**Food-borne Pathogens**

Food is a basic necessity of humans for their survival on the Earth. Food is any substance consumed by humans which provide nutrition and strength to the body. Most of the food that we consume is either plants or their products. Besides plant, some lower organisms like aquatic or poultry animals are major source of food for us.

Any kind of contamination in food cause food-borne diseases in humans. Contamination may occur due to microorganism, improper handling of food, improperly cooked food or may occur in ready to eat food items. Water used in irrigation can also be a source of contamination of vegetables and fruits.

Bacteria and Helminths are major causative agents of food infection in humans. While number of diseases caused by fungi, virus and protozoa are less. Microorganisms like Bacteria and fungi produce toxins when they are ingested and cause mild to severe disorders in the humans. Helminths were ingested in the form of cysts or eggs, they multiply and develop into adults in intestine. There abundance in intestine cause intestinal blockage and abdominal bloating.

The conventional methods to detect food borne pathogens include there culture in nutrient media followed by various biochemical tests.

These methods are more time consuming, less specific and more laborious. So there is a need to develop a method based on molecular technology which is more quick and highly specific.

Current rapid detection methods includes ATP Bio-luminescence, Immunological detection, In-situ hybridization, bio-sensors, pyrosequencing, PCR based genotype etc.

The database of unique probe and primer for food borne human pathogen (FOODPATH). This database contains 76 food borne pathogens which were responsible for causing various diseases in humans. This database contains Bacteria (26), Fungi (13), Protozoa (5), Virus (9) and Helminths (23).

**Bacterial Food Pathogens**

Bacteria are microscopic single-celled organisms that thrive in diverse environments. They can live within soil, in the ocean and inside the human gut. Human’s relationship with bacteria is complex. Sometimes they lend a helping hand, by curdling milk into yogurt, or helping with our digestion. At other times they are destructive, causing diseases like pneumonia and food poisoning.

In a 2012, David A. Relman, a microbiologist at Stanford University, states that there are about 10 times more microbial cells than human cells in the human body. The highest numbers of microbial species are found in the gut.

Some bacteria has an ability to cause diseases in humans. These pathogens express a wide range of toxic molecules that binds with the host’s cell and facilitates different harmful responses.

The human gut is most suitable place for bacteria, where they get plenty of nutrients available for their sustenance.

Generally, they cause food poisoning, diarrhea or other gastrointestinal diseases. Bacteria enters into the host organism through contaminated food. After ingestion, they get colonize and start affecting the host’s metabolism. These pathogens need oxygen, moisture, warm temperature and pH for growth and colonization and human body provide them favourable conditions to bloom inside when ingested.

Most common bacterial foodborne pathogens are: Campylobacter jejuni, Clostridium perfringens, Salmonella spp., Escherichia coli O157:H7. Other common bacterial foodborne pathogens are: Bacillus cereus, Escherichia coli,

Listeria monocytogenes, Shigella spp.,Staphylococcus aureus, Staphylococcal enteritis , Streptococcus , Vibrio cholerae, including O1 and non-O1, Vibrio parahaemolyticus, Vibrio vulnificus, Yersinia enterocolitica and Yersinia pseudotuberculosis. Brucella spp., Corynebacterium ulcerans, Coxiella burnetii or Q fever and Plesiomonas shigelloides.

Bacterial cell produce toxins in response to outer stimulus.

Exotoxins are usually heat labile proteins secreted by certain species of bacteria which diffuse into the surrounding medium.

Endotoxins are heat stable lipopolysaccharide-protein complexes which form structural components of cell wall of Gram Negative Bacteria and liberated only on cell lysis or death of bacteria.

**Viral Food Pathogens**

The virus particles are 100 times smaller than a single bacteria cell. Viruses by themselves are not alive. They cannot grow or multiply on their own and need to enter a human or animal cell and take over the cell to help them multiply. These viruses may also infect bacterial cells.

They do not possess their own machinery for replication, they take over human or bacterial machinery to grow and bloom inside host’s body.

In recent years, viruses have been increasingly recognized as important causes of food borne

disease. They are highly resistant to heat, temperature, freezing and UV light so they can survive into the food for longer periods.

Viruses have emerged as causes of food borne disease, according to data compiled by the Centers for Disease Control and Prevention. Viruses that cause food poisoning are hepatitis A and E, norovirus, poliovirus, rota virus, adeno virus etc.

When such viruses enters and replicate in our body they produce toxins or some bi-products that accumulate within the host’s cell. They are cytotoxic in nature.

Hepatitis A is a virus that affects the liver for a few weeks up to several months. Norovirus has been reported to be responsible for outbreaks of severe gastrointestinal illness. About 20 million people in the U.S. become sick from these highly contagious viruses every year.

Rotavirus causes severe, watery diarrhea that can lead to dehydration. The illness occurs most often in babies and young children.

### Fungal Food Pathogens

Fungi are living organisms that are distantly related to plants. They are uni- or multi- cellular eukaryotic microorganisms. As eukaryotes, fungal cell contain a membrane bound nucleus where the DNA is wrapped around the histone proteins. Unlike plant cells they do not possess chloroplast or chlorophyll. They show wide range of different colors through cellular pigments. These pigments are associated with cell wall and plays important role in protecting them from UV radiation and it can be toxic also.

