: by blood-feeding and biting arthropods. The pathogen multiplies within the arthropod vector, and the pathogen is transmitted when the arthropod takes a blood meal or bites. There are three types of biological transmission as given below:

1. Cyclodevelopment transmission/Cyclical transmission

- The parasites undergo several molts in the body of the vector.
- No multiplications takes place in the body of the vector.
- The only pathogens that are transmitted this way are filarial nematodes, start out as microfilariae and develops into an infectious larvae.

2. Propagative transmission

- In this type of transmission, the pathogen multiplies within the body of the vector, but does not undergo any changes in form.
- Most viral diseases fall into this category.
- Plague (a bacterial disease is also an example)
- Any stage of these pathogens can infect a vertebrate host.

3. Cyclopropagative transmission/ Propagative and Cyclical transmission

- Both multiplication and changes in the life form of the pathogen occur within the vector.
- Examples are malaria, leishmaniasis, both caused by protozoan parasites.

10.4.4 PATHOGENESIS

The viral diseases like chickungunya, dengue, zika, yellow fever, sandfly fever are manifested in five steps (1)implantation of virus at the portal of entry, (2) local replication, (3) spread to target organs (disease sites), and (4) spread to circulation (5) virus uptake by the vector during a blood meal. The vector then spreads the virus to new individuals.

The main steps of pathogenesis of any bacterial disease like plague, trench fever, relapsing fever, epidemic and endemic typhus involve transmission, colonization, adhesion, invasion, survival in the host and tissue Injury. Once the bacteria comes into circulation it is taken up by the vector during a blood meal and then it is transmitted to other uninfected individuals.

The protozoa like plasmodium (causing malaria) or trypanosome (causing leishmaniasis and chagas disease) have a life cycle including asexual and sexual stages. Some stage of their life cycleoccurs in insect vector and other stages in man. The details of life cycle are represented in self-explanatory figures 3.3,3.4 and 3.5. You can go through the figure and underlying explanations to have an idea about the life cycle of these protozoans.

The lymphatic filariasis is infection with the filarial worms, Wuchereriabancrofti. These parasites are transmitted to humans through the bite of an infected mosquito and develop into adult worms in the lymphatic vessels, causing severe damage and swelling (lymphoedema). The adult worms, which usually stay in one tissue, release early larval forms known as microfilariae into the host's bloodstream. These circulating microfilariae can be taken up with a blood meal by the arthropod vector; in the vector, they develop into infective larvae that can be transmitted to a new host (Fig. 3.6)

10.4.5 Prevention and Control

Mosquito control

Anti-Larval Measures- Environmental control measures are directed at reducing the mosquito breeding places by environmental manipulation and modification. Chemical control is done by the use of larvicides like Kerosene, Paris Green and synthetic insecticides. Biological control can be done by using a larvae eating fish known as Gambusia.

- Anti-Adult Measures- Insecticidal residual spray of DDT, Malathion and space spray (fogging) of pyrethrum extract.
- Personal Protection- Most of the mosquitoes except Aedes generally bite at night. Therefore, mosquito nets can offer protection during sleep. The mosquitoes should be light coloured with the diameter of each hole less than 0.0475 inch. Screening of doors and windows with nets also prohibit the entry of mosquitoes inside the house.

Control of vectors largely depend on measures taken to dispose of waste. In addition, specific measures often have to be applied to decrease vector population and decrease their contact with human population commonly used methods are:

- o Drainage of stagnant water
- o Use of larvicides
- o Use of insecticides
- o Use of vector traps
- o Use of insect repellents
- o Maintenance of hygiene and sanitation
- o Sunlight exposure of bedding etc.

Check Your Progress Exercise 2

Note: a) Tick the correct answer .

b) Check your progress with possible answers given at the end of the unit.

Q1. Which of the following mosquito-borne disease is caused by virus?

a) Dengue

b) Malaria

c) Filaria

d) None of the above

Q2. Propagative transmission is seen in

a) Filaria

b) Plague

c) Leishmaniosis

d) Malaria

Q3. The disease transmitted by *Reduviid* bug is

a) Leishmaniasis

b) Japanese encephalitis

c) Chagas disease

d) Epidemic typhus

Q4. Fogging is a method to kill the mosquito at which stage of their life cycle?