Like animals they are heterotrophs: they use complex compounds as a source of carbon.

Fungi like mushrooms, molds and yeasts have been eaten for several thousand years. Although some types of fungi are poisonous to humans. Pathogenic fungi are mainly associated with food crops like maize, wheat or barley.

Fungal contamination of food is one of the most prevalent cause of disease. They produce toxins that cause diseases.

Mycotoxins can cause acute and chronic illnesses, induce cancer, and damage vital organs such as the liver kidney and brain. Fungi like Fusaria, Trichothecium, Cephalosporium etc may contaminate grains and produce illness with symptoms such as vomiting, diarrhea, headaches, chills, dizziness, and blurred vision.

Aflatoxins are produced by molds which favor nuts, corn, millet, and figs. These toxins may produce symptoms like loss of appetite and jaundice immediately and with repeated exposure, they are also carcinogenic.

The common fungi, which grow on food, even in the refrigerator, are Penicillium and Aspergillus. Over 15 tremorgenic mycotoxins have been isolated from these fungi.

The mycotoxin (ochratoxin A) is a common contaminant of foods and beverages such as beer, coffee and wine. It is produced as a secondary metabolite of moulds from Aspergillus and Penicillium genera. It inhibits protein synthesis by competition with phenylalanine, its structural analogue and also enhances the production of oxygen free-radicals. Its multiple toxic effects include cytotoxicity, teratogenicity, genotoxicity, mutagenicity and carcinogenicity.

### Protozoan Food Pathogens

Protozoa are unicellular, motile, eukaryotic and heterotrophic microorganisms. They are bound to moist or aquatic habitat. They establish a symbiont relationship with organisms like bacteria, fungi and mammals or they are parasitic to them.

Pathogenic protozoa are commonly transmitted through food in developing countries. The vast majority of protozoa do not harm us. But there are a few that cause disease. The main protozoa of concern are Toxoplasma, Crptospordium and Giardia in developed countries. In developing countries the main problem is with Cyclospora, Entamoeba and Sarcocytis. Like virus, they do not multiply on food. Protozoan parasite can be ingested in form of cysts through food.

Some species of protozoa are part of the normal microbial flora of animals, and live in the guts of insects and mammals, helping to break down complex food particles into simpler molecules.

Cryptosporidium parvum and Giardia lamblia are parasitic protozoa which live in the guts of animals.

Giardia lamblia is a common parasite that can cause villous atrophy, a similar kind of wasting of the gut's villi that is seen in Celiac Disease. Villous atrophy reduces gut absorption of several minerals, nutrients and fat soluble vitamins.

Entamoeba histoltica is another common parasite. This nasty parasite can infect adjacent organs such as the liver where it can form cysts, abscesses and can even form pus.

C. parvum possesses numerous surface glycoproteins thought to play a role in pathogenesis.

Cyclospora causes a syndrome of prolonged, intermittent diarrhea associated with profound fatigue and anorexia and it infects the upper intestine.

**Helminths food pathogens**

Helminths are large, eukaryotic and multicellular organisms. They are commonly known as parasitic worms or intestinal worms, although not all helminths are intestinal parasites. Helminth includes three major groups: cestodes (tapeworms), trematodes (flukes) and nematodes (roundworms). These organisms are microscopic but when they develop into adults can be seen with naked eyes.

Helminths form three main life-cycle stages: eggs, larvae and adults. Adult worms infect definitive hosts (those in which sexual development occurs) whereas larval stages may be free-living or parasitize invertebrate vectors, intermediate or paratenic hosts. Nematodes produce eggs that embryonate in utero or outside the host. The emergent larvae undergo 4 metamorphoses (moults) before they mature as adult male or female worms. Cestode eggs released from gravid segments embryonate to produce 6-hooked embryos (hexacanth oncospheres) which are ingested by intermediate hosts. The oncospheres penetrate host tissues and become metacestodes (encysted larvae). When eaten by definitive hosts, they excyst and form adult tapeworms. Trematodes have more complex life-cycles where ‘larval’ stages undergo asexual amplification in snail intermediate hosts. Eggs hatch to release free-swimming miracidia which actively infect snails and multiply in sac-like sporocysts to produce numerous rediae. These stages mature to cercariae which are released from the snails and either actively infect new definitive hosts or form encysted metacercariae on aquatic vegetation which is eaten by definitive hosts.

Helminths are transmitted to the [final host](https://en.wikipedia.org/wiki/Definitive_host) in several ways. The most common infection is through [ingestion](https://en.wikipedia.org/wiki/Ingestion) of contaminated vegetables, drinking water, and raw or undercooked meat. Contaminated food may contain eggs of nematodes such as Ascaris, Enterobius, and Trichuris; cestodes such as Taenia, Hymenolepis, and Echinococcus; and treamtodes such as Fasciola.

The main effects derived from intestinal helminth infection are sickness, tiredness and diminished physical fitness due to the deprivation of essential nutrients caused by the presence of worms in the intestine. In children, these health problems determine anemia and malnutrition and often lead to impaired mental and physical development, weakened memory and cognition.