a) Larva

b) Pupa

c) Adult

d) Egg

Table 10.5 - Common vector borne diseases, pathogen and their symptoms

Vectors	Diseases	Pathogen	Symptoms
Aedes sp. (Mosquito)	Chikungunya	Chikungunya virus	Fever, joint pain, headache, muscle pain, joint swelling, or rash
	Dengue fever	Flavivirus	Sudden high fever, Severe headaches, Pain behind the eyes Severe joint and muscle pain, Fatigue,
Anopheles sp. (Mosquito)	Zika Malaria	Zika virus *Plasmodium sp*. (Protozoa)	Fever, headache, conjunctivitis Fever, shaking chills, headache, muscle aches, and tiredness
	Lymphatic filariasis (in Africa)	*Wucheriaba-ncrofti* (Helminth)	acute inflammation of lymphatic vessels (lymphangitis) along with high temperatures, shaking chills, body aches, and swollen lymph nodes.
Culex sp. (Mosquito)	Japanese encephalitis	West Nile Virus	Fever, tremors, nausea, vomiting, stiff neck, spastic paralysis
	Lymphatic filariasis (in America)	*Wucheriaba-ncrofti* (Helminth)	

Phlebotomus sp. (Sandflies)	Leishmaniasis	*Leishmania sp.* (Trypanosome)	Prolonged fever, weight loss, weakness, enlarged spleen, liver, bleeding
	Sandfly fever (phelebotomus fever)	Phlebo virus	fever, rash, diffuse muscle pain, headache, loss of appetite, nausea and vomiting.
Muscadomestica (House fly)	Myiasis	----------	itching, a sensation of movement, and sometimes sharp, stabbing pain.
Glossinasp (Tsetse fly)	Sleeping sickness (African trypanosomiasis)	*Trypanosoma brucei* (protozoa)	Fever, severe headaches, irritability, extreme fatigue, swollen lymph nodes, and aching muscles and joints
Xenopsyllacheopis (Rat flea)	Plague	*Yersinia pestis* (bacteria)	Fever, headache, chills, and weakness and one or more swollen, tender and painful lymph nodes
	Typhus fever	*Rickettssiatyphi* (bacteria)	Fever, chills, body ache, muscle pain, loss of appetite, cough, rash
Pediculus humanus corporis (Human body louse)	Epidemic typhus	*Rickettssiaprowzeskii* (Gram negative bacteria)	Fever with weakness, dizziness, headache (with pain behind the eyes), conjunctival injection, and severe back and leg (shin) painsBleeding, coma, headache, facial droop, stiff neck
	Trench fever	*Bartonella Quintana* (bacteria)	
	Relapsing fever	*Borrelliarecurrentis* (basteria)	
Tritomain festans (Reduviid bug)	Chagas disease (American trypanosomiasis)	*Trypannosomacruzi* (Protozoa)	Flu like symptoms like fever, headache and/ or swelling or a sore near the eye or on the side of the face where the bite or infection occurred (visible in fewer than half of infected people)·

10.5 LET US SUM UP

Food, water and vector can transmit disease causing bacteria, virus, protozoa and helminthes. Pathogens to man may be unicellular virus, bacteria, protozoa or multicellular helminths. Food borne illness can be classified as intoxication or

infection.Food borne diseases are often related to intestine discomforts.Water borne diseases are often associated with polluted water drinking.Diseases caused by protozoa discussed in this unit are amoebic or giardial dysentery, diarrhoea, malaria, sleeping sickness, kalaazar, etc. Community efforts should be directed towards improving water supply and sanitation to achieve goal of health for all.Vectors transmit the diseases from one human to another.Arthropod vectors include mosquito, housefly, sandfly, tse-tse fly, flea, louse, bed bug, Some of the diseases transmitted by the vectors are also mentioned in this unit. Proper sanitation and hygiene are very important to prevent spreading of food borne, water borne or vector borne diseases

10.6 KEY WORDS

Symptoms : Any subjective evidence of disease

Pathogenesis : is the process by which a disease or disorder develops

Illness : a disease or period of sickness affecting the body or mind.

Endotoxins : Endotoxins are toxins produced by bacteria and excreted into surrounding environment after the cell lysis (breaking of cell membrane), which are mainly composed of polysaccharides.

Enterotoxin : a toxin produced in or affecting the intestines, such as those causing food poisoning or cholera.

Diagnosis : act of identifying a disease from its signs and symptoms.

Sanitation : refers to public health conditions related to clean drinking water and adequate treatment and disposal of human excreta and sewage.

Arthropoda : It is one of the phylum of the animal kingdom which includes animals with jointed legs.

Insect : It is one of the class of the phylum Arthropoda which includes animals withsix jointed legs.

10.7 REFERENCES AND SUGGESTED FURTHER READINGS

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10.8 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress Exercise 1

Q1. c) Botulism

Q2. b) 2hrs

Q3. a) Enterotoxins

Q4. b) Mushroom

Check Your Progress Exercise 2

Q1. Chlorine

Q2. Boiling

Q3. Trophozoite

Q4. b) Giardiasis

Check Your Progress Exercise 3

Q1. a) Dengue

Q2. b) Plague

Q3. c) Chagas disease

Q4. c) Adult